EXPLORING FATIGUE CHALLENGES AND CONTRIBUTING FACTORS IN THE SOUTH AFRICAN AVIATION INDUSTRY AMIDST THE COVID-19 PANDEMIC: INSIGHTS FROM BLUNT-END STAKEHOLDERS

BY

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ABSTRACT

Background: Despite the global aviation industry's ongoing commitment to safety, crew fatigue remains a persistent and pressing issue. Within South Africa, fatigue management was primarily governed by regulations, however, there was ongoing debate about whether these regulations adequately reflected the latest scientific evidence and operational demands. This study addressed this gap by investigating perceptions about fatigue and fatigue management from management and decision-makers (blunt-end stakeholders) within the South African aviation sector. This study aimed to investigate the perceptions surrounding fatigue and fatigue management among management and decision-makers (blunt-end stakeholders) within the South African aviation sector. Specifically, it sought to contribute to ongoing research dedicated to developing a better understanding of whether, how, and why regulations pertaining to fatigue management may need to change. By exploring the perspectives of blunt-end stakeholders, the study aimed to uncover insights into the challenges and potential gaps in current regulations, with the ultimate goal of informing potential regulatory adjustments to enhance aviation safety. **Methodology**: A cross-sectional, qualitative exploratory design investigated perceptions about fatigue and fatigue management among blunt-end stakeholders in the South African aviation industry. Data was collected through online semi-structured interviews and written open-ended questionnaires to capture diverse perspectives. The methodology aimed to comprehensively understand fatigue-related experiences and perceptions among pilots and cabin crew, considering the unique challenges posed by the COVID-19 pandemic. Participants were selected using purposive and snowball sampling, ensuring representation from various regulatory categories and industry sectors. The study employed a thematic analysis approach to analyse data collected through online semi-structured interviews and written open-ended questionnaires. Thematic analysis facilitated the identification of key patterns and themes in the perceptions of blunt-end stakeholders within the South African aviation industry regarding fatigue and fatigue management **Results**: The thematic analysis of data from thirteen South African aviation industry stakeholders unveiled insights into crew fatigue challenges and regulatory concerns. Participants emphasized crew fatigue as a significant safety risk linked to entrenched crew mentalities, where instances of disregarding fatigue management protocols posed imminent safety risks. Additionally, outdated regulations were cited, hindering optimal crew rest periods and modern fatigue mitigation technologies, with discrepancies in regulatory support exacerbating challenges across operational contexts. Aviation stakeholders expressed apprehensions regarding the efficacy of existing Flight and Duty Regulations, advocating for amendments to enhance fatigue management practices. The COVID-19 pandemic further exacerbated fatigue issues, leading to shifts in crew morale, increased stress levels, and regulatory challenges, necessitating adaptive fatigue management strategies and proposed risk mitigation plans, including regulatory adjustments and enhanced stakeholder engagement. **Discussion**: The study investigated the intricate landscape of fatigue-related risks within the aviation industry, recognizing the systemic and context-specific nature of these challenges. It is evident from our findings, in line with previous research, that fatigue within the aviation sector is not merely an isolated issue but a multifaceted consequence of systemic factors. Our study highlights the pressing need for revisiting the current Flight and Duty Periods (FDPs) and overall fatigue management strategies to address these underlying systemic issues effectively. Unlike static safety concerns, fatigue-related risks evolve dynamically, influenced by technological advancements, industry practices, and external factors such as the ongoing COVID-19 pandemic. Our analysis elucidated the complex interplay between safety protocols, operational standards, and the well-being of crew members, emphasizing the need for a nuanced approach in mitigating fatigue-related risks. Central to our findings is the recognition of the limitations of existing regulations in adequately addressing emerging challenges associated with crew fatigue. Our study underscores the imperative of regulatory agility in safeguarding both passengers and crew members, advocating for continuous evaluation and refinement of regulatory frameworks. Specifically, there is a critical need to revisit and adapt current FDPs and fatigue management strategies to align with the systemic causes of fatigue identified in our research. **Conclusion**: This study contributed a comprehensive analysis of crew fatigue in South African aviation, focusing on perspectives of blunt-end stakeholders. It highlighted widespread recognition of fatigue's safety implications, exacerbated by factors like economic stressors and regulatory deficiencies, including those intensified by the COVID-19 pandemic. Participants advocated for regulatory reforms to enhance crew rest provisions and address scheduling challenges. The research underscored the need for a proactive, collaborative approach prioritizing aviation professionals' well-being. Recommendations emphasized tailored regulations, technology integration, and ongoing collaboration among stakeholders to refine fatigue management strategies and ensure industry resilience.

Keywords: Fatigue; Aviation; COVID-19 pandemic; Blunt-End Stakeholders.

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LIST OF ABBREVIATIONS

AASA – Airlines Association of Southern Africa

ALPA-SA – Airline Pilots' Association of South Africa

AOC – Air Operator Certificate

CAA – Civil Aviation Authority

CASA – The Civil Aviation Safety Authority of Australia

COVID-19 – Coronavirus (SARS-COV-2 virus)

EASA – European Aviation Safety Agency

FAA – Federal Aviation Authority (USA)

FAR – Federal Aviation Regulations

FDP – Flight Duty Period

FRMS – Fatigue Risk Management Systems

FTL – Flight Time Limitations

GDP – Gross Domestic Product

HRO – High-Reliability Organisation

IATA – International Air Transport Association

ICAO – International Civil Aviation Organisation

IEA – International Ergonomics Association

IFALPA – The International Federation of Airline Pilots Association

NGO – Non-Governmental Organisation

NTSB – National Transportation Safety Board

OSA – Obstructive Sleep Apnea

REM – Rapid Eye Movement

SACAA – South African Civil Aviation Authority

SARPs – Standards and Recommended Practices

SCN – Suprachiasmatic Nucleus

SMS – Safety Management System

SWS – Slow-Wave Sleep

TCCA – Transport Canada Civil Aviation

UK-CAA – Civil Aviation Authority (United Kingdom)

WOCL – Window of Circadian Low

CHAPTER 1 - INTRODUCTION

1.1 Background to Study

The aviation industry – a 'steady' pillar in the world of transport – has been an increasing centre of the global socio-economic fabric (ICAO, 2021a). The industry underpins social connections and facilitates access to goods and services (including trade, jobs, healthcare, and education) (ICAO, 2021a). Safety is a core value of rapid and dependable air services, and international cooperation on safety by governments and industry groups such as the International Civil Aviation Organisation (ICAO) has helped make commercial air travel one of the safest ways to travel (ICAO, 2021b). Although commercial air travel is one of the safest ways to travel, operating in the aviation industry is not risk-free. Instead, safety is the state in which risks associated with aviation activities related to, or indirectly supporting aircraft operation, are reduced, and controlled to an acceptable level (ICAO, 2016). In the realm of aviation, various factors contribute to the potential risks faced by the industry. These risks encompass equipment failure, environmental-/weather-related incidents, pilot errors, air traffic control issues, ground/cabin crew errors, incidents involving other aircraft, and events related to terrorism, conflict, or criminal activities (Janic, 2000; Oster et al., 2013).

Within the spectrum of risks inherent to a safety-critical environment such as aviation, fatigue stands out as a critical concern. The consequences of fatigue extend beyond individual performance, encompassing the safety of the entire aviation workforce and, consequently, the overall flight safety (Reis et al., 2013; Wingelaar-Jagt et al., 2021). The unique challenges posed by modern aviation, including stressful working conditions, extended duty periods, frequent take-offs and landings, and disruptions to circadian rhythms due to irregular schedules, contribute to crew fatigue (Åkerstedt et al., 2021; Efthymiou et al., 2021; Kandera et al., 2019; Reis et al., 2016; Wingelaar-Jagt et al., 2021). These challenges hinder the crew's ability to obtain adequate rest and sleep, resulting in cumulative sleep loss and fatigue over consecutive duties (Åkerstedt et al., 2021; Efthymiou et al., 2021; Kandera et al., 2019; Reis et al., 2016; Wingelaar-Jagt et al., 2021). The implications of crew fatigue pose ongoing challenges to well-being, performance capacity, and flight safety, exacerbated by the intricate balance required between the three (Avis et al., 2019; Rajaveräjä, 2019; Wingelaar-Jagt et al., 2021). Thus, effective fatigue management becomes imperative within the aviation industry.

Fatigue management refers to the tailored strategies adopted by aviation service providers and operational personnel to address and mitigate the safety implications associated with fatigue. It is important to note that there are various ways in which fatigue can be managed in aviation, and the ICAO standards and recommended practices (SARPs) advocate for a three-step process of fatigue management (ICAO, 2016). This process provides a comprehensive framework for addressing the safety implications of fatigue within the aviation industry. The first step, known as the basic approach, involves service providers adhering to hard limits set by the regulator (ICAO, 2016). Following this approach ensures a fundamental level of fatigue management within the prescribed regulations. The second step, termed the SMS approach, allows service providers to manage fatigue risks using Safety Management System (SMS) processes while staying within the defined limits (ICAO, 2016). This approach introduces a more flexible and dynamic system for fatigue management. The third step, known as the fatigue risk management system (FRMS) approach, requires service providers to meet additional requirements, providing them with flexibility beyond prescriptive limitation regulations (ICAO, 2016). This approach recognizes the evolving nature of operational demands and allows for a more adaptive and tailored fatigue management strategy.

In addressing state-mandated flight and duty restrictions, ICAO emphasizes two key considerations imperative for regulatory authorities during the formulation or modification of these limits prior to implementation. To begin, the restrictions must reflect a balance of the most recent scientific information about sleep and circadian-related disciplines, as well as the most recent operational experience and insights (ICAO, 2015). Second, the design of these duty time limits should take into account the precise operational situation in which they will be used, while also being supported by context-specific data. In response to these recommendations and in light of evolving scientific knowledge and operational requirements, regulatory authorities worldwide have revised their Flight and Duty Limitations. These regulatory bodies include the Federal Aviation Administration (FAA) in the United States of America, the European Aviation Safety Agency (EASA) in Europe, the Civil Aviation Safety Authority (CASA) of Australia, the Civil Aviation Authority of New Zealand, and Transport Canada Civil Aviation (TCCA) in Canada (CASA, 2019; Civil Aviation Authority of New Zealand, 2017; EASA, 2014; Government of Canada, 2018). These revisions have encompassed various measures, such as extending rest periods, modifying flight duty times to allow for more recovery time, reducing consecutive duty periods, managing crew workload by limiting the number of sectors per duty, decreasing the number of consecutive night flights, and minimizing consecutive early sign-ons and late finishes (CASA, 2019; Civil Aviation Authority of New Zealand, 2017; EASA, 2014; Efthymiou et al., 2021; Government of Canada, 2018). It is important to note that while universally accepted working arrangements remain elusive, these endeavours to mitigate the effects of disruptive and fatiguing duties represent concerted efforts aimed at curtailing the impact of sleep deprivation and fatigue on aviation safety.

In the realm of risk management, which includes those associated with fatigue, effective collaboration among regulators, operators, and flight crew is imperative. To elucidate the intricate nature of risk management and its hierarchical dynamics within the aviation industry, Rasmussen's (1997) socio-technical system model becomes instrumental. This model delineates the involvement of sharp-end stakeholders, such as pilots, in carrying out the work processes associated with risk, while also highlighting the role of blunt-end stakeholders — comprising management and decision-makers (union representatives, industry associates, airline and scheduled operators, non-scheduled operators, and regulator representatives) — who, while not directly engaged in the risky work process, significantly influence it (Rasmussen, 1997). Furthermore, the model elucidates the nuanced interplay of bottom-up, middle-out, and top-down approaches adopted by stakeholders across different hierarchical levels in managing environmental stressors (Rasmussen, 1997). Importantly, the model underscores the need to comprehend the extent of vertical integration within the aviation industry. Vertical integration refers to the degree to which various aspects of the aviation industry, from regulatory bodies to airlines and operators, are interconnected and work together seamlessly. This interconnectedness is vital for a comprehensive grasp of the risk management processes within the aviation sector.

In 2016, the Airline Pilots Association of South Africa (ALPA-SA) took a significant step within the South African context by initiating an appeal for action, urging regulatory authorities to reevaluate the existing Flight Time Limitations (FTL). This call for change sparked a dialogue within the South African aviation sector, involving key stakeholders such as the APLA-SA, the Airlines Association of Southern Africa (AASA), and the South African Civil Aviation Authority (SACAA). This consortium engaged in a prolonged and substantive debate on the adequacy of prevailing Flight Time Limitation regulations. Over time, a consensus emerged that these regulations did not align with the latest insights from sleep and fatigue science, nor did they address the evolving operational demands in South Africa.

Despite industry-driven interest in understanding fatigue and its implications for safety and well-being, research on the prevalence of and factors contributing to fatigue in aviation has been extensive in various contexts, but notably less so in South Africa (Blair, 2022; Tambala et al., 2017). It is crucial to understand the reported incidence of crew fatigue across the South African aviation sector, along with the typical work- and non-work-related causes perceived by the crew. Blair (2022) conducted research focused on the self-reported prevalence of crew fatigue and the contributing factors from the perspective of sharp-end stakeholders in the South African aviation industry. There is, however, a significant gap in the literature concerning the views of blunt-end stakeholders in South Africa. Internationally, some research has explored the self-reported prevalence of crew fatigue and contributing factors from the perspective of management and decision-makers (blunt-end stakeholders). Most notably, Tambala, *et al.* (2017) conducted a study on fatigue on the flight deck, addressing challenges and mitigations related to fatigue in the Norwegian aviation sector. Yet, within the South African context, this perspective remains poorly understood. Therefore, this study aims to fill this gap by investigating the views of blunt-end stakeholders, as well as to address the overall lack of research on fatigue in the South African aviation industry. Throughout the remainder of this research paper, the term 'blunt-end stakeholders' referred specifically to ‘management and decision-makers’ in the aviation industry.

As emphasized by ICAO (2016), effective fatigue management required tailored regulations and rostering practices informed by current scientific and operational insights. While existing data often focused on pilots and cabin crew, fatigue management involved stakeholders beyond the cockpit and cabin, including union representatives, airlines, and regulatory bodies. This study aimed to bridge this gap by exploring the perspectives of industry personnel across different organisational levels within the South African aviation sector. Insights from these stakeholders were crucial for informing potential revisions to South Africa's Flight Time Limitations (FTL) and for developing a comprehensive understanding of fatigue management strategies. Considering the varied interests and roles of these stakeholders, obtaining diverse perspectives was essential for addressing safety, economic, and schedule-related concerns.

At the onset of data collection, the aviation industry was confronted with the unprecedented challenges posed by the COVID-19 pandemic. The timing of this research project coincided with the initial phases of the pandemic, introducing a unique context that necessitated a comprehensive understanding of its impact on various aspects of the industry. The pandemic induced a series of disruptions, including a significant loss in revenue, altered schedules, reduced flights, diminished fleet numbers, and a decline in available crew (Dube et al., 2021; Gössling, 2020; IATA & ICAO, 2020; Mhalla, 2020). In alignment with the concerns raised by the International Federation of Air Line Pilots' Associations (IFALPA) in their 2020 statement, the pandemic had exerted pressure on operators and crew, which influenced various challenges to aviation safety, including crew fatigue management. The adaptation to COVID-19 restrictions stretched regular fatigue measures for flights, especially in scenarios such as repatriation flights, where extended durations and limited opportunities for rest at destination ports became the norm. Cargo operations face continuous challenges, with pilots confronting heightened restrictions. As IFALPA emphasizes, the current operating environment presents unprecedented challenges, and the established safety defences may not function at their optimal levels. This temporal intersection with the pandemic becomes particularly relevant as the study delves into the exploration of fatigue risks within the aviation sector, where the dynamic changes brought about by the pandemic are crucial for the understanding of the broader context and implications.

1.2 Problem Statement & Research Aims

Previous research has extensively addressed fatigue factors among cockpit and cabin members, primarily outside of South Africa (Caldwell, 2005; Caldwell et al., 2009; EASA, 2014, 2019; Jackson & Earl, 2006; Powell et al., 2007). However, limited research within South Africa hinders discussions on fatigue-related challenges and potential adjustments to local flight and duty limits. While prior studies in South Africa focused on crew members' self-reported prevalence (Blair, 2022), a significant gap exists in understanding the perspectives of safety managers, decision-makers, industry associations, regulators, and union members regarding fatigue contributory factors. Bridging this gap is vital for comprehensive fatigue management, especially considering the role of management and decision-makers in aviation's socio-technical risk management system (Rasmussen, 1997).

This research aims to integrate the thoughts of various stakeholders within the South African aviation industry, addressing the lack of insight into the experiences and perspectives of safety managers and decision-makers on pilot and cabin crew fatigue. Moreover, the study recognizes the unique challenges brought about by the COVID-19 pandemic. The altered operational landscape, stringent health regulations, and the balance between domestic responsibilities and workload highlight the need to investigate the pandemic's impact on fatigue and its contributory factors. This research not only fills a gap in existing literature but also contributes valuable insights into the effects that this extraordinary global crisis had on aviation safety, with particular focus on fatigue management.

1.2.1 Research Aim

The study aimed to explore the self-reported challenges of fatigue and its contributory factors from blunt-end stakeholders in operations in the South African aviation industry. Additionally, the study aimed to explore the self-reported thoughts on the current flight and duty regulations in relation to fatigue and possible recommendations to amending the regulations. Finally, due to the unique effects of a global pandemic during this research project, the study aimed to explore the self-reported impact of the COVID-19 pandemic on the prevalence of fatigue, its contributory factors, and plans to manage fatigue from blunt-end stakeholders. Hence, the research objectives were to:

1. determine blunt-end stakeholders' experiences and insights into the challenges of fatigue and its contributory factors prior to the pandemic.
2. explore blunt-end stakeholders' thoughts on the current Flight and Duty Regulations in relation to fatigue and possible recommendations to amending the flight and duty period regulations.
3. determine blunt-end stakeholders' thoughts on the impacts of the COVID-19 pandemic on the emerging fatigue risks and proposed management of fatigue in the industry.

These objectives would be addressed through the following research questions:

1. What are the blunt-end stakeholders' experiences and insights on the self-reported challenges of fatigue and its contributory factors in the South African aviation industry prior to the pandemic?
2. What are blunt-end stakeholders' thoughts of the current flight and duty period regulations and possible recommendations to amending the flight and duty period regulations?
3. What are blunt-end stakeholders' thoughts on the impacts of the COVID-19 pandemic on the emerging fatigue risk and proposed management of fatigue in the industry?

CHAPTER 2 - BACKGROUND LITERATURE

2.1 Aviation and Safety: An Overview

The global aviation landscape is characterized by a vast network of more than 5,000 airlines operating a fleet exceeding 25,000 commercial aircraft, connecting people to over 3,700 airports worldwide (Oliver Wyman, 2017). Over the past three decades, the aviation industry has experienced a consistent average annual growth rate of approximately 5% (Mazareanu, 2020). In 2019 alone, global airlines facilitated more than 38.3 million scheduled flights, serving over 4.5 billion passengers, underscoring the sector's unparalleled scale and impact (ICAO, 2019). This significant expansion can be attributed to ongoing technological advancements in aircraft design, allowing for improved accessibility and extended flight ranges, including the emergence of Ultra-Long-Range aircraft (FAA, 2010; IATA, 2020b; Mazareanu, 2020).

Shifting the focus to the South African context, the aviation industry plays a vital role in the nation's economy. In 2017, the South African aviation sector contributed a substantial US$9.4 billion (ZAR 133.96 billion) to the country's Gross Domestic Product (GDP) (IATA, 2016, 2018). An additional US$5.1 billion in gross value was generated by foreign tourists' spending, underscoring the sector's pivotal role in the nation's economy (IATA, 2016). Employment opportunities within the South African aviation industry were significant, with over 70,000 South Africans employed, and an additional 130,000 jobs created through local supplier networks (IATA, 2016). Annually, approximately 390,000 aircraft operations, including both scheduled and non-scheduled flights, take place in South Africa, with the majority falling under scheduled aviation operations (IATA, 2016).

2.1.1 Safety in the Aviation Industry

While aviation is generally considered an ultra-safe mode of transportation (Wingelaar-Jagt et al., 2021), various factors pose safety challenges in the industry. These encompass the impacts of climate change, weather-related risks, infectious diseases (such as COVID-19), bio-hacking, insider threats, civil unrest, flights in conflict zones, human trafficking, contraband smuggling, inadequately documented passengers, and terrorism (IATA, 2018).

In exploring this spectrum of safety concerns, it is essential to establish a coherent connection to the subsequent focus of this research. This study focuses on a specific safety issue within the aviation industry - pilot fatigue. The subsequent section delves deeper into understanding the complexities and implications of this challenge, providing a more explicit link between the broader context of aviation safety and the specific safety concern addressed in this research.

2.2 Fatigue

Fatigue is a complex concept that poses a challenge when it comes to its definition. It is often inferred from observable behaviours, even though it cannot be directly observed or objectively measured (Williamson et al., 2011). This state is commonly associated with various acute and chronic illnesses, such as central or peripheral nervous system disorders, cystic fibrosis, infections, asthma, gastrointestinal disorders, metabolic abnormalities, and even in the context of normal, healthy functioning (Aaronson et al., 1999; Caldwell et al., 2019; Hickie et al., 2006; Nap-van der Vlast et al., 2017; Sun et al., 2015). The observable behaviours linked to fatigue include feelings of weakness, tiredness, and a lack of energy (Phillips, 2015; Williamson et al., 2011). This makes defining fatigue challenging.

2.2.1 Defining Fatigue

Fatigue is a multifaceted phenomenon resulting from complex interactions between biological processes, psychosocial experiences, and behavioural expressions. There is not a single universally agreed-upon definition due to the diverse contexts in which it is studied, including physiological, performance-related, subjective, or combinations thereof (Aaronson et al., 1999; Bendak & Rashid, 2020; Dawson et al., 2011; Di Milia et al., 2011; S. Lee & Kim, 2018; Noy et al., 2011). Despite the variations, many concur that fatigue often arises as a consequence of exertion (Phillips et al., 2017) or as a response to sleep deprivation and prolonged physical or mental exertion (ICAO, 2016).

The diversity of definitions is highlighted by examples from different categories and authors, illustrating the intricate nature of defining fatigue. For instance, the Oxford Dictionary (n.d.) describe fatigue as *"a feeling of being extremely tired, usually because of hard work or exercise."* Aaronson *et al.* (1999, pg. 46) contribute a subjective perspective, defining it as *"the awareness of a decreased capacity for physical and/or mental activity."* Physiologically, fatigue is described by Williamson et al., (2011, pg. 499) as "*a biological drive for recuperative rest"* while Gander et al., (2011, pg. 574) offers a performance-related definition as *"the inability to function at the desired level due to incomplete recovery from the demands of prior work."*

This multitude of perspectives emphasizes the intricate nature of fatigue, underlining its subjective, physiological, and performance dimensions. The complexities of defining fatigue are further compounded by the varied contexts in which it is experienced, reflecting the intricate interplay of factors such as rest and sleep history, circadian effects, psychosocial factors, individual traits, and environmental conditions (Phillips, 2015).

2.2.2 Types of Fatigue

Besides the diversity in definitions, fatigue can be categorized spatially as mental or muscular fatigue or temporally as acute or chronic fatigue (Lee & Kim, 2018; Piper, 1989; Techera, 2017). Mental fatigue, a psychobiological state resulting from extended periods of demanding cognitive activities, is characterized by a feeling of energy depletion and tiredness. It hampers information processing, reduces competence and productivity, and increases the risk of errors (Boksem & Tops, 2008; Harrison & Horne, 2000; Lee & Kim, 2018). Muscular fatigue, on the other hand, refers to the decrease in physical ability to exert force or perform tasks after extended physical activity and high-intensity work (Lee & Kim, 2018; Techera, 2017). Muscular fatigue is often caused by factors such as high-intensity work, prolonged work duration, or improper work posture (Lee & Kim, 2018). Although these types can be distinguished, they are often experienced in combination to varying degrees and proportions, resulting in performance decrements (Techera, 2017).

Acute fatigue stems from physical or mental exertion, insufficient recovery, or emotional stress and is considered a normal regulatory response to adverse conditions that affect healthy individuals (Aaronson et al., 1999; Gander et al., 2011; Techera, 2017). Its effects are short-lived, and recovery typically involves factors such as good quality sleep, a healthy diet, regular exercise, and stress management

(Aaronson et al., 1999; Gander et al., 2011; Techera, 2017). In contrast, chronic fatigue, which shares symptoms with acute fatigue, is a persistent state with no direct relation to activity or exertion and is often attributed to multiple, additive, or unknown causes (Aaronson et al., 1999; Techera, 2017).

The onset of fatigue can manifest as mental, physical, or emotional symptoms (Caldwell et al., 2003; Cole, 2012; Techera, 2017). Although fatigue's assessment and description can be challenging due to the multitude of factors and dimensions involved, it remains a crucial subject of study. Managing fatigue requires a combination of strategies, including adequate sleep, a balanced diet, regular exercise, and stress management. However, chronic fatigue, once experienced, cannot be reversed by sleep alone (Aaronson et al., 1999; Gander et al., 2011; Techera, 2017). Understanding fatigue becomes even more paramount when considering contextual demands, as different environments can drive fatigue in unique ways. This is particularly evident in the realm of aviation.

2.2.3 Fatigue in Aviation

In the context of aviation, fatigue is defined according to the International Civil Aviation Organisation (ICAO) (2016, pg. XV) as a *"physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, or workload (mental or physical activity) that can impair a person's alertness and ability to perform safety-related operational duties."* Aviation is widely recognized as one of the safest modes of transport globally, yet fatigue remains a significant hazard that predictably impacts various aspects of human performance, potentially contributing to aviation accidents or incidents (Caldwell, 2005, 2012; Coombes et al., 2020; ICAO, 2016; National Transportation Safety Board, 2019; Roach, Sargent, et al., 2012; Wilson et al., 2007).

Despite the strides made in aviation safety, fatigue continues to pose challenges due to changes in the way airline companies operate (Kandera et al., 2019; Samel et al., 1995a; Tambala et al., 2017; Wingelaar-Jagt et al., 2021). With growing commercial competition and a global shortage of pilots, the industry operates around the clock, leading to atypical shift patterns that require pilots to work irregular hours and extended shifts, resulting in reduced sleep and recovery time (Caldwell, 2005; Dawson et al., 2011; ICAO, 2016; Signal, 2014). In light of this, fatigue in aviation cannot be entirely eliminated but must be effectively managed (ICAO, 2016) This need for effective fatigue management in the aviation industry is further underscored by the historical contributions of fatigue to accidents and incidents within the industry.

2.2.3.1 Fatigue Related Incidents and Accidents in Aviation

Fatigue is a recognized contributing factor in various contexts, leading to accidents, injuries, and fatalities (Caldwell, 2012; Gaines et al., 2020; Marcus & Rosekind, 2017). It impairs the performance and safety of individuals, particularly in settings with irregular working hours such as aviation (Williamson et al., 2011). Between 2011 and 2015, there were 407 aircraft accidents in the commercial air transport industry, resulting in 1,858 fatalities worldwide (International Air Transport Association, 2015). Fatigue was identified as a contributing factor in a portion of these accidents, accounting for 3% of all accidents and 6% of fatal accidents (International Air Transport Association, 2015). In non-fatal accidents, fatigue contributed to 2% of the cases. In Africa during the same period, there were 54 aircraft accidents, resulting in 322 fatalities (International Air Transport Association, 2015). However, fatigue was not identified as a contributing factor in any of these accidents in the commercial air transport industry. In 2015, Africa had the highest accident rate among regions, with 7.9 accidents per million sectors (International Air Transport Association, 2015).

From 2016 to 2020, there were 262 aircraft accidents globally in the commercial air transport industry, leading to 1,112 fatalities (International Air Transport Association, 2021). Fatigue was identified as a contributing factor in 6% of all accidents and a more significant 18% of fatal accidents. In non-fatal accidents, fatigue contributed to 3% of cases. In Africa during this period, there were 32 aircraft accidents, resulting in 198 fatalities. In 2020, Africa had an accident rate of 22.27 accidents per million sectors, the highest among all regions. Again, fatigue was not recognized as a contributing factor in any of these accidents in the commercial air transport industry. Nonetheless, Table 1 below highlights the most notable fatigue-related accidents in the aviation industry.

Table i: Most Notable Fatigue-Related Accidents

Year	Airline	Description and Factors Implicated in the Accidents
1997	Korean Air	Korean Airlines Flight 801 crashed into a hill near Antonio Won Pat Airport, claiming 228 lives. Captain's fatigue degraded performance and contributed to failure to execute the approach (NTSB, 1997).
1999	American Airlines	American Airlines Flight 1420 crashed in Little Rock, Arkansas, killing eleven. Fatigue contributed to impaired performance during approach in adverse weather conditions (NTSB, 1999).
2007	One-Two-Go Airlines	Flight 269 crashed in Phuket, Thailand, killing 90. Crew fatigue, extended working hours, and deficiencies in training and safety programs were contributing factors (Ministry of Transport Thailand, 2007).
2009	Colgan Air	Colgan Air Flight 3407 crashed, killing 50. Fatigue was identified, as pilots commuted long distances and slept in the crew lounge before the flight (NTSB, 2009).
2010	Ethiopian Airlines	Ethiopian Airlines Flight 409 crashed after take-off, killing all 90 on board. Fatigue among crew members was widely assumed to have played a role (Ministry of Public Works & Transport, 2010).
2010	Air India Express	Air India Express Flight 812 crashed in Mangalore, India, killing all 158. Fatigue, combined with a prolonged sleep before take-off, may have contributed to errors in judgment during landing (Ministry of Civil Aviation, 2010).
2016	Fly Dubai Flight 981	Fly Dubai Flight 981 crashed in Rostov-on-Don, Russia, killing 62. Crew's potential operational fatigue, turbulence, and lack of psychological preparation were contributing factors (Interstate Aviation Committee, 2016).

These incidents were selected based on their significant impact and the clear documentation of fatigue as a contributing factor. It is essential to note that this table is not exhaustive, and there may be previous and more recent incidents not covered here. The information is derived from official investigation reports, such as those from the National Transportation Safety Board (NTSB) and relevant aviation authorities, ensuring the reliability and accuracy of the data. The global aviation accident and incident records in the commercial air transport industry and the most notable fatigue-related accidents (Table 1) highlight the significant challenge that fatigue poses to the safety-critical aviation industry. Consequently, it is imperative to explore the factors influencing fatigue in aviation to mitigate the number of accidents and incidents.

2.3 Factors Influencing Fatigue in Aviation

Fatigue is a critical issue in modern aviation due to factors such as irregular working hours, extended duty periods, circadian disruptions, and inadequate sleep opportunities (Caldwell, 2005; Caldwell et al., 2009; Wingelaar-Jagt et al., 2021). These factors can lead to increased sleep loss and reduced rest periods for pilots, making them more susceptible to fatigue (Wingelaar-Jagt et al., 2021). To better understand this, it is essential to review relevant literature, briefly, on sleep, its regulation, and its relevance in aviation.

2.3.1 Sleep in Humans

Sleep is a crucial aspect of human life, accounting for about one-third of our daily routine (Carskadon & Dement, 2011). Sleep plays a vital role in learning and memory, synaptic plasticity, restorative functions, neural detoxification, alertness, performance, and overall well-being (Banks & Dinges, 2007; Mignot, 2008). The need for quality sleep varies among individuals, but most adults require seven to nine hours of sleep each night (Hirshkowitz et al., 2015). Sleep quality and timing are influenced by two primary regulators: the sleep homeostatic process and the circadian rhythm.

2.3.1.1 Sleep Homeostasis Process (Process S)

The sleep homeostatic process, also known as "Process S," is a complex biochemical system. It entails the accumulation of sleep-inducing substances within the brain, such as Gamma-Aminobutyric acid (GABA), a neurotransmitter known for its stress-reducing and sleep-inducing properties (Borbély et al., 2016; Fang & Rao, 2017; Gottesmann, 2002). This process operates similar to a pressure system, where prolonged wakefulness results in an increased sleep pressure. The only effective means to alleviate this pressure is through sleep (Borbély et al., 2016; Fang & Rao, 2017). To delve deeper into the details of Process S, it is essential to consider the factors influencing its dynamics. The duration and quality of sleep obtained, coupled with the continuous duration of wakefulness, intricately shape the homeostatic process (Borbély, 1982). Notably, after periods of sleep deprivation, there is a phenomenon known as recovery sleep, indicating the presence of a homeostatic mechanism governing sleep (Porkka-Heiskanen, 2013).

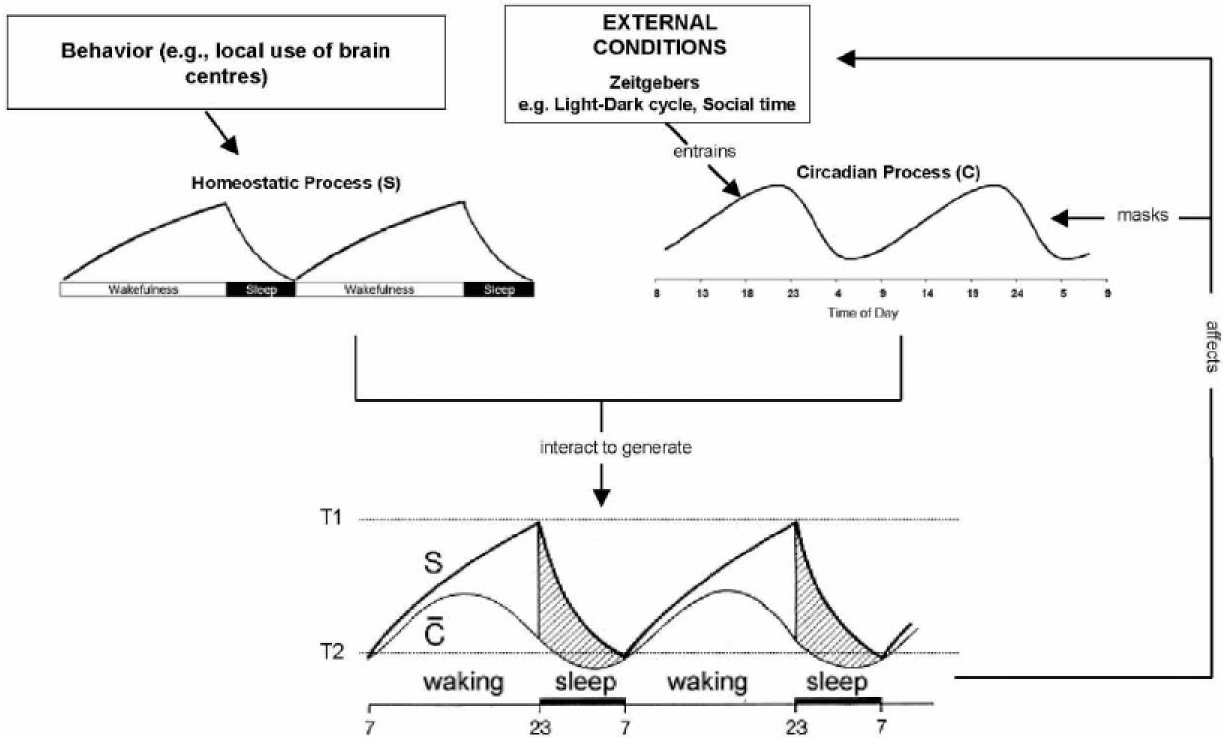

Figure 1: Representation of the two-process model of sleep regulation modified from Borbely (1982) and from Daan, Beersma, and Borbely (1984) (taken from Schmidt, Collette, Cajochen, & Peigneux, 2007)

During wakefulness, the internal drive for sleep intensifies, reaching its peak during the first Non-Rapid Eye Movement (NREM)/ Rapid Eye Movement (REM) cycle of sleep (Borbély, 1982). This escalation is accompanied by an increase in slow-wave activity (SWA) in the electroencephalogram (EEG), serving as a physiological marker of sleep pressure (Borbély et al., 2016). The cumulative effect of prolonged wakefulness is highlighted by occurrences such as brief intrusions of sleep, known as micro-sleeps, and involuntary 'dozing off' (Bougard et al., 2018; Goel et al., 2009; Torsvall & Åkerstedt, 1988). To illustrate the wave-like system associated with Process S (see Figure 1), it is crucial to recognize its role in sleep-wake homeostasis. As depicted in Figure 1, the longer an individual remains awake, the more the sleep pressure cumulates, increasing the necessity for sleep to alleviate this pressure (Borbély et al., 2016; Fang & Rao, 2017).

2.3.1.2 Circadian Rhythm Process (Process C)

The circadian rhythm, also known as “Process C”, intricately governed by neurons in the suprachiasmatic nucleus (SCN), is the output of the SCNs interactions with the environmental changes (Czeisler et al., 1999; Edgar et al., 1993). Beyond merely controlling the sleep-wake cycle, the circadian rhythm process extends its influence to modulate physical activity, regulate food consumption, and orchestrate variations in body temperature, heart rate, muscle tone, and hormone secretion (Edgar et al., 1993). The SCN, with a period slightly longer than 24 hours (circadian rhythm), actively synchronizes with the external 24-hour light-dark cycle through a process known as entrainment (Czeisler et al., 1999). Light, both artificial and natural, detected through the eyes, plays a pivotal role in this synchronization, with retinal signals transferred to the SCN, thereby synchronizing the daily rhythm to approximately 24 hours (Lewis et al., 2018; Roenneberg & Merrow, 2016; Weaver et al., 1998). This synchronization influences various physiological processes, including the release of cortisol and melatonin, hormones that play a crucial role in regulating alertness and performance (Schwartz & Roth, 2008).

Notably, the circadian rhythm's impact on sleep-wake behaviour is profound, creating two peak sleepiness times during a 24-hour day—the nadir or Window of Circadian Low (WOCL) around 03h00 to 05h00 and the post-lunch dip from approximately 15h00 to 17h00 (Dinges et al., 1996; ICAO, 2016). These peak sleepiness times are a result of the intricate interaction between the circadian rhythm and the homeostatic process (Process S) discussed earlier, forming a delicate balance between alertness and sleepiness (Dijk et al., 1992). Challenges such as shift work and transmeridian travel can disrupt this synchronization by altering the timing of zeitgebers, especially light exposure, leading to an initial disruption in the circadian rhythms, eventually resulting in a phase shift (Czeisler & Buxton, 2017). The consequences include disturbances in the timing of sleep propensity, manifesting as difficulty initiating or maintaining sleep during specific periods, such as the evening wake maintenance zone and the WOCL (Dijk & Czeisler, 1995). Understanding these intricate details of the circadian rhythm process is crucial, as disruptions caused by various personal and work-related factors in the aviation industry may contribute to sleep loss, circadian disruption, and an increased risk of fatigue. To further explore the implications of these circadian disruptions, the subsequent section will delve into the critical aspect of sleep loss and its effects, shedding light on its prevalence in society and the aviation industry.

2.3.1.3 Sleep Loss

In the context of aviation, concerns about fatigue, sleep loss and its impact on health and job performance have garnered increasing attention (Bendak & Rashid, 2020; Bonnet & Arand, 1995; Davy, 2014; Ferrera & De Gennaro, 2001; Hartzler, 2014; ICAO, 2016; Odle-Dusseau et al., 2010; Ohayon, 2008). This section aims to delve more specifically into the aviation industry's unique challenges related to sleep disruption and its implications on fatigue. Shift work schedules, prevalent in the aviation sector, often deviate from conventional sleep-wake patterns, potentially disturbing the biological and social aspects of the sleep-wake process (Åkerstedt & Landström, 1998; Davy, 2014). Pilots and aviation personnel may find themselves attempting to sleep at times that conflict with their internal circadian rhythms, contributing to sleep deprivation and fatigue (Reis et al., 2016).

Research highlighted the cumulative nature of sleep loss, wherein repeated instances of inadequate sleep accumulated, leading to a sleep debt. This sleep debt significantly impaired various cognitive functions beyond mere knowledge retention, decision-making, and overall performance. For instance, studies demonstrated that prolonged sleep deprivation could severely compromise attention span, problem-solving abilities, and emotional regulation (Belenky et al., 2003; Davy, 2014; Durmer & Dinges, 2005; Federal Aviation Administration, 2012; Folkard et al., 2005; Noy et al., 2011; Rogers et al., 2003). In a study investigating shift work risks, the consequences of such decrements in cognitive abilities pose heightened risks of errors, injuries, and, in extreme cases, fatalities within the aviation domain (Folkard & Tucker, 2003). To enhance safety and well-being in aviation, it is imperative to explore the factors contributing to sleep loss within this industry. This would further illuminate the various personal and operational demands that play a role in disrupting sleep patterns among aviation professionals, offering insights into effective management strategies for mitigating the resultant fatigue and ensuring optimal performance.

2.3.2 Personal Factors That Influence Sleep

Sleep is influenced by various personal factors, briefly touched upon in this section, including age, lifestyle behaviours, diet, stress, and commuting (Bendak & Rashid, 2020; Bercovitch & Tsai, 2012; Costa, 2003; Lim & Foldvary-Schaefer, 2012). Non-work-related factors like health status, parenting, and commuting play a role in an individual's ability to obtain sufficient and high-quality sleep (Brown & Whitehurst, 2011; National Research Council, 2011; Reis et al., 2016). Although other factors affecting sleep, such as sleep disorders, medication use, and medical conditions, exist, they are beyond the scope of this thesis. However, understanding the impact of personal factors, along with work-related factors, on sleep is crucial for fatigue management.

Sleep needs remain relatively stable in adulthood, typically ranging between seven to nine hours (D'Ambrosio & Redline, 2014). However, the ability to obtain this optimal amount can vary with age (Co et al., 1999a; Crowley, 2011; D'Ambrosio & Redline, 2014; Espiritu, 2008; Gadie et al., 2017; Li et al., 2018; Ohayon et al., 2004). Aging is accompanied by changes in hormone production, including a reduction in melatonin secretion, possibly contributing to disrupted sleep patterns in older adults (Vitiello, 2006). With advancing age, there's a noticeable shift in sleep timing characterized by earlier bed and wake times, resulting in lighter, shorter, and less restorative sleep, typically around the age of 50 (Dijk et al., 2000; Monk, 2005). In aviation settings, parental status, evolving with age, significantly impacts crew sleep patterns. Young parents with children under three are vulnerable to sleep disturbances due to childcare, leading to increased fatigue during duties compared to crew with grown-up children, who are less likely to have their sleep disrupted (Reis et al., 2016). Consequently, poor sleep's impact on crew members may vary based on parental status and age (Reis et al., 2016).

Various lifestyle factors, including caffeine, smoking, and alcohol consumption, significantly impact sleep quality (Ohida et al., 2001; Reut & Lana, 2013; St-Onge et al., 2016). Caffeine blocks adenosine receptors, promoting alertness and reducing grogginess (Barry et al., 2005; Jaehne et al., 2012; Van Dongen et al., 2001). Consuming caffeine close to bedtime can delay sleep onset by inhibiting adenosine binding to adenosine receptors (O'callaghan et al., 2018; Roehrs & Roth, 2008). Nicotine, present in tobacco, is associated with longer sleep onset times and various sleep-related issues, such as difficulties falling asleep and shortened sleep duration (Jaehne et al., 2012; Phillips & Danner, 1995; Redline et al., 2004; Soldatos et al., 1980). Moderate alcohol consumption, defined as no more than two drinks per day (Green et al., 2010), reduces REM sleep, leading to disrupted sleep and impaired recovery (Chakravorty et al., 2016; He et al., 2019). Heavy alcohol consumption (exceeding four drinks a day) is linked to prolonged sleep onset and increased disruptions throughout the night (Chakravorty et al., 2016; Reid et al., 1999). As blood alcohol levels decline, it is generally the first two stages (of four) of NREM sleep that tend to increase, along with REM sleep, which often contributes to multiple awakenings (Chakravorty et al., 2016).

With respect to diet, numerous studies have indicated that the consumption of carbohydrates can impact sleep patterns (Afaghi et al., 2007; Kwan et al., 1986; Lindseth et al., 2013; Phillips et al., 1975; Yajima et al., 2014). Both high-carbohydrate diets and low-carbohydrate diets have been linked to alterations in sleep architecture (Yajima et al., 2014). Sleep, being a complex physiological process, was influenced not only by dietary factors but also by various health conditions and medications. Respiratory physiology, for instance, was altered during sleep, potentially leading to hypoventilation, hypoxemia, and exacerbation of underlying respiratory diseases (Bercovitch & Tsai, 2012). Moreover, patients with chronic lung diseases often experienced sleep disruption and nocturnal hypoxemia, which could be further influenced by respiratory medications. While these medications aimed to improve disease control and alleviate symptoms, they may have inadvertently interfered with normal sleep patterns, highlighting the delicate balance between managing health conditions and promoting restful sleep (Bercovitch & Tsai, 2012). Stress, a disturbance to the body's equilibrium, includes physiological and psychosocial stressors (Chen et al., 2014; McEwen & Stellar, 1993; Spitzer et al., 1999). Work-related stressors for pilots encompass factors such as inexperience, workplace conflicts, and time pressures (Little et al., 1990; Mohr, 2000; Young, 2008a).

Commuting, defined as the daily journey to and from work, poses challenges for understanding its impact on sleep (Brown & Whitehurst, 2011; National Research Council, 2011). Variables like commute duration and traffic delays make it difficult to measure its effects (Brown & Whitehurst, 2011; National Research Council, 2011). A lengthy commute may necessitate an earlier wake-up, potentially reducing time spent in bed and available for sleep. Post-commute activities further limit the hours of rest before the next workday (Brown & Whitehurst, 2011; National Research Council, 2011).

2.3.3 Operational Demands Influencing Fatigue in Aviation

In addition to the various personal factors that influence sleep and subsequently contribute to fatigue, many operational factors need to be considered as well. As mentioned previously, the majority of the research conducted on the operational demands-related factors contributing to fatigue in aviation have focused on scheduled aviation (and in particular short- and long-haul operations) which are highlighted below. These include, but are not limited to, the nature of operational demands (*short- and long-haul flights*), the characteristics of operational demands (*extended duty periods, consecutive duties, inopportune working times, other duty types, quick turnarounds, and rest periods*), and workload and environment related operational demands (*number of sectors and environmental factors*). These are reviewed in more detail in the next section.

2.3.3.1 Nature of Operational Demands

2.3.3.1.1 Short-haul Operations

Short-haul flights are defined as those that last no more than three hours in duration (Wilkerson et al., 2010). Short-haul flights typically cover shorter distances, usually within a region or country (Co et al., 1999a; Wilkerson et al., 2010). Short-haul flights are typically serviced by smaller aircraft, such as regional jets or narrow-body planes, with planes designed for shorter flights and limited fuel capacity (Co et al., 1999a; Wilkerson et al., 2010). Short-haul flights generally require a smaller crew, including one or two pilots and a minimal number of cabin crew members. While these are discussed in more detail below, previous research has highlighted that for short-haul operations, fatigue was experienced when duties included early starts, late finishes, extended wakefulness due to extended duty periods, high workload due to the number of sectors, or a combination of these factors (Arsintescu et al., 2022; Bourgeois-Bougrine & Descartes, 2003; Co et al., 1999a; Honn et al., 2016; Powell et al., 2007, 2008; Vejvoda et al., 2014).

2.3.3.1.2 Long-haul Operations

Long-haul flights refer to operations that are longer than six hours in duration (Reis et al., 2016; Wilkerson et al., 2010). Long-haul flights involve much greater distances, often crossing international borders and spanning continents (Reis et al., 2016; Wilkerson et al., 2010). Long-haul flights use larger aircraft, such as wide-body jets, that are capable of carrying more passengers and fuel for extended journeys due to features such as larger fuel tanks, more advanced avionics, and enhanced passenger amenities. Long-haul flights require a larger crew due to the extended duration of the journey. This includes additional flight crew members to ensure sufficient rest periods during long flights, and more cabin crew to manage the needs of passengers over extended periods. While these are discussed in more detail below, previous research has highlighted that for long-haul operations, fatigue was experienced when duties included early starts, late finishes, night-time flying, extended wakefulness due to duty periods, circadian dysrhythmia due to transmeridian travel, and disrupted sleep/wake behaviour, or a combination of these factors (Bourgeois-Bougrine & Descartes, 2003; Caldwell, 2005; Goode, 2003; Roach, Petrilli, et al., 2012; Sallinen et al., 2017; Samel et al., 1995b).

2.3.3.2 Characteristics of Operational Demands

2.3.3.2.1 Extended Duty Periods

Extended duty periods refer to periods during which crew members are on duty for an extended duration without adequate rest or breaks (SACAA, 2011a). Extended duty periods are commonly associated with both short- and long-haul flights and have shown to contribute to crew fatigue (Caldwell, 2005; Gawron, 2016; Powell et al., 2007; Reis et al., 2016). Extended duty periods are commonly associated with extended wakefulness as crew are required to be awake for lengthy periods whilst on duty (Caldwell, 2005). Furthermore, extended wakefulness has been shown to have an impact on sleep loss which may affect the alertness and performance (Hartzler, 2014). In short-haul flights, the extended duty periods contributing to crew fatigue were attributed to a combination of irregular rosters and number of sectors (Bourgeois-Bougrine & Descartes, 2003; Powell et al., 2007, 2008). A study done by Rosekind et al. (1994) observed that crew in short-haul experienced a delayed onset of sleep, shorter sleep duration, and an awakening time approximately one and a half hours earlier than their usual schedule while on trips. Despite the average duty day being 10.6 hours for domestic commercial pilots, one-third of their duty days exceeded 12 hours, limiting the time available for adequate off-duty sleep (Rosekind et al., 1994).

In long-haul flights, the extended duty periods contributing to crew fatigue were attributed to a combination of irregular rosters and long distances flown (Bourgeois-Bougrine & Descartes, 2003; Roach et al., 2011). Long-haul flights are likely to have duty periods of more than eight hours, putting them at high risk of fatigue-related performance impairment (Hartzler, 2014). Although long-haul flights tend to provide rest facilities for crew relief, the quality of sleep that crew obtained was less than the quality of sleep obtained at home for the same duration (Roach et al., 2010). In relation to accident data, research done by Goode (2003) highlighted a significant causal relationship between flight duration and accident frequency. The study indicated that of the accidents linked to human error, 20 percent occurred when the pilot had been working for more than ten hours, while five percent occurred when the pilot had been working for more than 13 hours (Goode, 2003). However, these flight durations only accounted for 10 percent and one percent of total flying time, respectively (Goode, 2003).

The specific regulations and guidelines regarding extended duty periods vary depending on the aviation authority and the type of operations. In South Africa, the maximum duty period varies depending on the number of crew, number of sectors, the time period in which the duty period starts, and whether or not they are acclimatised to the local time (SACAA, 2012). Furthermore, the rostering limits may be extended by in-flight relief or split duty, and on the day the pilot-in-command (PIC) may, at his or her discretion, further extend the FDP actually worked (SACAA, 2012).

Moreover, it is essential to consider the impact of extended duty periods on ultra-long-range (ULR) flights, as highlighted by recent studies. Gläsener et al. (2023) conducted a study on fatigue among air crew on ULR flights. Their findings revealed a significant increase in fatigue during the course of ULR flights, particularly during night hours at the WOCL However, objective concentration performance showed no significant deterioration over time. This suggests a selective concentration retrieval, allowing crew to maintain punctual concentration performance even as fatigue progresses (Gläsener et al., 2023). Holmes et al. (2012) explored sleep and sleepiness during an ULR flight operation between the Middle East and the United States. The study found evidence to indicate that the ULR operation is well-designed from a fatigue management perspective. Sleepiness was maintained at an acceptable level during critical phases of flight, and the recommended in-flight rest structure enabled pilots to obtain adequate in-flight sleep to control sleepiness. Sleepiness also improved towards the end of the return flight due to circadian regulation. These findings emphasize the importance of considering ULR flights in discussions on extended duty periods and fatigue management (Holmes et al., 2012).

2.3.3.2.2 Consecutive Duties

Research indicates that crew members on short-haul flights can be assigned to work for four to five consecutive days, encompassing challenging tasks such as early morning and late-night shifts, high-workload periods during the day, and nighttime flights throughout this consecutive timeframe (Marqueze et al., 2017; O'Hagan et al., 2016; Pellegrino & Marqueze, 2019). Although there are often limits on the number of consecutive workdays, the combination of numerous back-to-back workdays and disruptive scheduling practices results in insufficient time for recovery, leading to sleep deprivation and cumulative fatigue (Bourgeois-Bougrine & Descartes, 2003; Yuliawati et al., 2015). This is attributed to the challenges crew members face in getting to bed, winding down, and sleeping (which may extend beyond 23h00), coupled with early wake-up times (potentially before 06h00), preventing them from obtaining adequate sleep or sufficient rest over consecutive days (Gillet & Tremblay, 2021; Goffeng et al., 2019; Marqueze et al., 2017).

2.3.3.2.3 Disruptive Working Times

Operational demands, specifically pertaining to the timing of duty periods, play a crucial role in influencing fatigue among aviation crew members. One significant aspect is the initiation of work duties during the early hours, commonly referred to as ***early starts***, defined as a duty that commences in the period 06h00 to 06h59 local time (SACAA, 2012). A more specific categorization designates very early starts as duties beginning between 02h00 and 04h59 (Åkerstedt et al., 2021). Co et al. (1999) observed that early starts may truncate normal sleep duration, resulting in sleep loss. Despite attempts by crew members to adjust their sleep schedules, the natural inclination of the circadian clock to lengthen the day makes it challenging to achieve sufficient sleep (Co et al., 1999a). Late finishes, which will be discussed subsequently, may further impede the attainment of adequate rest before early starts.

Notably, early starts are frequently associated with diminished sleep quality prior to duty, as aircrew members often need to wake up earlier than usual to report to work on time (Caldwell, 1997; Ingre et al., 2014; Roach, Sargent, et al., 2012). This curtailed sleep duration is linked to heightened sleepiness, adversely impacting alertness and performance during duty hours (Avers & Johnson, 2011; Caldwell, 1997, 2005). Research suggests that, particularly in short-haul operations, fatigue is frequently attributed to early start times, often in conjunction with extended duty periods (Åkerstedt et al., 2021; Bourgeois-Bougrine et al., 2003; Caldwell, 1997; Gander et al., 1998; Jackson & Earl, 2006; Powell et al., 2007). Spencer & Robertson (2002) emphasized that the fatiguing effects of early starts become more pronounced when consecutive early starts are worked without a rest day, aligning with Åkerstedt et al. (2021) findings that consecutive early duties over seven days are associated with elevated self-reported fatigue levels.

Beyond early starts, ***late finishes***, occurring when a duty concludes between 22h00 and 23h59 local time, emerge as another significant factor influencing crew sleep and rest (SACAA, 2012). Previous studies indicate that pilots and cabin crew experience moderate to severe fatigue when duty periods end late at night after short-haul flights (Jackson & Earl, 2006; Van Den Berg et al., 2020; Vejvoda et al., 2014). Sallinen et al. (2021) underscored a heightened probability of fatigue at the top of descent due to the impact of late finishes on the crew. Additionally, late finishes may restrict the time available for recovery, especially when crew members are scheduled for duty the following morning after a late finish (Flightline Weekly, 2021; Jackson & Earl, 2006; Powell et al., 2007). Crew members may attempt daytime sleep after extremely late finishes, but the quality and duration of such sleep are compromised due to circadian-driven alertness, daylight, and environmental noise (Caldwell, 2005; Jackson & Earl, 2006; Powell et al., 2007). Moreover, recent research by Arsintescu et al. (2022) corroborates that both early starts, and late finishes contribute to reduced alertness and performance among short-haul airline pilots. The study found that fatigue ratings and performance varied by the time of day, with the worst outcomes observed at the end of late finishes. The encroachment on the biological night was associated with worsened fatigue and performance, emphasizing the interaction between sleep deficiency, time awake, and time of day (Cohen et al., 2010). These findings align with the broader literature, indicating that both early starts, and late finishes warrant attention in fatigue risk management strategies (Powell et al., 2007; Sallinen, Van Dijk, et al., 2021; Vejvoda et al., 2014).

Additionally, insights from a large-scale European Union study by (Sallinen, van Dijk, et al., 2021) reinforced the significance of time of day in predicting fatigue during night and late finish duties. The study highlighted a higher probability of fatigue at the top of descent during night and late finish flight duty periods (FDP) compared to daytime duties. Notably, the impact of late finishes on fatigue levels was comparable to that observed during night FDP, challenging conventional expectations regarding fatigue levels during evening duties. This deviation is attributed to late finishes extending a few hours beyond the typical evening duty period, occurring between 23h00 and 01h59. The findings underscored the need for distinct fatigue management strategies for early starts and late finishes, emphasizing their unique characteristics and implications on aircrew alertness and performance. Furthermore, Vejvoda *et al.*'s (2014) study on short-haul pilots reinforced the notion that late finishes result in higher fatigue levels compared to early starts, despite shorter duty durations and longer preceding sleep periods in late finishers. The study emphasized the strong predictive role of time awake, both during and before a flight duty period, in determining fatigue at duty end, surpassing the influence of prior sleep duration. While the absence of measured endogenous circadian phase was acknowledged, the study suggested its likely impact on the observed results. These findings align with the understanding that human alertness and performance are stable for approximately 16 hours when well-rested and in sync with the circadian cycle. However, late-finishing duties that fall on the declining limb of the circadian wake drive impose increased sleep pressure, contributing to heightened fatigue levels (Dijk et al., 1992; Vejvoda et al., 2014). These insights collectively underscore the importance of considering the time of day and circadian factors when addressing the operational demands that impact aircrew fatigue in aviation.

One crucial aspect influencing fatigue in aviation is the timing of operational demands, particularly during ***nighttime flying***. Nighttime duties are defined as occurring from 15 minutes after sunset to 15 minutes before sunrise, with some variations across countries (SACAA, 2011b). Crew that operate during the night face the challenge of working against their natural sleep inclination, requiring wakefulness during the night and sleep during the day (Flightline Weekly, 2021; Gundel et al., 1995; Ingre et al., 2014; Sallinen, Van Dijk, et al., 2021; Samel et al., 1997). Night FDP are particularly associated with extended on-duty periods and are significant predictors of fatigue, especially when they overlap with the WOCL (Sallinen, Van Dijk, et al., 2021). Night flights disrupt the crew's natural circadian rhythm, compelling them to resist the urge to sleep at night and subsequently sleep during the day, leading to cumulative sleep loss and sleep debt (Van Dongen et al., 2003). This disruption has cascading effects on crew alertness and concentration in subsequent duties (Caldwell, 2005; Ingre et al., 2014).

Additionally, Sallinen et al. (2017) found that both short-haul and long-haul FDP covering the early (00h00-03h00) and late (03h01–06h00) parts of the domicile night (00h00–06h00 at home base) consistently result in reduced sleep sufficiency and subjective alertness. The study indicates that FDP overlapping with the domicile night led to reduced sleep-wake ratios and decreased subjective alertness, suggesting a need for effective on-duty alertness management strategies during such periods. Moreover, Bourgeois-Bougrine et al. (2003) emphasized the role of sleep loss in pilot fatigue, citing night flights and jet lag as primary contributors. Their findings revealed that the poor quality and quantity of sleep, especially after night flights, increased fatigue levels. For long-haul flights, consecutive night flights within a short timeframe further exacerbated fatigue. Similarly, for short-haul flights, multi-leg flights and early wake-ups were identified as factors contributing to increased fatigue. The results from this study highlight the potential impact of time constraints, high numbers of legs per day, and consecutive workdays on fatigue in short-haul flights.

2.3.3.2.4 Other Duty Types

Standby, or reserve duty, is the designated period during which a crew member must remain at a specified location, ready to be called for flight duty at the discretion of the operator (SACAA, 2011b). Whether stationed at the airport or at home, this duty introduces a potential source of stress for the crew, given that they can be summoned for duty at any moment (Bamberg et al., 2012; Berger, 1999). One additional challenge associated with standby duties is the likelihood of prolonged wakefulness and disrupted sleep-wake patterns, especially when these duties occur at night (Arnedt et al., 2005; Bamberg et al., 2012; Co et al., 1999b; Ziebertz et al., 2015). Such conditions pose a risk when crew members are called for duty towards the end of their standby period.

Research on the impact of standby and reserve duty on sleep and fatigue in aircrew is scarce. Nonetheless, a prior study by (Van Den Berg et al., 2019) emphasized the need to enhance standby facilities at airports to ensure that cabin crew were well-rested and alert when called for duty. Given the limited existing research on standby or reserve duty, there is a clear imperative for further investigation into the effects of this type of work on both cabin crew and cockpit crew.

2.3.3.2.5 Rest Periods

A rest period is a continuous break after or before duty, during which the crew is relieved of all responsibilities (Caldwell et al., 2009; Efthymiou et al., 2021; SACAA, 2011b). Currently, according to Civil Aviation Regulations, crew members are granted a nine-consecutive-hour rest between duties (SACAA, 2011a). This rest period is crucial for reversing the effects of both mental and physical exertion, facilitating recovery (Techera et al., 2016). It is essential for crew to ensure sufficient sleep before duty by maximizing rest before the commencement of duty. Adequate sleep post-duty is equally important for recovery (Efthymiou et al., 2021; Karhula et al., 2018; Rudari et al., 2016; Van Den Berg et al., 2020). However, insufficient rest periods (less than 12 hours) may hinder the crew from obtaining consolidated and quality sleep, impacting their alertness in subsequent duties and overall recovery, especially after extended or irregular duties (Efthymiou et al., 2021; Karhula et al., 2018; Rudari et al., 2016; Van Den Berg et al., 2020).

Furthermore, the timing of the rest period can affect the crew if it falls between duties, forcing them to rest under external factors like daytime noise (Efthymiou et al., 2021; Rudari et al., 2016). The rest period is not solely about sleep but also about fulfilling basic physiological needs and spending time with family. Concerns have been raised about augmented crew flights, where factors such as flight timing, circadian phase, and flight duration influence in-flight sleep and fatigue levels (Gander et al., 2014). Planning for different flights must consider these factors. Additionally, cabin crew duty periods may extend beyond the apparent 12-hour rest period, as they need to attend to passengers even after the aircraft's engines are turned off (Van Den Berg et al., 2019). This can impact the available time for cabin crew rest.

2.3.3.2.6 Circadian Dysrhythmia (Jet Lag)

Circadian dysrhythmia, commonly known as jet lag, arises from the disruption of the sleep/wake cycle experienced by long-haul pilots when rapidly changing time zones (Anne Eriksen & Åkerstedt, 2006; Bendak & Rashid, 2020; Caldwell et al., 2008; FAA, 2013). While not a common occurrence due to the brief stays of pilots in different time zones, it is a robust predictor of fatigue (Anne Eriksen & Åkerstedt, 2006; Bendak & Rashid, 2020; Caldwell et al., 2008; FAA, 2013). Jet lag is triggered by a misalignment between the internal biological clock and ambient time resulting from rapid eastward or westward travel across numerous time zones (Drake & Wright, 2010). Symptoms are exacerbated by disrupted or diminished sleep before and during travel (Drake & Wright, 2010).

Attempting to sleep in the new time zone at the ambient bedtime before the traveller's biological night leads to immediate circadian misalignment and jet lag symptoms, especially after an eastbound jet flight (Drake & Wright, 2010; Waterhouse et al., 2000). Common symptoms include daytime tiredness, drowsiness, and sleeplessness in the new time zone, with sleepiness and exhaustion prevailing throughout the day due to alertness during the biological night (Drake & Wright, 2010; Waterhouse et al., 2000). Jet lag is a complex phenomenon with a range of subjective and objective symptoms. The term encompasses feeling tired during the day by the new local time, yet being unable to sleep at night, reduced concentration, motivation for training, increased headaches, irritability, loss of appetite, and bowel irregularities. These symptoms vary in intensity, being more pronounced with an increase in number of time zones crossed, particularly in eastward transitions (Waterhouse et al., 2000). Studies on athletes indicate that both mental and physical performance decline during jet lag, with shorter and more fractionated sleep than normal (Waterhouse et al., 2000). The duration of these symptoms tends to last about one day per time zone crossed, with full recovery needed for the athlete's performance to return to its peak. Training schedules may need to be adjusted during this recovery period, recognizing the potential for under-achievement (Waterhouse et al., 2000).

The aviation industry's around-the-clock operations, driven by commercial demands, pose challenges to human physiology due to factors such as shift work, night work, irregular duty rosters, and time zone transitions (Samel et al., 1995a). These demands, inherent in both domestic and international aviation, necessitate the continuous availability of flight crew, contributing to fatigue, sleepiness, and jet lag. The risk to safety is evident, emphasizing the importance of incorporating scientific knowledge on fatigue, human sleep, sleepiness, and circadian physiology into 24-hour air operations.

In addition to these factors, layovers play a crucial role in pilot fatigue during transmeridian flight operations. (Roach, Petrilli, et al., 2012) found that the length of layovers significantly impacted pilot sleep, subjective fatigue levels, and sustained attention. The study indicated that short layovers exacerbate the difficulties associated with long-haul trips, affecting pilot fatigue levels during layovers and recovery after trips. Furthermore, Li et al. (2022) highlighted the importance of crew composition and layover conditions, emphasizing the need for better in-flight resting environments and optimized layover procedures to alleviate fatigue and enhance operational safety. Powell et al. (2010) explored the effects of additional layover days on pilot fatigue, demonstrating that the impact varies based on the type of operation involved, thus emphasizing the nuanced relationship between layovers and fatigue in aviation.

Modern advancements in aviation, characterized by highly computerized cockpits and the trend towards reduced crew sizes, have significantly transformed operational conditions within the cockpit. These technological developments aim to enable longer flights and enhance overall efficiency. It is important to note that despite these advancements, fundamental human physiological principles governing factors such as fatigue, circadian rhythms, and sleep-wake cycles remain unchanged. Flight-duty time regulations must adapt to ensure adequate rest times during and after long-haul operations, considering the impact on circadian rhythms and sleep-wake cycles. Surprisingly, current national rest-duty regulations inadequately address these aspects, highlighting the need for comprehensive regulation that accounts for both day and night aspects, including rest duration after transmeridian flights (Dinges, 1995; Samel et al., 1995a). In connection to these considerations, the subsequent section delves into workload and environment-related operational demands, with a specific focus on the significant impact of the number of flight sectors undertaken during a duty period on crew fatigue.

2.3.3.3 Workload and Environment-Related Operational Demands

2.3.3.3.1 Number of Sectors

Crew fatigue is significantly influenced by the number of flight sectors undertaken during a duty period. This fatigue, particularly experienced by cockpit crew, results from multiple take-offs and landings, as emphasized by various studies (Honn et al., 2016; Powell et al., 2007; Yuliawati et al., 2015). Short-haul schedules, specifically those involving four to five sectors per day, have been identified by the (FAA, 2010) as particularly fatiguing, leading to changes in alertness and performance. Take-offs and landings are considered demanding tasks, inducing high workload for pilots (Bourgeois-Bougrine et al., 2003; Honn et al., 2016; Powell et al., 2007; Yuliawati et al., 2015).

Regional crew on short-haul flights, as reported by Co et al. (1999), face five times higher workload phases (take-off, cruise, landing) compared to long-haul crew, posing an increased risk of fatigue-induced performance decline. Powell et al. (2007) noted a linear increase in perceived fatigue with the number of flight segments, regardless of the flight duration. This finding aligns with Sallinen et al.’s (2021) discovery that the number of sectors is the sole FDP characteristic predicting elevated fatigue levels during daytime descents. In a laboratory study, (Honn et al., 2016) observed greater fatigue in pilots during five-sector simulated duty periods compared to a single, simulated long-haul segment, as indicated by performance on the Psychomotor Vigilance Test (PVT). Although this study had limitations, being conducted in a laboratory using simulated aircraft, it underscores the impact of multiple take-offs and landings on performance and self-rated alertness (Bourgeois-Bougrine et al., 2003; Powell et al., 2007).

Powell et al. (2007) conducted a study on pilot fatigue in short-haul operations, revealing that the number of sectors and duty length significantly influenced fatigue. Duty length and the number of sectors increased fatigue linearly, with time of day exerting a weaker influence. The study also highlighted the complex interaction between duty length, timing, and sleep impact on fatigue, emphasizing the importance of considering these factors in fatigue assessment. Moreover, Arsintescu et al. (2020) found that a higher self-reported workload is associated with slower reaction time and higher ratings of fatigue. Weak but significant correlations were observed between mean pilot workload, as measured by NASA-TLX, and PVT performance, Samn-Perelli ratings, sleep duration, number of sectors, and flight duration. Pilots experienced more PVT lapses and slower response speed when workload was rated higher. The highest correlations were found between PVT performance and workload, suggesting that workload was rated higher when fatigue was also rated higher. The study further confirmed the relationship between fatigue and multiple flight sectors, aligning with previous findings (Flynn-Evans et al., 2018; Honn et al., 2016; Powell et al., 2007).

Furthermore, fast turnarounds involve the efficient unloading of an aircraft upon its arrival at the gate and the subsequent preparation for its next departure (Schultz, 2018). This concept is particularly linked to low-cost airlines that operate short-haul flights, aiming to minimize the crew's resting time before the subsequent flight due to the constrained interval between arrivals and departures (Samel et al., 1991). Furthermore, the period between the conclusion of the crew's current workload (after the aircraft has fully stopped and all passengers have disembarked) and the commencement of preparations for the next flight is brief. Consequently, quick turnarounds limit the time available for the crew to recuperate and rest.

2.3.3.3.2 Environmental Factors

Fatigue in aviation is significantly influenced by environmental factors, impacting the workload of the crew (Bendak & Rashid, 2020; Lee, 2010). Examples of such factors include lightning, convective turbulence, airframe icing, and precipitation (Buck & Buck, 2013). These elements heighten the crew's workload, demanding increased attention and vigilance during flight (Buck & Buck, 2013). Additionally, internal aircraft noise and turbulence contribute to disturbances in aircrews' sleep architecture and subjective sleep quality during in-flight rest (Buck & Buck, 2013; Kulesa, 2003; Zaslona et al., 2018).

In addition to the factors previously discussed, it is essential to consider hassle factors identified in the systematic review by Bendak & Rashid (2020). Hassle factors encompass non-scheduling causal factors that contribute to fatigue and adversely affect performance in the aviation industry (Bendak & Rashid, 2020). Lee & Kim, (2018) conducted a study involving 929 pilots, exploring contributors to work-induced fatigue. They identified partnership among crew members, hotel environment, aircraft environment, and ethnic differences as elements contributing to the formation and accumulation of fatigue. Moreover, advanced automation in the cockpit, while reducing cognitive workload, may lead to reduced stimulation, increased boredom, and a rise in perceived fatigue, especially in long-haul flights (Roach, Petrilli, et al., 2012). Weak lighting and the absence of tangible feedback through analogue controls can exacerbate this increased feeling of fatigue (Lee & Kim, 2018).

It's crucial to emphasize that these factors interact in a complex manner, affecting the sleep, workload, and fatigue of the crew, and their individual effects are challenging to isolate. In summary, crew fatigue in aviation stems from the intricate interplay of diverse work and non-work-related factors. Therefore, effective fatigue management necessitates an understanding of these aforementioned factors, coupled with the application of the latest scientific findings, technological advancements, and operational experience.

2.4 Fatigue Management in Aviation

The factors influencing crew fatigue, as well as the safety-critical nature of the industry, highlight the vital need for fatigue management. The ways by which aviation service providers and operational employees address the safety implications of fatigue is through fatigue management (ICAO, 2016). Traditionally in the aviation industry, fatigue has been managed globally and nationally using a prescriptive rule-based limitation regulation approach. This method sets maximum duty limits and minimum off-duty limits for pilots to work within to manage the risk of fatigue, usually as part of a safety management system (SMS) approach (Gander et al., 2011; ICAO, 2016; Signal, 2014). However, ICAO developed Standards and Recommended Practices which provide aviation service providers and operational employees methods to address the safety implications of fatigue.

2.4.1 ICAO SARPs Addressing the Safety Implications of Fatigue

The ICAO standards and recommended practices (SARPs) support a three-step process of fatigue management, which refers to the methods by which aviation service providers and operational personnel address the safety implications of fatigue (ICAO, 2016). The first step, also referred to as the basic approach, is when service providers follow hard limits set by the regulator (ICAO, 2016). The second step, also referred to as an SMS approach, is when service providers manage fatigue risks using SMS processes within the prescribed limits (ICAO, 2016). The third step, also referred to as the fatigue risk management system (FRMS) approach, is when service providers meet additional requirements to have flexibility outside of prescriptive limitation regulations (ICAO, 2016). In contrast, while the first two steps outlined by ICAO adhered to a prescriptive rule-based limitation regulation approach, they represented distinct methods within the broader framework of fatigue management in aviation. Whereas the transition to the third step, known as the FRMS approach, marked a departure from strict prescriptive regulations. Here, service providers were granted additional flexibility to tailor fatigue management strategies to their specific operational contexts. The following sub-sections examined the fatigue management approaches highlighted above.

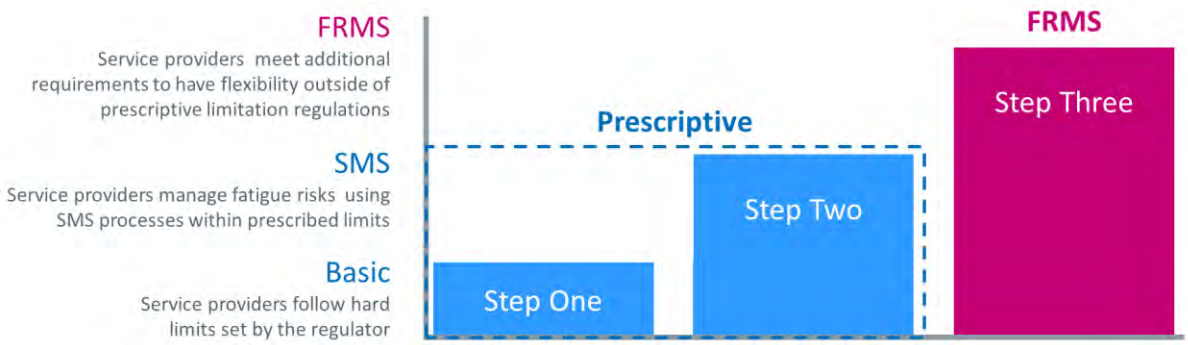

Figure 2: ICAO Standards and Recommended Practices for Fatigue Management Approaches (taken from ICAO, 2016)

2.4.1.1 Prescriptive Limitations (Under a Broader SMS)

For various groups of aviation workers, crew fatigue has traditionally been managed through prescriptive limitation restrictions which establish maximum work durations and minimum non-work periods (Dawson & McCulloch, 2005; Gander et al., 2011; ICAO, 2016). In essence, the prescribed limits are informed state parameters within which the service provider must manage fatigue-related hazards as part of their existing safety management practices (ICAO, 2016). Prescriptive limitations minimise exposure to some of the causes of fatigue by limiting the length of time awake required for work, the duration of continuous time on job, and the availability of sleep and other non-work activities (Gander et al., 2011). Prescriptive limitations are often easy to comprehend and do not require specific expertise to grasp what is and is not authorised (Gander et al., 2011). Prescriptive limitations also appear straightforward to enforce, by requiring service providers to keep records that can be inspected by the regulator (Gander et al., 2011). Although fatigue is one of the probable dangers that the SMS should examine in a prescriptive approach, data-driven information related to fatigue is not particularly and actively collected unless the SMS has recognized a fatigue concern (ICAO, 2016).

2.4.1.2 Fatigue Risk Management Systems

Service Providers can implement various methods to enhance safety, resource management, and operational flexibility. One such method is the performance-based approach, known as Fatigue Risk Management Systems (FRMS). According to ICAO (2016) FRMS is defined as *“A data-driven means of continuously monitoring and* *managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness."* While FRMS can offer benefits, it may not be the primary focus of this study, as the main issues and challenges we aim to address extend beyond the realm of FRMS. FRMS is designed to reduce actual fatigue risk within specific operations, as opposed to dealing with predicted fatigue risk in a general manner, which is the foundation of prescriptive limits (ICAO, 2016). Additional requirements associated with FRMS include maintaining a safety level comparable to that achieved by adhering to prescriptive constraints and incorporating fatigue as one of the hazards to be managed using generic Safety Management System (SMS) techniques (Gander et al., 2011; ICAO, 2016).

It is important to note that even within the context of FRMS, maximum duty times and minimum rest (or non-work intervals) are still necessary (Gander et al., 2011; ICAO, 2016). However, these parameters can be proposed by the Service Provider and may differ from mandated limitations (Gander et al., 2011; ICAO, 2016). Approval for these variations must be obtained from the State regulator, and the Service Provider must demonstrate that they have the necessary processes and mitigations in place to maintain an acceptable level of risk (Gander et al., 2011; ICAO, 2016). In summary, while FRMS is a valid approach for managing fatigue risk, this review will explore a broader spectrum of issues and challenges that require the cooperation of various safety management stakeholders at different levels within the industry.

2.4.2 The Socio-Technical System involved in Risk Management.

As mentioned previously, aviation is widely recognized as one of the safest modes of transport globally, yet fatigue remains a significant hazard that impacts various aspects of human performance, potentially contributing to aviation accidents or incidents alongside other hazards and risks (Caldwell, 2005, 2012; Coombes et al., 2020; ICAO, 2016; National Transportation Safety Board, 2019; Roach, Sargent, et al., 2012; Wilson et al., 2007). A hazard refers to a situation or an item that possesses the capacity to result in harm to individuals, harm to machinery or structures, material loss, or a decline in the capability to execute a specified task (Stolzer et al., 2023). In the context of managing risk for aviation safety, it is important to concentrate the term "hazard" on conditions that have the *potential* to induce or contribute to the unsafe operation of aircraft or safety-related equipment, products, and services (ICAO, 2013). According to ICAO (2013) safety risk is defined as *"the projected likelihood and severity of the consequence or outcome from an existing hazard or situation".*

Risk management is commonly recognized as a comprehensive procedure that encompasses the identification of potential risks and the implementation of measures to mitigate and oversee them (Müller et al., 2014). This involves a cyclical approach that includes communication, documentation, control, early warning systems, and improvement (Müller et al., 2014). This broad characterization of risk management as an all-encompassing process can be more specifically defined as *"…the permanent and systematic recording of all kinds of risks with regard to the existence and the development of the enterprise. It involves analysing and prioritizing recognized risks as well as defining and implementing adequate strategic or surgical measures to minimize non-tolerable risks"* (Wittmer et al., 2011).

According to Rasmussen (1997) the problem space of risk management in dynamic society as a loss of control of physical processes capable of harming people or destroying property causes injury, pollution of the environment, and loss of investment. The activity of individuals, which can either cause an accidental flow of events or divert a normal flow, shapes the propagation of an accidental course of events (Rasmussen, 1997). As a result, safety is dependent on the regulation of work processes in order to prevent unintended outcomes that affect individuals, the environment, or investments (Rasmussen, 1997). And according to ICAO (2016, pg. xvi), safety is defined in aviation as *"The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level."*

Rasmussen's (1997) model, 'the socio-technical system involved in risk management' (Figure 3.), highlights that there are various levels involved in risk management from blunt-end legislators to the sharp-end system operators. At the top, society attempts to regulate safety through the legal system: safety, alongside jobs and trade balance, is a top priority (Rasmussen, 1997). The legislation clarifies the relative importance of competing goals and defines the limits of what constitutes reasonable human conditions (Rasmussen, 1997). Political and legal sciences are the subject of research at this stage. (Rasmussen, 1997). Then there is the level of government and trade associations, labour unions, and other interest groups (Rasmussen, 1997). Here, the law is interpreted and put into practice in the form of rules to regulate operations in specific types of workplaces and for specific types of employees (Rasmussen, 1997).

This is the degree to which management scientists and occupational sociologists' function (Rasmussen, 1997). The rules must now be understood and enforced in the sense of a specific organisation, considering the work processes and equipment used (Rasmussen, 1997). To make the rules operational, many specifics taken from local environments and processes must be introduced, and new disciplines, such as work psychologists and experts in human-machine interaction, are once again involved (Rasmussen, 1997). Finally, at the most fundamental level, the engineering disciplines involved in the development of standard operating procedures for the applicable operational states, including disruptions, as well as the design of active and potentially hazardous processes and equipment (Rasmussen, 1997).

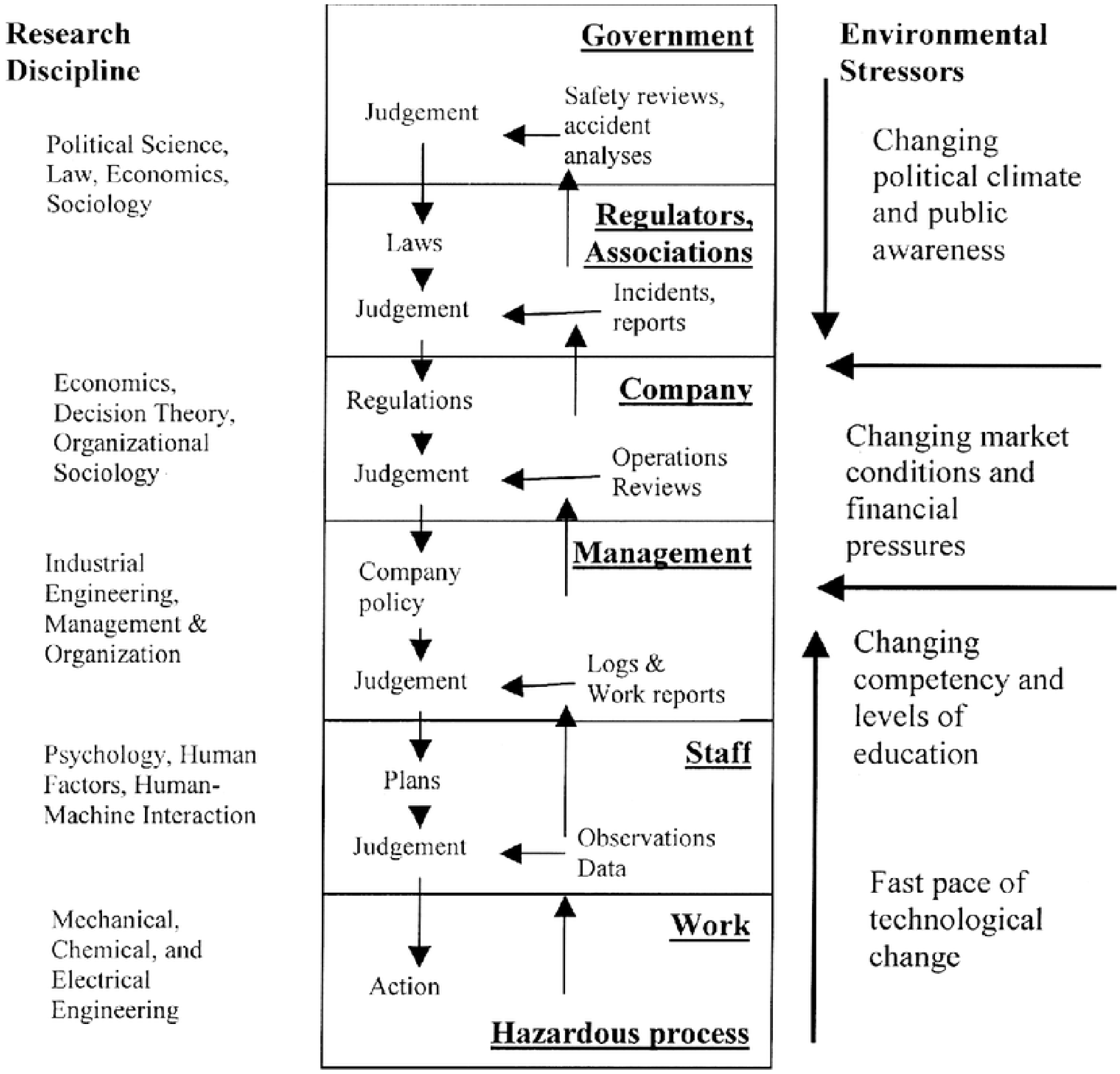

Figure 3: The socio-technical system involved in risk management (taken from Rasmussen, 1997).

In addition, Rasmussen indicates that the system is ever-presently exposed to environmental stressors. Rasmussen places these environmental stressors down to the dynamic nature of society in which the system is placed. These stressors can range from the fast pace of technological change, changing competency and levels of education, changing market conditions and financial pressures, and changing political climate and public awareness (Rasmussen, 1997). In some very fundamental ways, these trends have a profound impact on the necessary approach to modelling system behaviour, and it raises the issues of structural decomposition versus functional abstraction, as well as cross-disciplinary research versus multi-disciplinary collaboration (Rasmussen, 1997).

Furthermore, Rasmussen highlights that conventionally the socio-technical system involved in risk management is decomposed according to the various organisational levels, which are then the objects of study within different disciplines. The result of this is that risk management at the upper levels is usually studied with a 'horizontal' orientation of study through the technological hazard sources (Rasmussen, 1997). However, Rasmussen argues that more research into the vertical interaction among the levels of socio-technical systems is needed in this situation, with a focus on the nature of the technological hazard that is supposed to be monitored.

Thus, Rasmussen brings about the idea of a disconnect between the blunt-end stakeholders and the sharp-end system operators in the management of risk. Rasmussen places this down to the 'horizontal' orientation of disciplines within each level of the socio-technical system and the dynamic society in which the system is placed. Rasmussen argues that there should be a vertical interaction among the levels. Thus, the development of this research project looks to integrate the thoughts and perceptions of various blunt-end stakeholders, within the South African aviation industry's socio-technical system, on pilot and cabin crew fatigue at the sharp-end. The following section delves into the South African aviation industry as a Socio-Technical System in Fatigue Risk Management.

2.4.3 Roles and Responsibilities of Blunt-End Stakeholders in Fatigue Management in Aviation

Effective fatigue management in aviation requires various stakeholders to understand and perform their roles and responsibilities. The responsibility for fatigue management falls on to the regulators, industry (companies/operators) and the individual crew member (Gander et al., 2011). Although all stakeholders involved are responsible for fatigue management, they each perform different roles. Thus, the regulators provide guidelines and regulations on FDP, as well as ensure that operators/companies' FDP adhere to the regulations during roster design. Pilots operate according to the regulations and inform the operators of instances of fatigue. Finally, the unions serve to protect the common interest of the pilots and serve to connect the pilots with the safety-management stakeholders. These dynamics were further explored in the following sub-section, where we delved into the influence of various international aviation industry organisations on safety standards and practices within the international aviation industry.

2.4.3.1 The International Aviation Industry

There are three leading Non-Governmental Organisations (NGOs) that influence the level of safety in the aviation sector worldwide (Tambala et al., 2017). The regulatory bodies are represented by the ICAO, the International Air Transport Association (IATA), and the International Federation of Air Line Pilots' Association (IFALPA). The ICAO is a specialist organisation within the United Nations that oversees the management and governance of the International Civil Aviation Convention (ICAC) (ICAO, 2020). A consensus is reached with its members on international civil aviation standards and recommended practices and policies to promote a safe, efficient, secure, economically sustainable, and environmentally responsible civil aviation sector (ICAO, 2020). Much of the industry is represented by the IATA, a global trading organisation accounting for 83 percent of global airlines (IATA, 2020a; Tambala et al., 2017). It is an association that mainly serves to help its member airlines to operate safely, securely, efficiently, and economically under clearly defined rules (IATA, 2020c; Tambala et al., 2017).

Alongside this, many individuals (pilots) are represented by the IFALPA, an international non-profit organisation created to express the views of the pilot on critical issues (IFALPA, 2020; Tambala et al., 2017). Their mission is to promote the highest level of aviation safety in the world and to be the global advocate of the piloting profession; to provide representation, services, and support to their members as well as the aviation industry (IFALPA, 2020). However, the IATA and IFALPA do not represent all pilots and carriers.

2.4.3.2 The South African Aviation Industry

In South Africa, the regulator is the South African Civil Aviation Authority (SACAA), while the Airlines Association of Southern Africa (AASA) and Commercial Aviation Association of South Africa (CAASA) represent aviation operations, and the Airline Pilots' Association of South Africa (ALPA-SA) represents the individuals (pilots). Although the ALPA-SA, AASA, and CAASA only represent commercial carriers, the

ALPA-SA does not represent all pilots. For this research project, the focus of the stakeholders of interest is on SACAA, AASA, ALPA-SA, and CAASA.

2.4.4 South African Aviation Industry as a Socio-Technical System in Fatigue Risk Management

In the realm of aviation safety research, it is evident that the majority of studies have predominantly concentrated on the experiences and perspectives of those directly involved in the operational "sharp-end" of the aviation industry, including pilots, air traffic controllers, and maintenance personnel (Tambala et al., 2017). These studies have yielded invaluable insights into the intricacies of operational procedures and have significantly contributed to enhancing aviation safety. However, what has been noticeably underrepresented in the literature is an exploration of the perceptions and roles of individuals who operate at the "blunt-end" of the aviation system, such as regulators, safety managers, and system designers. While some exceptions, such as Tambala (2017), have delved into the perceptions of blunt-end stakeholders, this research is notably scarce, particularly in the context of the South African aviation industry. The dearth of literature in this regard presents a significant knowledge gap and calls for a more comprehensive understanding of the aviation safety landscape. In the study by Tambala (2017), Norwegian pilots were found to have experienced varying levels of fatigue, with some admitting to having fallen asleep on the flight deck due to exhaustion. These experiences were reported by both sharp-end stakeholders as well as blunt-end stakeholders. Stakeholders in the Norwegian aviation sector acknowledged fatigue as an ongoing challenge that required continuous attention (Tambala et al., 2017). The experience of fatigue was highly individualized, and there was an observed under-reporting of fatigue in Norway (Tambala et al., 2017). The study emphasized the need for increased fatigue reports by both the Norwegian Civil Aviation Authority (NCAA) and airlines to address issues effectively, as frontline personnel advocated for necessary changes (Tambala et al., 2017).

Recently, Blair (2022) made a noteworthy contribution by focusing on the perceptions of "sharp-end" stakeholders, specifically pilots and crew, within the South African aviation industry, shedding light on their perspectives and experiences. Blair (2022) identified a significant prevalence of fatigue in the South African aviation industry, as reported by the crew in the study. The concerns raised by the crew regarding factors contributing to fatigue aligned with existing research, yet also highlighted the unique operating conditions in South Africa (Blair, 2022). The study served as a foundation for investigating specific aspects of crew working time that disrupted sleep, with the aim of enabling more predictable rostering to minimize fatigue (Blair, 2022). Additionally, it provided an opportunity for regulators and other stakeholders to consider improving the FTL to reduce the incidence and risks associated with crew fatigue (Blair, 2022). This research marked a step towards bridging the existing gap in understanding the broader aviation safety context within the South African context. Building upon this important groundwork, the subsequent section of this thesis will delve into an exploration of the various "blunt-end" stakeholders involved in risk management in the South African aviation industry. This study aims to address this critical knowledge gap and provide insights into the perceptions and roles of those individuals who contribute significantly to the aviation safety ecosystem from a different vantage point. By doing so, this research endeavours to provide a more holistic and nuanced understanding of aviation safety in the South African context. The following sub-chapters delves into the different vantage points within the South African aviation industry and highlights their various roles within the industry.

2.4.4.1 Department of Transport

The Department of Transportation (DoT), a division of the South African government, has the role of facilitating the development of integrated, efficient transportation systems by developing a framework of sustainable policies, regulations, and models to support government economic, social, and international development strategies (Department of Transport, 2023a). Competitive transportation pricing, safety and security improvements, a reduction in infrastructure backlogs, improved access, and a reduction in transit time are among the goals that the DoT hopes to achieve through provision of policy framework, regulation, and implementation models (Department of Transport, 2023a).

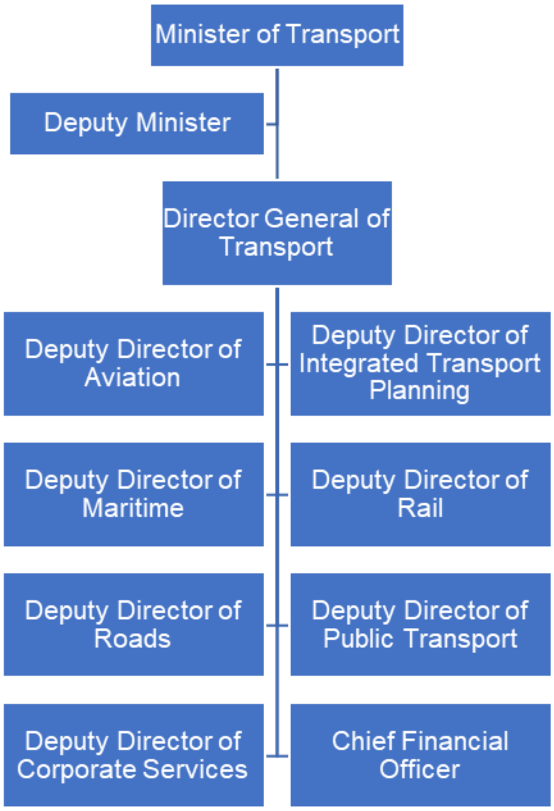

Figure 4: Organogram of The Department OF Transport South Africa (taken from Department of Transport, 2023b)

2.4.4.2 South African Civil Aviation Authority (SACAA)

SACAA, an agency of the DoT, is a schedule 3A public entity that is a stand-alone authority charged with controlling, promoting, regulating, supporting, developing, and enforcing civil aviation safety and security (SACAA, 2017b). This is achieved through compliance with the SARPs of the ICAO whilst considering the local context (SACAA, 2017a). The SACAA's mission is to regulate civil aviation safety and security in support of the sustainable development of the South African aviation industry (SACAA, 2017a). The roles and responsibilities of the SACAA include ensuring aviation security, safe aviation infrastructure, aviation safety operations, and accident and incident investigation (SACAA, 2017b).

The role in aviation security is to ensure the security of airports, air operations, cargo, and the safe transportation of dangerous goods (SACAA, 2017a). The role in aviation infrastructure is to ensure that South African airports, helistops, heliports, and airspace are safe and that off-airport structures that may affect the safety of air navigation comply with safety standards (SACAA, 2017a). The role in aviation safety operation is to ensure that there is regulatory compliance and safety oversight of all air operators, aviation training organisations, designated flight examiners, designated aviation medical examiners, and aircraft maintenance engineers (SACAA, 2017a). In addition, the air safety operations are also responsible for flight inspections, maintenance of examinations, testing standards, and aviation medical standards in the South African aviation context (SACAA, 2017a). The role in accident and incident investigation is determining the probable cause of such accidents (SACAA, 2017a).

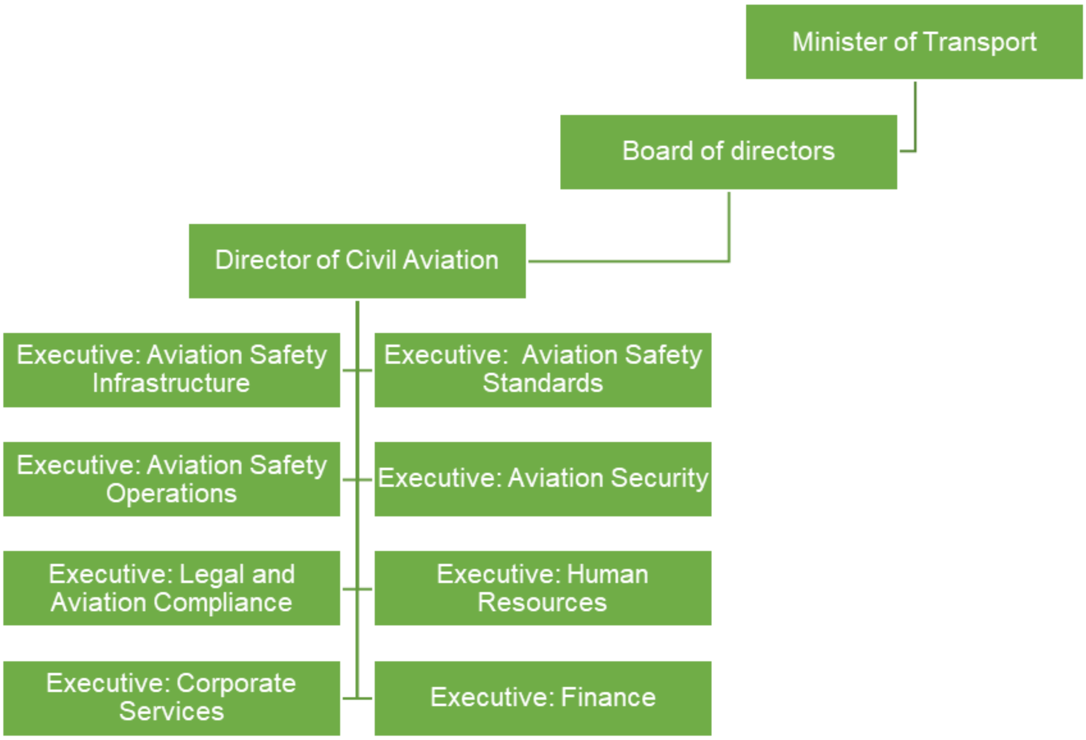

Figure 5: Organogram of The South African Civil Aviation Authority (SACAA, 2018).

2.4.4.3 Airline Pilot Association of Southern Africa (ALPA-SA)

ALPA-SA, a non-profit organisation that is described as the "*voice of the pilots*", is a trade union that caters for the needs of the flight deck crew (ALPA-SA, 2020). Thus, there is no commercial interest but rather sole focus on the flight deck crew's needs. The roles and responsibilities of ALPA-SA are to ensure safe systems and the application of professional standards, represent the members at relevant national and international forums, exchange pertinent technical, industrial, and professional information, uphold the honour and dignity of members, and ensure that responsible, accurate and informed publicity regarding the affairs of the association and the industry (ALPA-SA, 2020). In order to achieve their roles and responsibilities, members must strive for cooperation in all that affects the common interest while respecting individual employment rights and privileges (ALPA-SA, 2020).

2.4.4.4 Airline Association of South Africa (AASA)

AASA is the leading representative organisation that promotes and protects the interests of its member airlines operating within Southern Africa (AASA, 2020). AASA works together with leaders of the aviation industry, senior public and government officials on policy, operation, safety, security, and financial matters affecting the overall profitability of the airlines and their continued sustainability (AASA, 2020). AASA also leads and coordinates the airline industry position on aviation issues, as well as consumer legislation, environment, and tourism matters, and provides media response to important industry issues (AASA, 2020). The roles and responsibilities of AASA includes the representation of South Africa Development Community (SADC)-based airlines on the SADC Civil Aviation Committee as the Airline Consultative Member and participate and contribute to the ICAO and IATA (AASA, 2020). AASA aims to ensure a healthy, commercially successful airline sector in this region (AASA, 2020).

2.4.4.5 Commercial Aviation Association of South Africa (CAASA)

CAASA is an independent non-profit organisation that aims to serve, promote, oversee, advance, and mutually protect the interest of the general and commercial aviation industry, and to act as a link between the industry and government, government agencies and other public bodies within the Southern African region (CAASA, 2020). CAASA provide a platform for all members of the commercial aviation industry to voice their concerns and participate in the affairs of the sector (CAASA, 2020). Consequently, the CAASA has evolved as the respected and effective lobbying force on behalf of Commercial and General Aviation (CAASA, 2020).

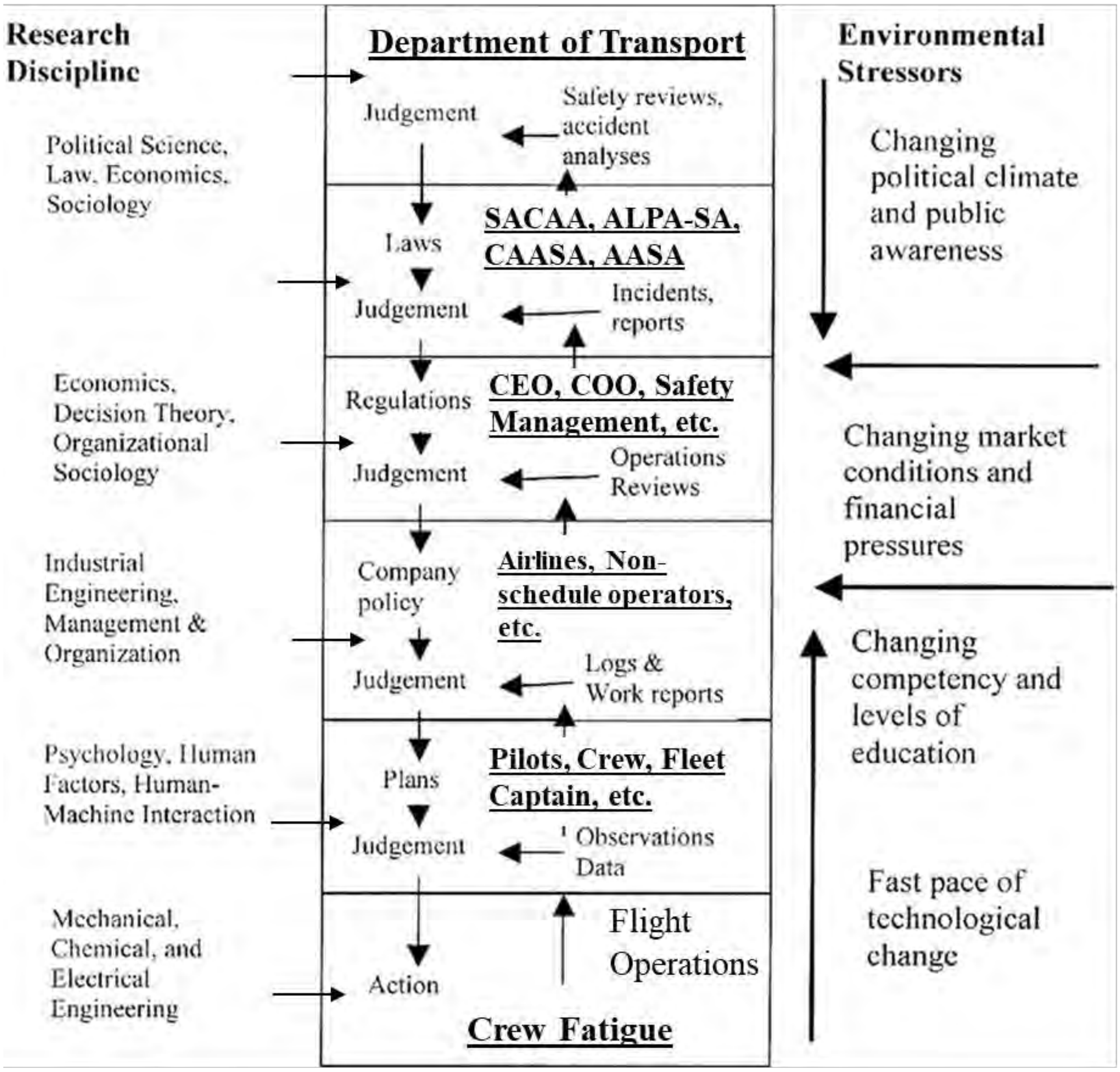

Figure 6: The socio-technical system involved in risk management in the South African aviation industry (adapted from Rasmussen, 1997).

2.5 Fatigue Management in the South African Aviation Industry

In South Africa, the majority of fatigue management in aviation makes use of a prescriptive rule-based limitation approach as part of an SMS approach. The SACAA is South Africa's stand-alone authority in charge of controlling, promoting, regulating, supporting, developing, and enforcing civil aviation safety and security (SACAA, 2017a). This is achieved by complying with the SARPs of the ICAO while considering the local context (SACAA, 2017a). The DoT has adopted the schedule Civil Aviation Regulations (CAR) (2011) recommended by the Director of the SACAA under section

155(1) of the Civil Aviation Act, 2009, (Act No. 13 of 2009) (Department of Transport, 2012). Additionally, the Director of SACAA is empowered to issue technical standards for civil aviation (SACATS) on the matters which are prescribed by regulations under section 163 of the Civil Aviation Act, 2009 (Department of Transport, 2012). The technical standards contain the standards, rules and requirements which are applicable in respect of particular Parts of the Regulations. The CAR Part 121.02.13 and CAR Part 135.02.9 requires each operator to establish a scheme for the administration of flight time and duty periods (Department of Transport, 2012). Operators bear sole responsibility for such schemes being in full compliance with any Acts, Laws and Regulations that are external to the South African Civil Aviation Regulations, notwithstanding any approvals given by the SACAA (Department of Transport, 2012). The provisions to be included in flight time and duty schemes are as prescribed in the SACATS Part 121 and 135 (Department of Transport, 2012) (See Appendix C - SACATS Part 121 Flight Time and Duty Period & Appendix D – SACATS Part 135 Flight Time and Duty Period). However, building upon the regulatory framework above, the following section discusses the historical amendments in FTL regulations around the world.

2.5.1 Historical Amendments in Flight and Duty Periods

Flight Time Limitation regulations have been introduced to address aircrew fatigue, taking a prescriptive approach (Caldwell et al., 2009; Missoni et al., 2009; SACAA, 2011a). Traditionally, fatigue management focused on regulating work hours (Dawson & McCulloch, 2005), but the evolving aviation industry, influenced by technological advancements, scientific research, and operational experience, necessitated a more nuanced strategy (Dawson & McCulloch, 2005; Gander et al., 2011). This updated approach acknowledges the importance of considering factors such as different time zones, the number of flight sectors, duty duration, and acclimatization (Gander *et al.*, 2011).

Within the last 15 - 20 years, various countries, including those in Europe, the United States of America (USA), Canada, and Australia, have re-examined and adjusted their FTL regulations, incorporating the latest scientific insights, research findings, and operational experiences. While not exhaustive, the next section provides an overview of notable regulatory changes observed in different countries. These changes encompass: (i) reduced annual flying times, (ii) shorter duty periods, (iii) the introduction of Fatigue Risk Management Systems (FRMS), (iv) the implementation of flight time specification schemes to accommodate diverse airline operation demands, (v) extended FDP facilitated by in-flight rest facilities on long-haul flights, (vi) advanced notification requirements for reserve duty crew, (vii) adjusted rest periods to reflect industry dynamics, (viii) prohibition of unfit crew from operating flights, (ix) scheduling modifications to mitigate the impact of disruptive schedules, and (x) proposals to reduce consecutive early starts and late finishes (Caldwell et al., 2009; EASA, 2019; Efthymiou et al., 2021; Government of Canada, 2018; Houston, 2019).

Nevertheless, a 2019 review conducted by European Aviation Safety Agency (EASA) assessed the efficacy of EU regulations pertaining to flight and duty limitations, emphasizing that relying solely on prescriptive limits is insufficient to mitigate high fatigue levels during night flights (EASA, 2019). The findings underscored the need for additional research and complementary measures to assist air operators in developing more effective fatigue risk management strategies for night duties (EASA, 2019). Furthermore, research by Efthymiou et al. (2021) aimed to investigate the perceived impact of European FTL changes on safety, alertness, and fatigue, as perceived by cabin crew and pilots. The study revealed a neutral or negative perception across all three variables. According to Efthymiou et al. (2021), this underscored concerns among those operating under the regulations regarding their effectiveness. The negative perceptions may stem from varying interpretations airlines have regarding FTL and may not accurately reflect the overall regulation (Efthymiou et al., 2021). However, the study suggests that these results could indicate a broader dissatisfaction with the regulatory changes related to FTL (Efthymiou et al., 2021).

2.5.2 Flight Duty Period Dispute in Aviation in South Africa

There has been an ongoing debate between ALPA-SA, the SACAA, and the AASA around the adjustment of current FDP. ALPA-SA argue that the flight duty period laws, as captured in the Civil Aviation Regulation (CAR) Part 121 & Part 135 (see Appendix A: Part 121 of CAR and Appendix B: Part 135 of CAR), are not in line with the latest sleep science and operational experience around fatigue and fatigue management.

As ICAO (2016) contends, effectively addressing fatigue through well-designed regulations and rostering practices requires context-specific data informed by the latest scientific advancements and operational insights.

Additionally, there has been an increasing number of complaints of fatigue from crew to the SACAA and the ALPA-SA with the growing demand for air travel nationally and internationally, and the global shortage of pilots. ALPA-SA has been negotiating with the AASA and management from the various operators to recognise the presence and potential adverse effects of pilot fatigue on staff health and overall aviation safety (Blair, 2022). In 2017, the industry rejected ALPA-SA's proposed amendment to the current regulations, which argued that it was too conservative and not economically viable (Blair, 2022. In 2018, a proposal to the CAA stated that South Africa consider amending the flight times and duty periods regulations to one similar to that of the EASA regulations, however, with the informed scientific data to the context of the South African industry (Blair, 2022). However, with the discussions around the amendments of flight duty period regulations ongoing, the outbreak of the Coronavirus (SARS-COV-2 virus), referred to as COVID-19, severely impacted the world and aviation industry.

2.6 The Impacts of COVID-19 on Aviation

2.6.1 South African 'Lockdown' and Aviation

In response to the outbreak of COVID-19, the South African government implemented a nationwide 'lockdown' under the Disaster Management Act, 2002 (Act No. 57 of 2002). This measure compelled many industries to cease operations unless deemed essential. To curb the rapid spread of the virus and facilitate the reintegration of workers into the economy, the Department of Co-Operative Governance and Traditional Affairs (DoCGTA), in collaboration with the Department of Health, formulated the Risk Adjustment Strategies for Economic Activities (DoCGTA, 2020). The Risk Adjustment Strategies for Economic Activities comprised five alert levels, guiding the gradual easing of restrictions (DoCGTA, 2020).

At alert level 5, both domestic and international passenger flights were prohibited (DoCGTA, 2020). Only repatriation flights, intended for bringing back stranded South

Africans or transporting foreigners to their home countries, and essential services were permitted to operate (DoCGTA, 2020). Approval for departure or landing required specific authorization (DoCGTA, 2020). Subsequently, at alert level 4, the ban persisted for both domestic and international passenger flights (DoCGTA, 2020). However, repatriation and cargo flights continued, with unchanged approval procedures for departure or landing (DoCGTA, 2020). All movements remained subject to case-by-case approval and authorizations (DoCGTA, 2020).

During alert level 3, domestic air travel was limited to business purposes, with a daily flight cap and travel authorization contingent on the purpose (DoCGTA, 2020). The reopening of airport services guided flight scheduling, prioritizing high-priority airports for initial openings (DoCGTA, 2020). Similarly, at alert level 2, domestic air travel was restricted, with a daily flight cap and travel authorization based on the reason (DoCGTA, 2020). Finally, at alert level 1, domestic air travel was restored (DoCGTA, 2020).

2.6.2 The Impacts on the Industry Globally and in South Africa

The outbreak profoundly impacted the competitiveness and cash flow of airlines. Cancellations resulted in substantial financial losses for airlines, affecting sales and incurring additional costs. This, in turn, affected various sectors of the travel industry, such as hotels and retailers, reliant on high-spending tourists (Mhalla, 2020). ICAO, (2023a) reported a 50% overall reduction in seats offered by airlines, a 60% reduction in passengers (2,703 million), and approximately USD 372 billion in losses of gross passenger operating revenues for 2020. Preliminary estimates for 2021 indicated a 40% reduction in seats, a 49% reduction in passengers (2,201 million), and approximately USD 324 billion in losses. Furthermore, the forecasted impact for 2022 included a 25% reduction in seats, a 29% reduction in passengers (1,280 million), and approximately USD 175 billion in losses (ICAO, 2023a).

Recognizing the severity of the crisis, the IATA, the AASA, and the Board of Airline Representatives of South Africa (BARSA) urged the South African government to provide specific financial assistance to the aviation sector (IATA, 2020c). IATA estimated a $3 billion reduction in market revenue for South African airlines in 2020, 56% below 2019 levels, posing a risk to 252,100 jobs and $5.1 billion of South African GDP directly tied to aviation and air-dependent tourism (IATA, 2020c). The closure of one airline and extensive restructuring of two others resulted in a virtual disappearance of South Africa's air transport and tourism sector's GDP contribution (IATA, 2021). The potential loss of over 80% of aviation-related jobs underscored the urgent need to restore connectivity (IATA, 2021). The volume of air travel involving South Africa in 2020 experienced an 84% decline compared to 2019 levels, with international flights decreasing by 98% and domestic flights facing a 69% reduction (IATA, 2021). Despite the resumption of domestic flights in June 2020, the reestablishment of international air connectivity had been a gradual process (IATA, 2021).

2.6.3 Restarting the Industry and Management of Fatigue during COVID-19

Restarting the aviation industry, which had ceased operations, ensuring it does not contribute significantly to the spread of COVID-19, presented an unprecedented challenge in commercial aviation history (IATA & ACI, 2020). However, with the gradual easing of lockdown restrictions, business and commercial flights received approval to resume operations, provided they comply with lockdown regulations. The ICAO, Airport Council International (ACI), Civil Air Navigation Services Organisation (CANSO), IATA, The International Air Cargo Association (TIACA), World Food Programme (WFP), and World Health Organisation (WHO) collaborated closely to help develop specific guidelines for aviation, aiming to ensure adequate planning and action at all levels to mitigate the effects of human outbreaks.

Upon the resumption of flights, the IATA & ACI (2020) cautioned the aviation industry to continue managing fatigue due to additional risk factors. They emphasized that emergent fatigue hazards and risks should consider both work- and non-work-related factors, including personal stressors, layovers/slip port, and adequate sustenance (IATA & ACI, 2020). They also highlighted shifts in safety behaviour, such as reduced reporting and reluctance to be removed from duty, as important considerations (IATA & ACI, 2020). Additionally, attention should focus on current working or return-to-work factors (IATA & ACI, 2020). IATA and ICAO recommended that fatigue risk identification should continue being predictive, proactive, and reactive to effectively manage fatigue. During a webinar session focused on addressing challenges in the aviation industry amidst the COVID-19 pandemic, concerns were raised about convincing management to prioritize fatigue management. This discussion emerged due to the unprecedented circumstances faced by the aviation sector, where the resumption of operations amid the pandemic necessitated renewed attention to fatigue management, an aspect that had been previously overlooked during normal operations. Other concerns included the increased factors influencing fatigue, operators extending flight duty limits, and health and safety concerns related to the pandemic (IATA & ACI, 2020).

2.6.4 Emerging Fatigue Impacts From COVID-19

The aviation industry faced unprecedented challenges during the COVID-19 pandemic, with a particular focus on crew fatigue (ICAO, 2023b). While exploring the return to normal operations within the dynamic COVID-19 conditions, various concerns emerged, including uncertainties related to extended validity periods, reduced roster publication timelines, and restricted fatigue mitigation options due to decreased aircraft flying programs (ICAO, 2023b). Challenges were compounded by limitations in contingency options, layover restrictions affecting rest periods, uneven workload distribution, and increased demands on training captains (ICAO, 2023b). Rostering encountered hurdles in adhering to flight and duty limits, potential disruptions during delays, and challenges accommodating additional time for airport procedures (ICAO, 2023b). Crew hesitancy to report fatigue-related hazards may have been influenced by an over-supply of pilots, raising concerns about the adequacy of state-prescribed regulations in the rapidly changing environment (ICAO, 2023b). To proactively manage safety risks, operators subsequently implemented Safety Management Systems (SMS) (ICAO, 2023b).

In response to these challenges, recommendations from recent studies have underscored the importance of additional literature in understanding and addressing flight crew fatigue during the COVID-19 pandemic. Notably, Sun et al. (2022) conducted a study on the fatigue risk assessment for international flights under the COVID-19 outbreak response exemption policy, emphasizing the importance of coordinating crew rotations and the overall safety of the exemption policy. Similarly, the study by Sun et al. (2023) assessed pilot fatigue risk on international flights under the prevention and control policy of the Chinese civil aviation industry during COVID-19, highlighting the feasibility and safety of exemption policies in reducing pilot fatigue risk. Furthermore, research by Li et al. (2023) introduced the Quick Coherence Technique (QCT) biofeedback as an intervention to enhance pilots' psychophysiological resilience to the impact of COVID-19. QCT was described as a mental and emotional self-regulation technique that had been shown to increase one's level of heart-rate variability (HRV) coherence. HRV coherence was associated with improved physiological functioning and emotional well-being. Essentially, QCT involved a series of steps aimed at achieving a state of coherence between the heart, mind, and emotions, which could help individuals manage stress and enhance resilience in challenging situations such as those encountered during the COVID-19 pandemic.

Additionally, Sabaner et al. (2022) evaluated fatigue and sleep problems in cabin crew during the early COVID-19 pandemic period, emphasizing the association between fatigue and sleep disturbances with anxiety, fear, and uncertainty surrounding COVID-19. The study suggests that psychosocial support and physical activity may contribute to reducing fatigue in cabin crew members. Hilditch & Flynn-Evans (2022) reported on the impact of COVID-19 on the schedules, fatigue, sleep, and sleepiness of USA commercial pilots. Notably, the study highlighted the importance of addressing issues related to changes in shift timing, unpredictability in scheduling, and the impact of stress on pilots' sleep and overall well-being (Hilditch & Flynn-Evans, 2022).

2.7 Summary and Restatement of the Research Aims

The background literature delves into the intricate landscape of fatigue management within the South African aviation industry. Emphasizing the country's adherence to international standards set by the ICAO through the SACAA, the regulatory framework is explored. The study underlines the historical evolution of FTL regulations globally, highlighting shifts from prescriptive approaches to more risk-based strategies, considering factors such as time zones, flight sectors, and duty duration. A pivotal point of discussion centres around the ongoing debate between the ALPA-SA, SACAA, and the AASA regarding the adequacy of current flight duty period regulations. ALPA-SA contends that existing regulations do not align with the latest sleep science and operational insights, urging for context-specific, scientifically informed amendments.

This research aims to comprehensively explore the self-reported challenges of fatigue and its contributing factors as perceived by blunt-end stakeholders in South African aviation operations. Against the backdrop of evolving international regulations and localized debates, the study also investigates the impact of the unprecedented COVID-19 pandemic on the prevalence of fatigue and its contributing factors within the industry. By elucidating these perspectives, the research seeks to provide valuable insights that can inform future policy adjustments and operational strategies for fatigue management in the South African aviation sector.

CHAPTER 3 - METHODOLOGY

3.1 Study Design

This study adopted a cross-sectional, qualitative exploratory design, utilizing both online semi-structured interviews and written open-ended questionnaires. The selection of a cross-sectional study design for this research was deliberate and rooted in the unique characteristics of the study population and objectives. The study aimed to capture a snapshot of fatigue-related experiences and perceptions across different cohorts of fatigue-management stakeholders within the South African aviation industry. By employing a cross-sectional design, data was collected from these diverse groups at one specific point in time. The decision to opt for a qualitative approach was driven by the nature of the research questions, which sought to explore the subjective experiences and perceptions surrounding fatigue and its contributory factors among pilots and cabin crew. Qualitative research is well-suited for delving into the nuanced and contextual aspects of human experiences, allowing for a rich understanding of the multifaceted dimensions of fatigue in the aviation context (Flick, 2009; Hennink et al., 2020; Stutterheim & Ratcliffe, 2021).

The primary method involved conducting online semi-structured interviews with blunt-end stakeholders within the South African aviation industry. This approach was chosen for its ability to facilitate in-depth discussions and capture nuanced perspectives on the subject. Recognizing the challenges posed by the COVID-19 pandemic, an alternative method of data collection was introduced and was necessitated by requests from participants who wanted to participate but could not or did not want to sit the interview. Written open-ended questionnaires (with the same questions asked in the interview) were administered online to overcome time and availability constraints. This dual approach allowed for a more comprehensive exploration of blunt-end stakeholders perspectives within the South African aviation industry, accommodating participants' diverse preferences and logistical constraints imposed by the pandemic. While the combination of semi-structured interviews and open-ended questionnaires contributed to the richness and depth of the qualitative data collected for this study, it is crucial to acknowledge that this approach also presented certain limitations. The effectiveness of the dual-method approach, while enhancing the comprehensiveness of data collection, introduced challenges. The shift from interviews to written questionnaires altered the dynamic of participant interaction, potentially impacting the depth of responses. Written responses lack the spontaneity and probing opportunities inherent in face-to-face interviews, which could influence the richness of the qualitative data.

3.2 Data Collection Method

The study made use of two methods to collect information from participants. The primary method, semi-structured interviews (SSI) were used to gather rich and deep qualitative data from the relevant blunt-end stakeholders. The secondary method, online open-ended questionnaires were used to overcome the time and availability constraints posed by the pandemic and gather the required qualitative data from the relevant blunt-end stakeholders.

3.2.1 Semi-Structured Interviews

In this qualitative cross-sectional study, SSI were chosen as the research method to focus on specific areas or topics of interest pertaining to blunt-end stakeholders within the South African aviation industry. SSI involve the utilization of an interview questionnaire or schedule containing predetermined primary questions or question stems, accompanied by subsequent sub-questions or "probes" (McIntosh & Morse, 2015). Furthermore, according to McIntosh & Morse (2015) it is imperative that these inquiries be crafted in an open-ended manner, designed to elicit unstructured responses, and stimulate substantive discussion. Whereas a completely unstructured interview has the risk of not eliciting from the participants the topics or themes more closely associated to the research questions under consideration (Rabionet, 2011). The formation of the questions that were asked to the participants for this study was assisted using the paper by McIntosh & Morse (2015). According to McIntosh & Morse (2015, pg. 4) "*to prepare the interview schedule, the researcher must (a) identify the domain of the topic under investigation including its boundaries, (b) identify the categories of the topic, and (c) identify the question stems. Once the questionnaire is drafted, it is critiqued and tested.*"

3.2.1.1 Identifying the domain of the topic

In this study, there were two primary domains of topic: (i) the self-reported challenges of fatigue and its contributory factors in pilots and cabin crew from management and decision-makers (blunt-end stakeholders) in operations in the South African aviation industry, and (ii) the exploration of the impact of the COVID-19 pandemic on the prevalence of fatigue and its contributory factors.

In conjunction with this, the boundaries for the scope of these domains were defined to establish which topics fell outside of the interests of this research project. The following boundaries were set to establish what would remain outside of the scope of this research: (a) non-fatigue-related factors, (b) sharp-end stakeholders, and (c) geographic scope.

(a) *Non-fatigue-related factors*: the research is specifically interested in fatigue and its contributory factors. Other factors influencing aviation operations that are not directly related to fatigue would be excluded, unless they interacted significantly with fatigue.

(b) *Sharp-end stakeholders*: the study was interested in individuals in management and decision-making roles (blunt-end stakeholders). Therefore, other stakeholders, such as those on the sharp-end (pilots and crew members) fell outside of the defined boundaries.

(c) *Geographic scope*: the study was centred on the South African aviation industry, meaning that experiences and factors related to fatigue outside of this geographic region were not considered within the research domain.

3.2.1.2 Identifying the categories of the topic

Four categories were identified for subdivision within the research topic, based on their shared characteristics, to help facilitate the analysis of the qualitative data. The following categories were identified as pertinent to addressing the scope of the topic:

(a) Demographic information

(b) Understanding and experiences on fatigue and its contributing factors

(c) Thoughts and recommendations on current flight and duty period

(d) Understandings and experience of emerging risks and fatigue management since the start of the pandemic.

3.2.1.3 Identifying the items of the categories

The following items (questions) were derived from the category pertaining to the 'demographic information'. Table ii below displays the identified items derived from the category pertaining to 'demographic information' as well as the justification for the identified items.

Table ii: The identified items derived from the category pertaining to demographic information and the justification for the items identified.

Category	**Questions**	**Justification**
Demographic information	1. What is your age? 2. What is your sex? 3. What is your job title? 4. In which part of the aviation industry do you work? 5. How long have you worked in your present job? 6. Are you involved in fatigue management in your role?	These questions were included in previous studies on fatigue in aviation by Bourgeois-Bougrine *et al.* (2003), Tambala (2017), and Blair (2022) as part of their methodology to survey the participants involved in the study.

The following items were derived from the category pertaining to the 'understanding and experiences on fatigue and its contributing factors' Table iii below displays the identified items derived from the category pertaining to the 'understanding and experiences on fatigue and its contributing factors' as well as the justification for the identified items.

Table iii: The identified items derived from the category pertaining to understanding and experiences on fatigue and it's contributing factors and the justification for the items identified.

Category	Questions	Justification
Understanding and experiences on fatigue and its contributing factors	1. Do you think that crew fatigue is a concern? 2. What do you think are the main contributing factors to crew fatigue? 3. Do you think that awareness of crew fatigue has changed over the last 5 years in the industry?	These questions aim to understand the relative perspective from the blunt-end stakeholders on fatigue prior to the COVID-19 pandemic and its contributing factors. Similar questions were included in previous studies on fatigue in aviation by Bourgeois-Bougrine *et al.* (2003), Tambala (2017), and Blair (2022) as part of their methodology.

The following items were derived from the category pertaining to the 'thoughts and recommendations on current flight and duty period'. Table iv below displays the identified items derived from the category pertaining to the 'thoughts and recommendations on current flight and duty period' as well as the justification for the identified items.

Table iv: The identified items derived from the category pertaining to the thoughts and recommendations on current flight and duty period and the justification for the items identified.

Category	Questions	Justification
Thoughts and recommendations on current flight and duty period	1. What are your thoughts on the current South African Flight and Duty Period regulations? 2. What recommendations would you make around amending the current FDP regulations in South Africa?	These questions are related to the ongoing discussion within the South African aviation industry regarding the change in flight duty period regulations. They aim to provide relative perspectives from blunt-end stakeholders on the current regulations and allow for additional comparison with various parts of the industry for any adjustments going forward. Similar questions were included in Blair (2022) as part of their methodology.

The following items were derived from the category pertaining to the 'understandings and experience of emerging risks and fatigue management since the start of the pandemic'. Table v below displays the identified items derived from the category pertaining to the ‘understandings and experience of emerging risks and fatigue management since the start of the pandemic’ as well as the justification for the identified items.

Table v: The identified items derived from the category pertaining to the understandings and experience of emerging risks and fatigue management since the start of the pandemic and the justification for the items identified.

Category	Questions	Justification
Understandings and experience of emerging risks and fatigue management since the start of the pandemic	1. Since the start of the pandemic, what have been the main impacts on your operation / on the stakeholders you represent / regulate? 2. What are your biggest concerns for the South Africa aviation industry? 3. Do you think that the COVID-19 pandemic and the challenges you have outlined above will present different or additional fatigue risks in your operation / for the stakeholders you represent / regulate? If so, what do you think these would be? 4. How are you planning to manage these risks in your operation / in the stakeholders you represent / regulate?	These questions are aimed at evoking perspectives from blunt-end stakeholders on the ongoing concerns of fatigue and the industry during the COVID-19 pandemic and the plans to manage them going forward. This was largely an exploratory process due to the recency; there was no information on the current situation within South Africa and the impact of the COVID-19 pandemic on the emerging risks of fatigue and the industry.

3.2.1.4 Piloting the interview schedule

The interview was shared amongst academics within the Human Kinetics and Ergonomics department at Rhodes University, and individuals from the regulator within the South African aviation industry for review and to provide any recommendations or adjustments to the interview protocol. The interview schedule was tested in mock conditions, with the supervisor of the study, that closely approximate the actual conditions in order to amend it before main data collection.

3.2.2 Online Open-Ended Questionnaires

In addition to the online interview procedure, an online open-ended questionnaire (sub-section 3.5.2.2) was made available to those individuals who showed interest in participating in the study, however, encountered constraints to be involved in the primary online interview process. The recruitment process and information provided prior to the interview procedure remained the same between the primary online interview and the online open-ended questionnaire. The questions that were asked in the open-ended questionnaires made use of the identified categories and items from the semi-structured interview above (see Table ii – v).

3.3 Selection of Participants

The research project used a purposive (and to some extent, snowball) sampling method to recruit appropriate participants. The purposive selection of participants began with blunt-end stakeholders from the South African aviation industry, specifically those holding senior positions within key organizations, such as the Air Line Pilots' Association South Africa (ALPA-SA), the South African Civil Aviation Authority (SACAA), the Airlines Association of Southern Africa (AASA), and the Commercial Aviation Association of South Africa (CAASA). These participants were chosen based on their significant influence on safety management practices within the industry. Furthermore, individuals with direct or indirect involvement in the development, implementation, or oversight of fatigue management policies and procedures were prioritized. This ensured that the study captured insights from those with relevant experience in managing or influencing fatigue-related safety outcomes.

A noteworthy aspect in participant selection involved a working group, as previously mentioned, which served as an excellent starting point. This working group, discussed in the literature (see sub-section 2.5.2), played a pivotal role in shaping the selection process by offering valuable insights and perspectives. The ongoing debate between ALPA-SA, SACAA, and AASA, as highlighted earlier (see sub-section 2.5.2), underscored the importance of including participants from this working group. Their active involvement contributed to a nuanced understanding of the industry dynamics and facilitated access to context-specific data related to fatigue management and operational experiences. Participants were also selected from various regulatory categories within the aviation industry, such as Part 93, Part 121, and Part 135, to provide a comprehensive understanding of how fatigue management practices differ across sectors.

The snowball selection of participants stemmed from seeking additional participants through those who had already partaken in the study. This approach allowed for the identification of other relevant safety-management stakeholders, ensuring a full range of perspectives from blunt-end stakeholders. Participants were encouraged to recommend colleagues or peers who also held relevant positions or expertise in the industry. This method enhanced the inclusivity and scope of the study by capturing a broader range of perspectives, particularly from those who might not have been initially considered but whose insights were deemed valuable by their peers.

The blunt-end stakeholders involved in this study play crucial roles in the risk management of the aviation industry. To better contextualize their roles within the Rasmussen model, it is essential to acknowledge the socio-technical system framework proposed by Rasmussen (1997). In this framework, the aviation industry is viewed as an intricate interplay between technical and social elements, where both sharp-end and blunt-end stakeholders contribute to the overall system performance. Figure 7 illustrates the various levels at which participation took place within this study, denoted by the red dotted line. As highlighted in the literature review (see sub-section 2.4.4), the Rasmussen model positions the blunt-end stakeholders—such as regulators, safety managers, and system designers—at the policy and strategic level of the socio-technical system. Their decisions and actions influence the overarching safety culture, policies, and procedures that guide the operational practices at the sharp end. By integrating the insights and perspectives of these blunt-end stakeholders into the Rasmussen model, we can better understand how their roles impact the operational dynamics and safety outcomes within the South African aviation industry.

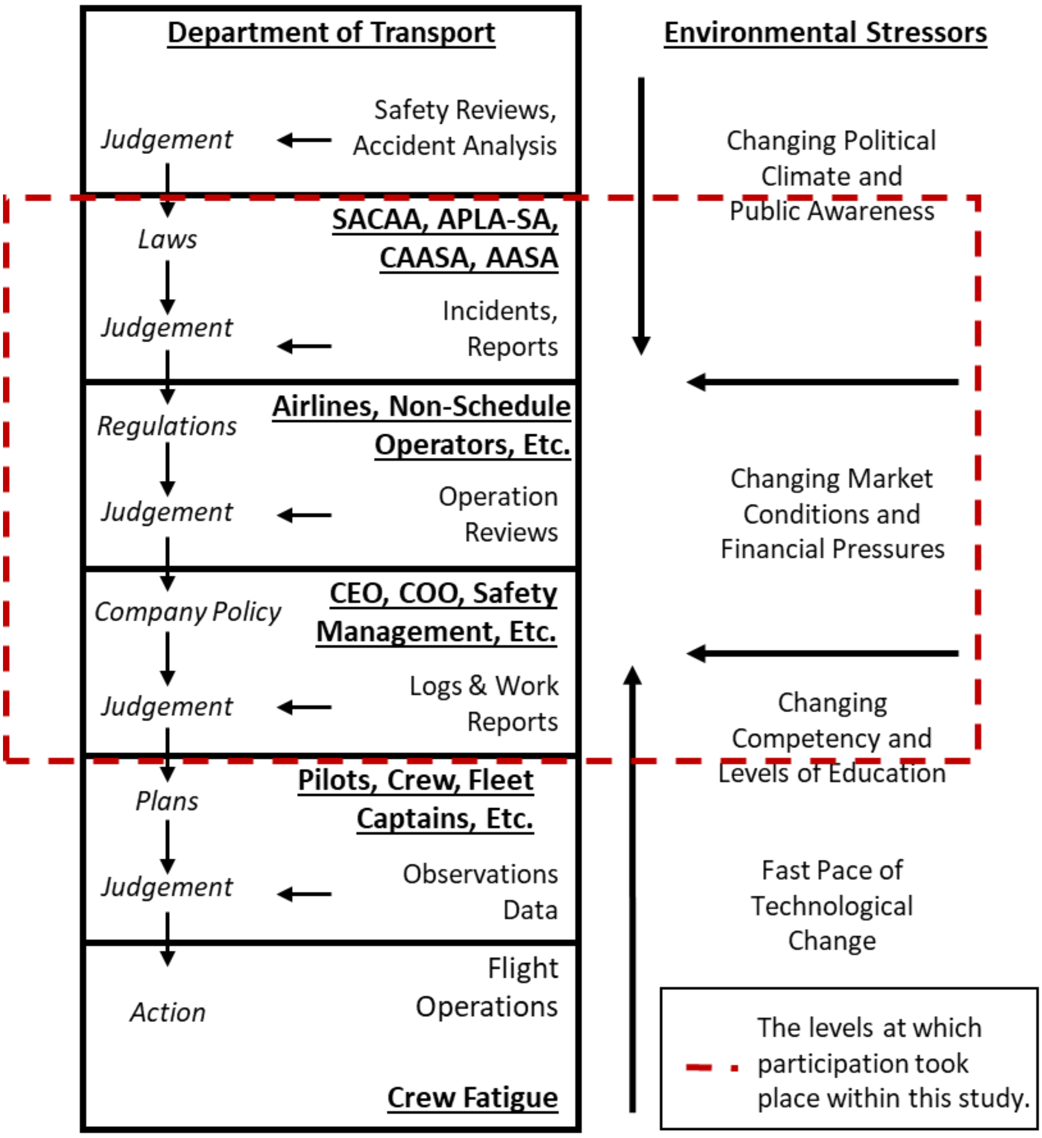

Figure 7: The socio-technical system involved in risk management in the South African aviation industry (adapted from Rasmussen, 1997).

From an operational perspective, participants were recruited from various regulatory categories, such as Part 93 (Corporate aviation operations and high-performance aircraft), Part 96 (Commercial operation of non-type certified 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 (Air transport operations: carriage of less than 20 passengers or cargo), Part 137 (Aerial work operations), Part 138 (Air ambulance operations), Part 141 (Aviation training operations), and Part 145 (Aircraft Maintenance Organisation).

3.3.1 Sampling Strategy and Inclusion Criteria

In contrast to Tambala et al.'s (2017) comprehensive approach, which encompassed individuals across the entire aviation industry in Norway, this research focused exclusively on safety-management stakeholders within the South African aviation industry. These stakeholders were intricately involved in various aspects of aviation safety management. While their direct influence on fatigue levels may not have been definitive, their decisions, policies, and practices could indirectly impact the fatigue experienced by crew. While Tambala et al. (2017) utilized a purposive sampling method in their study, this project's method adopted a similar approach with one notable refinement: narrowing the study to those identified safety-management stakeholders. The study introduced a collaborative element through the snowball sampling method for recruitment and selection, allowing recruited participants to actively contribute to the recruitment process by identifying additional relevant safety-management stakeholders or forwarding the research participation letter to potential participants, thus enhancing the inclusivity and scope of the study.

To be included in the study, participants needed to be actively involved in the South African aviation industry, particularly in roles related to safety management. They were required to possess knowledge and experience in the development or implementation of policies affecting fatigue management. Furthermore, participants needed to hold a position that allowed for decision-making or advisory input on operational practices within the aviation sector. By meeting these criteria, the study ensured that the selected participants were well-positioned to provide meaningful and relevant insights into the management of fatigue in the aviation industry.

3.4 Ethical Considerations and Approval Process

Prior to commencing the research process, the necessary ethical clearances were diligently sought and obtained. The Rhodes University Ethics Standards Committee (RUESC) – Human Ethics (HE) sub-committee granted approval with reference number HKE=2018-02: Fatigue in Aviation Research (see Appendix G for the ethical clearance form). Subsequently, with the approved ethical clearance in hand, formal permission was sought and granted by the South African Civil Aviation Authority (SACAA) to conduct the research within the broader aviation industry.

With the necessary approvals secured, the next phase involved engaging potential participants. Individuals were invited to partake in the study and were provided with essential documentation to ensure informed and voluntary participation. This documentation included a consent form, a letter of information detailing the study's purpose and procedures, and a letter of anonymity outlining the confidentiality measures in place (refer to Appendix I for the consent form and refer to Appendix E for the letter of information and letter of anonymity). Additionally, recognizing the complex network of stakeholders in the aviation industry, gatekeeper permissions were obtained from key organisations. The Air Line Pilots' Association South Africa (ALPA-SA), South African Civil Aviation Authority (SACAA), Airlines Association of Southern Africa (AASA), Commercial Aviation Association of South Africa (CAASA), and various operational companies all granted permission. These gatekeeper permissions, documented in Appendix H, signified the collective agreement of safety-management stakeholders to allow their respective members to participate in the study.

3.5 Data Collection Procedures

3.5.1 Participant Recruitment

The sample was recruited to participate in the study through an email sent directly to the participants, where the study was introduced, its purpose was stated, the measurements and procedures were disclosed. The email ensured that their participation would be voluntary, meaning they could withdraw at any point. Additionally, it included an attached consent form in which the participant was requested to read, fill out, and send back. Furthermore, the participants were informed of the next procedures. Participants were also requested to email back if they had any further requests or questions regarding the study. These requests or questions were further clarified to the participants in follow-up emails.

3.5.2 The Interview Procedure

3.5.2.1 Online Interview Procedure

Interviews were conducted one-on-one via the online video chat software – Zoom™. In addition, the online video interviews were recorded via the previously mentioned video chat software. The semi-structured interviews started with a greeting, introducing the interviewer and the interviewee before the video and audio were recorded. Following the greetings, a description of the primary and secondary research questions were given to the interviewee. To conclude the introductory part of the semi-structured interview, the interviewer further identified and disclosed the research personnel involved in the study to the interviewee. Following the introduction part of the semi-structured interview, the interviewer then described the process that followed. This included consent for the study and the semi-structured interview questions. The interviewer then discussed confidentiality and consent with the participant. This emphasised that the participant could withdraw their consent at any time without prejudice or bias from the interviewer.

Following approved consent, the interviewer began the interview questions (Appendix F: The Interview Protocol for the Study), which were recorded for later analysis. The questions were, for the most part, open-ended and allowed the researcher the latitude to ask follow-up questions, as well as to ask for clarification where necessary. And finally, the interviewer concluded the interview process by thanking the interviewee for being involved in the process and acknowledging that the interviewee would have access to the information after the research had been completed.

3.5.2.2 Online Open-Ended Questionnaires Procedure

Additional open-ended questionnaires were conducted online in a written response format. The open-ended questionnaires were made available to participants via email, which contained a letter of information about the study, the aims of the study, a consent form approving that they would be willing to participate in the study, as well as the open-ended questionnaires. Participants were asked to read the information relative to the study, fill out the consent form, and answer the open-ended questionnaire. Once completed, participants were required to email their consent information and their responses to the questionnaires back to the researcher for analysis.

3.6 Data Analysis Method

The participants' demographic information gathered from the semi-structured interviews was analysed using simple descriptive qualitative and quantitative analysis.

Furthermore, the rich qualitative data collected from the semi-structured interviews were analysed using a thematic analysis procedure. The thematic analysis procedure for this research project was based on the procedure outlined in the Braun & Clarke (2006) paper '*Using thematic analysis in psychology*'. Briefly, Braun & Clarke (2006) outlined a procedure for thematic analysis that included: (i) familiarizing with the data, (ii) generating the initial codes, (iii) searching for themes, (iv) reviewing themes, and (v) the generation and presentation of thematic maps (see sub-section 3.7.2).

3.7 Data Analysis Procedure

3.7.1 Participant Demographic Analysis Procedure

The participants' demographic information gathered from the semi-structured interviews was imported into Microsoft Excel, where it was analysed using simple descriptive qualitative and qualitative analysis. Firstly, due to the nature of the information and the need to maintain anonymity, participant's age and years of work experience in their current role were calculated using descriptive statistics in Microsoft Excel. These values were used to represent the participants' age and years of work experience in their current role as a whole. Furthermore, the participants were then separated into the number of males and females that were interviewed, the number of participants from different broad overview parts of the industry, and then finally if and how the participant manages fatigue in their operation. The analysed participant demographic information was then represented in text and Table iv (sub-section 4.2.1).

3.7.2 Thematic Analysis Procedure

Adopting Braun & Clarke's (2006) procedure for thematic analysis, the first phase involved familiarizing oneself with the data. This encompassed the transcription process, reading and re-reading the data, and noting down initial ideas. The interview questions were recorded using the integrated recording software on Zoom™ video chat and subsequently transcribed through Otter.ai (Otter.ai, Inc.), an artificial intelligence-driven speech-to-text conversion software. To ensure accuracy, the transcribed text from Otter.ai was cross-verified with the original audio recordings. Corrections were applied whenever discrepancies were identified between the transcribed text and the recorded audio. These discrepancies primarily stemmed from variations in accents, instances of stammering, or background noise interference. For instance, in one interview, a participant's accent led to misinterpretations of certain phrases, which required careful review and correction. Additionally, occasional stammering or overlapping speech posed challenges in accurately transcribing the dialogue, necessitating further scrutiny and adjustment. By cross-verifying the transcribed text with the original audio recordings, such discrepancies were promptly identified and rectified to ensure the integrity and accuracy of the data analysis process.

The subsequent phase involved *generating initial codes*, which refers to systematically coding interesting features of the data across the entire data set and collating data relevant to each code. This process was foundational to the thematic analysis, as it required not only a close examination of the data but also the ability to discern patterns that may initially seem fragmented or disconnected. Following the rechecking and corrections applied to the transcribed text, the transcribed text was imported into NVivo 12 (Lumivero), which was used to code the qualitative data gathered from the interviews. NVivo 12 is a qualitative analysis software that facilitates the importation, organization, exploration, and analysis of data. The coding process involved tagging and naming selections of text within each data item, organizing the data into meaningful groups that could later be synthesized into broader themes. Throughout this phase, particular attention was paid to ensuring consistency in how codes were applied across different interviews, thereby minimizing the risk of subjective bias during the analysis. Additionally, the iterative process of revisiting and refining codes played a critical role in capturing nuanced insights from participants' responses.

The next phase, *searching for themes*, involved collating codes into potential (or 'a priori') themes and gathering all relevant data for each theme (Braun & Clarke, 2006). This stage required an iterative process of examining the relationships between codes and determining how they could be clustered into broader, coherent themes that accurately reflected the data. NVivo 12 facilitated this by enabling the collation and restructuring of the hierarchy of the codes into specific themes. During this phase, careful attention was paid to ensuring that the themes generated were both distinctive and comprehensive, avoiding redundancy while also capturing the complexity of the data. For instance, when multiple codes exhibited overlapping content, decisions had to be made regarding whether to merge them under a single theme or to keep them distinct based on their conceptual differences. This phase also required the refinement of initial themes, where certain preliminary themes were either split into sub-themes or combined into more encompassing categories to align with the research objectives.

To further enhance transparency and consistency in deriving themes, additional steps were implemented. Specifically, themes were developed by closely examining the codes generated for each interview question and grouping related codes under broader conceptual categories. For example, codes related to "Disruptive Operating Hours" were consolidated into the overarching theme of "Schedule/Roster-related Factors." The criteria for grouping codes were based on shared underlying concepts and the frequency of their occurrence across multiple participants. Importantly, this phase of the analysis was not merely about identifying repetitive patterns; it also required a deeper exploration of subtle connections between codes that could provide new insights. To maintain consistency in theme identification across all interview questions, a cross-question comparison was conducted. This process involved reviewing codes and emerging themes from each interview question to identify overlapping or divergent patterns, thereby ensuring a consistent approach regardless of the variations in the focus of each interview question.

In the subsequent phase, *reviewing themes*, the analysis involved critiquing whether the themes worked in relation to the coded extracts (level one) and the entire data set (level two). This step was crucial in ensuring that each theme was well-supported by the data and that the thematic structure was coherent. The level one analysis involved re-reading the collated extracts for each theme to assess whether they formed a consistent and interpretable pattern. NVivo 12 was used to generate thematic maps, which visually represented the relationships between the identified themes and sub-themes. These maps served as a tool for refining the analysis, as they allowed for the identification of any gaps or inconsistencies within the thematic structure. In level two, the themes were reviewed in relation to the entire data set to confirm their validity and relevance. This involved revisiting the original interview data to ensure that the themes accurately encapsulated the participants' perspectives. Where inconsistencies were identified, the themes were either redefined or reorganized to better align with the overall findings of the study. The review process ultimately resulted in a set of robust, well-defined themes that provided a comprehensive understanding of the research questions.

In the final phase, *thematic maps were generated* for each interview question. To enhance the robustness of the thematic analysis, direct narrative extracts from participants were woven into the themes. This process involved aligning participant statements with the identified themes, adding depth and authenticity to the analysis. The participant narratives supporting each theme have been presented in the results chapter below (sub-section 4.2.2).

3.7.3 Integration and Analysis of Data from Semi-Structured Interviews and Open-Ended Questionnaires

To ensure a seamless integration of the data collected from the online semi-structured interviews (SSI) and the written open-ended questionnaires, a systematic approach was adopted. The qualitative data from the SSI and the questionnaires were first analysed separately to understand each data set's unique insights. The same coding framework was applied to both data sets, ensuring consistency and comparability. Following the separate coding, the data were merged, and any overlapping themes or unique insights were identified. The themes were then reviewed across the combined data set, and thematic maps were generated to represent the integrated data visually. Direct narrative extracts from both the SSI and the questionnaires were incorporated into the thematic analysis to add depth to the findings. This approach ensured that the integration was not merely mechanical but also analytical, capturing the nuances from both data sets. The final thematic maps were presented, providing a clear narrative that encapsulated the integrated insights from both the SSI and the questionnaires, thereby enriching the overall analysis.

3.7.3.1 Reflexivity

Reflexivity served as a cornerstone in qualitative research, necessitating a meticulous examination of the researcher's beliefs, judgments, and practices throughout the study. It underscored the researcher’s active participation, highlighting an integral role rather than that of a detached observer (Hammond, 2022). Beyond mere reflection, reflexivity demanded scrutiny of taken-for-granted assumptions, delving into predispositions and biases in data interpretation (Finlay, 1998). In this study, reflexivity was actively practiced to comprehend the dynamic interplay between the researcher and participants. The researcher’s positionality, encompassing background knowledge, behaviour, and underlying beliefs, was continuously examined to understand how these aspects influenced interactions. This introspection extended to recognizing the broader context of social identity, acknowledging that personal positions extended to the wider research discipline (Hammond, 2022).

The researcher’s perspective and voice in this study were shaped by a combination of cultural, political, social, and ideological factors. Growing up in South Africa, cultural identity reflected a blend of Western and African influences. These cultural backgrounds, combined with academic training in Human Kinetics and Ergonomics, informed the understanding of the complex interplay between human factors and safety in the aviation industry. Politically, views were influenced by the global discourse on workers' rights, occupational health, and safety regulations, which were particularly relevant in the context of aviation. Socially, experiences as a young professional navigating a rapidly evolving industry heightened awareness of the challenges faced by workers, especially in relation to fatigue and mental health. Ideologically, there was alignment with a human-centred approach that prioritized the well-being of individuals in high-stress environments. These perspectives inevitably influenced the research process, from the formulation of research questions to the interpretation of findings. There was a consciousness of the potential for these biases to shape interactions with participants and the analysis of data.

The perspectives and voices of the participants in this study, primarily aviation professionals, were central to the research process. Their experiences were shaped by diverse cultural and social contexts, occupational roles, and individual beliefs. During data collection, efforts were made to create an environment that allowed participants to express their views freely, without the imposition of the researcher’s biases. This was achieved by employing open-ended questions and actively listening to the narratives shared by participants, ensuring that their voices were authentically represented in the research findings. Understanding the participants' perspectives also required atonement to the power dynamics inherent in the researcher-participant relationship. The researcher's role, coupled with academic background, could influence how participants perceived the study and their willingness to share certain aspects of their experiences. Reflexivity was crucial in navigating these dynamics, enabling acknowledgment and addressing the potential impact of positionality on the data collection and analysis processes.

The perspectives of those to whom this research was reported, including academic peers, industry stakeholders, and regulatory bodies, also played a significant role in shaping the study. The findings of this research were scrutinized by individuals with varied interests and expectations, ranging from academic rigor to practical implications for aviation safety. This awareness informed the approach to presenting the research findings, balancing the theoretical contributions of the study with its practical relevance to the industry. In communicating the research findings, efforts were made to ensure that the perspectives of participants were faithfully represented while also addressing the concerns and expectations of the research audience. Reflexivity was employed to critically assess how the presentation of findings might have been influenced by the anticipated reception of different stakeholders, ensuring that the research remained transparent, rigorous, and relevant.

Reflexivity directly influenced key methodological decisions and the interpretation of research findings. For instance, when selecting research questions, prior experience in the aviation industry led to preconceived notions about the impact of fatigue. This awareness prompted the adoption of a more exploratory approach, formulating questions that allowed participants to express their experiences without being constrained by the researcher's expectations. In the data collection phase, the decision to use semi-structured interviews was influenced by reflexivity. Awareness of subject matter knowledge potentially leading to unintentional steering of the conversation prompted the design of open-ended questions that encouraged participants to share their insights freely, while ensuring that the researcher's views were not imposed. For example, when discussing fatigue management strategies, leading questions were avoided, and the focus was on allowing participants to describe their experiences in their own words.

During the analysis phase, reflexivity was crucial in interpreting the data. Initial interpretations were constantly revisited, questioning whether they were influenced by personal biases or assumptions. This reflexive practice led to the re-examination of certain themes that emerged from the data, ensuring that they genuinely reflected the participants' perspectives rather than the researcher's preconceptions. For instance, while analyzing the impact of the COVID-19 pandemic on fatigue levels, initial findings were attributed to external factors related to the pandemic. However, upon further reflexive examination, it was recognized that some interpretations were shaped by personal anxieties and uncertainties during the pandemic, prompting a more nuanced analysis that considered alternative explanations provided by the participants. By critically examining biases and assumptions, the aim was to mitigate potential sources of bias and enhance the validity and rigor of the study. Reflexivity not only informed these key methodological decisions but also provided a framework for interpreting the research findings in a way that was both transparent and aligned with the participants' lived experiences. The inclusion of specific examples of reflexivity in action further underscored its impact on the research process and contributed to the overall methodological transparency of the study.

In conclusion, reflexivity was not only acknowledged but actively practiced throughout this study. Continual interrogation of beliefs, judgments, and practices was conducted to enhance transparency, acknowledge biases, and deepen the understanding of the research process. Reflexivity significantly influenced the methodological choices made and the interpretation of research findings, ultimately contributing to the study's rigor and validity.

CHAPTER 4 - RESULTS

4.1 Participant Characteristics

Thirteen participants, comprising nine males and four females, participated in this study. The interviews were conducted under time and availability constraints, utilizing either a 'face-to-face' online semi-structured format or a written semi-structured interview, with eight participants opting for the former and five for the latter. The participants, with an average age of 48 ± 11 years and an average combined work experience of 9 ± 8 years in their current roles. This diversity aimed to provide a comprehensive perspective, with participants hailing from the union, industry associations, airline and scheduled operations, non-scheduled operations, and regulator sectors.

To elaborate on the industry segments represented: The pilots' Union (1 participant) represents the collective interests of the workforce; Industry Associations (3 participants) are engaged in diverse areas, including commercial aviation, recreational aviation, drone operations, and training; Airline and Scheduled Operations (5 participants) encompass commercial airlines operating on fixed timetables; Non-scheduled Operations (2 participants) involve operations such as charter flights, aerial work, and non-timetable-dependent services; and Regulator (2 participants) who govern and oversee various commercial entities, excluding recreational activities, with a focus on areas like training and maintenance.

The participants' responses were recorded and, to ensure confidentiality, anonymized by aggregating insights into their respective broad overview parts of the industry, as detailed in Table iv, which specifically outlines "Participants’ Involvement in Fatigue Management in Their Role." This categorization allows for a nuanced understanding of the diverse perspectives within the industry while safeguarding the anonymity of individual participants.

Table vi: Participants' Involvement in Fatigue Management in Their Role

Participants Represented as Broad Overview Parts of the Industry		Involvement in Fatigue Management in Their Role	
	Union	**Not officially**	However, involved in discussions around the amendments to FDP regulations.
	Industry Associations	**Yes**	Through the management of stress of colleagues brought about by job demands, depression and health issues.
		Not officially	However, in the ATOs (Approved Training Organisations), we must look at how many hours our pilots are putting in and how many hours the instructors are putting in.
	Airline and Scheduled Operations	**Not officially**	However, involved in the amendments in altering FDP regulations.
		Yes	Through education and training of crew pilots and cabin crew; Analyse additional fatigue risks (safety reporting system - interviews and questionnaires); Understand the risk; Implement mitigations for the identified risk.
		Yes	Through reviewing of reports in relation to breaches in FDP; and crew concerns relating to fatigue hazards;
		Yes	Through report creation of flights beyond the FDP; and providing operating and captains approval;
		Yes	Through involvement in Fatigue Safety Action Group.
		Yes	Through oversight of and implementation FRMP system and software for crew.
	Regulator	**Yes**	Through the development of fatigue management programme with operators; Approval of flight duty period schemes; Regulate flight duty period schemes; and Amending current Flight duty period regulations.
		Yes	Through the Exemption applications relating to operating outside of the current Legal framework.
	Non-Schedule Operations	**Yes**	Through the development and implementation of the fatigue risk management system for crew.
		Yes	Through the monitoring of crew fatigue and tracking of crew flight and duty period.

In addition to the participant characteristics, the semi-structured interviews seek to explore the understandings and experiences of the participants through thematic analysis of the relevant findings which was explored in the sub-chapter below.

4.2 Thematic Analysis Results of the Participants' Understanding and Experiences

In Figure 8, a hierarchical map illustrates how the final coding sections were employed in NVivo for categorizing interviewee responses concerning the research questions. The top tier reflects collective participant responses to the interview procedure, followed by tiers representing responses to the highlighted research questions and individual questions within the interview protocol. Themes and sub-themes, derived from participant responses, are further detailed in the subsequent sub-chapters.

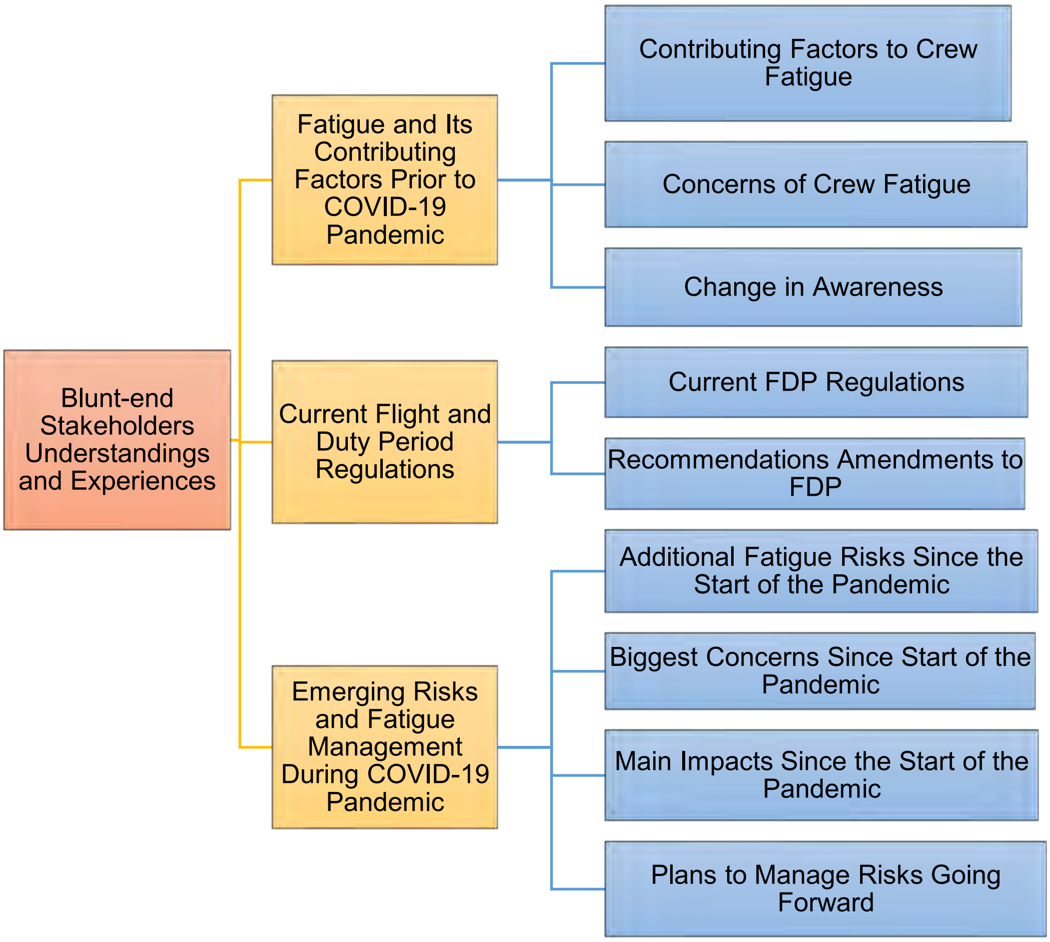

Figure 8: Hierarchical Map of the Final Coding Section Template

In relation to the final coding sections template shown in Figure 8, Table v shows how many participants gave answers which were coded in the different sections. Additionally, the total number of codes that were included in each node is also shown (see Appendix J for Table v: Number of individuals' responses seen in relation to the total codes in a node). Figure 8 aimed to explicitly convey the comprehensive structure of the obtained results displayed below.

4.2.1 Challenges of Fatigue and Its Contributing Factors Prior to the COVID-19 Pandemic

In the paragraphs below, included are relevant responses to the first research question, '*What are the management and decision-makers in operation experiences and insights on the self-reported prevalence of fatigue and its contributory factors in the South African aviation industry?'.*

4.2.1.1 Perceived Concerns About Crew Fatigue Prior to the COVID-19 Pandemic

Figure 9 displays the generated themes and sub-themes from the participants' responses for the interview question: *Prior to the COVID 19 pandemic, do you think that crew fatigue was a concern in your operation / in the stakeholders you represent / regulate and if so, why?* All thirteen participants unanimously acknowledged crew fatigue as a significant concern within the aviation industry prior to the COVID-19 pandemic. However, it is noteworthy that among these responses, four participants—two airline and schedule operators, one industry associate, and one non-schedule operator—highlighted a dual perspective on the issue. While the majority expressed concerns regarding crew fatigue, these four participants emphasized that the reasons surrounding why crew fatigue was not a concern were also articulated during the interviews. There were ten broad themes identified. Of the ten broad themes identified, eight of the themes indicated reasons for why crew fatigue was concern within the aviation industry. These eight themes were: *Crew Mentality and Attitude Towards Fatigue, Individual Variability, Lack of Knowledge and Awareness, Maintenance Delays, Managing Fatigue, Operation Specific Concerns, Outdated Regulations and Resistance to Change, and Volatility and Unstructured Nature of Non-Scheduled Operations*. Conversely, the remaining two themes identified indicated reasons for why crew fatigue was not a concern within the aviation industry. These two themes were: *Well-Managed Operations and Focusing on Revenue Generation within Operations.*

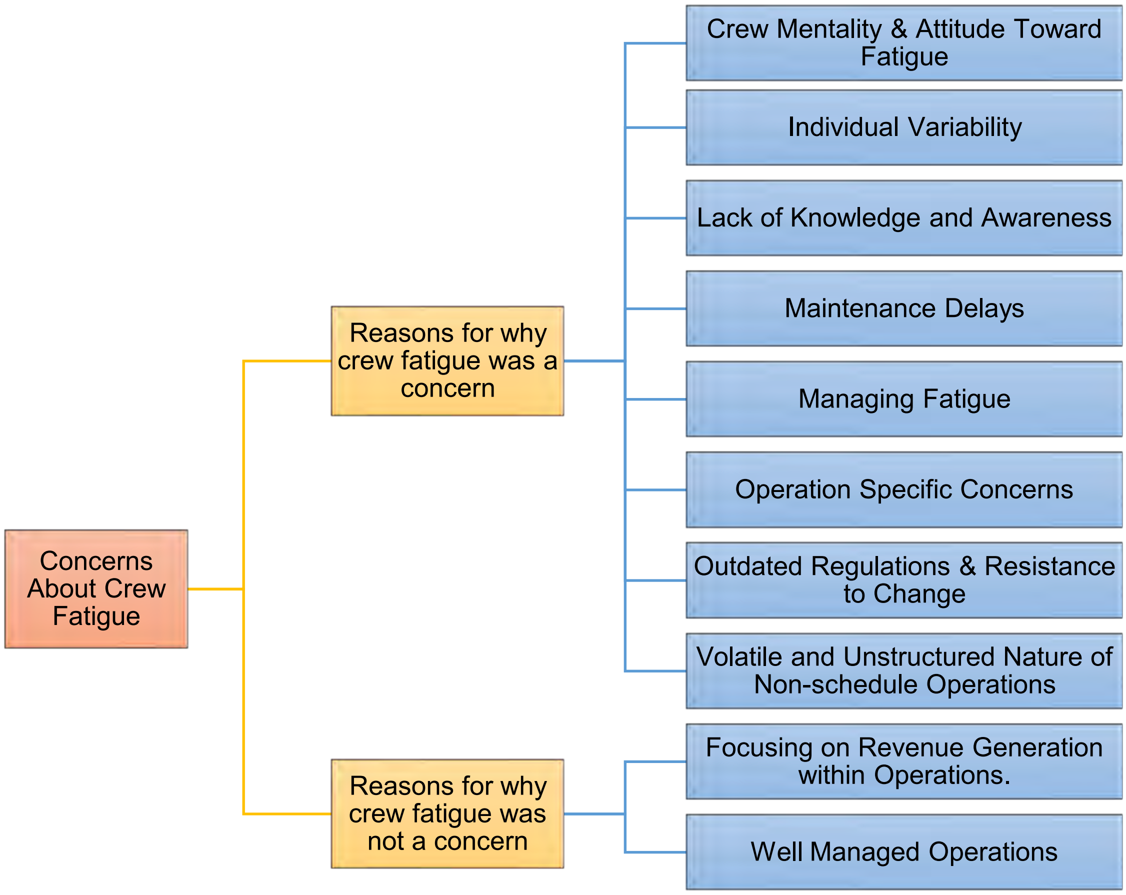

Figure 9: Thematic Map for the concerns about crew fatigue and their reasons

4.2.1.1.1 Reasons for why crew fatigue was concern within the aviation industry.

Crew mentality & attitude towards fatigue was highlighted to be reason for why crew fatigue was a concern. Participants reported that crew may be experiencing fatigue and persevering through the fatigue due to the individual desire for hero status or recognition or due to the obligation felt by crew to continue working to avoid repercussions. In the former scenario, a regulator noted an example of a crew member experiencing personal life issues that might have impacted their sleep, consequently rendering the crew member prone to a state of fatigue. Despite these challenges, the crew member continued to report to duty out of a sense of responsibility, as mentioned by the participant *"…people operating in the aviation environment, where they are rostered to do something, they have to do it, whether they fatigued or not. So, they end up lying, I guess, and unintentionally because they're like, I'm not really tired that did sleep last night, kind of, but my child was sick the whole time, maybe my husband's* *having an affair. So, I'm not sleeping at all, because I'm a bit traumatized or so you get people in those situations, but they still have to sign on for duty.”.* With the latter, the fear of repercussion, an industry associate further noted that this can be as result of “*Uncertainty of job security and their roles in the organisation.*”.

Participants consistently expressed concern about the impact of **individual variability** (or differences) on crew fatigue, attributing it to the complexity associated with understanding and managing fatigue risks. An airline and schedule operator added that more information regarding the physiological reaction of the human body should be captured within the regulations: *"Yes, it [fatigue] was [a concern]. And the reason I'm saying that is because the actual physiological reaction of a human body actually is not well captured in the current flight and duty. You have, you had studies that were done, which talked about people's you know, biorhythms, etc, etc. And we [people] are not all the same.".* It was further highlighted that individual variability exposes crew to different forms of contributing factors to fatigue and subsequently different means to manage them as a regulator mentioned *“The fatigue…. it also changes from it from individual to individual. So, you get your youngsters who may experience fatigue around socializing. And then of course, the roster and it is balancing the social lives with the roster. And then you get people in a more settled phase of life. We, they then start having children going through marital issues and being on a roster.”*

The theme a **lack of knowledge and awareness**, specifically a limited understanding surrounding fatigue, its contributing factors, and the management of fatigue, as captured by an airline and scheduled operator who said *“Yes. Due to lack of awareness and understanding of fatigue factors, responsibilities of each party involved, lack of awareness of short term and cumulative fatigue etc”.* In addition, an airline and schedule operator indicated there was a lack in awareness and understanding around the responsibilities of each party involved in fatigue management and it that was generating concern for crew fatigue as the participant mentioned.

Maintenance delays was highlighted as a cause for concern for fatigue as an airline and schedule operator stated that *“Maintenance delays had severe effects on* *operations, often leading to irregular scheduling, the call out of standby crew and subsequent roster amendments".*

Managing fatigue emerged as a crucial aspect, signifying an awareness of the risk of crew fatigue within the industry and an ongoing effort to actively address and mitigate fatigue. An airline and schedule operator stated *"Yeah. So, it's a concern in the fact that we were actively managing or looking for fatigue risk.".* Participants further highlighted that in well-run and well-managed air operator certificate (AOC) operation, otherwise known as non-scheduled operators, and commercial airline operations have initiated fatigue management systems that actively look for and manage fatigue risks. As an industry associate mentioned *"So, in the well run and well manage a AOCs. So, this is where your non-scheduled operators, absolutely, it was part of their considerations… The 'good' companies do have these programs in place, especially in the airlines.".*

It was indicated that there were **specific operations that had cause for concern** for crew fatigue due to the nature of the operations. Firstly, a regulator indicated that long-haul crew may experience fatigue due to **circadian dysrhythmia** from the change in time zones, as it was mentioned *"You've got your long-haul flights, who are constantly on a long-haul roster. So, they're constantly changing time zones."* A union member indicated that low-cost carriers may have cause for concern for crew fatigue due to **operations running minimum crew and maximum duty**. Furthermore, the participant added that the **early sign-on's with maximum sectors** generates cause for concern for crew fatigue, as it was mentioned *"…that was before low-cost carriers, see the low-cost carriers' operators, it's as minimum crew maximum duty kind of thing. So, in the past, you never really had any early sign-on with maximum sectors.".* A non-schedule operator highlighted that the firefighting operations may have cause for concern for crew fatigue due to the extended operating duties crew may be experiencing during on-call firefighting operations. Furthermore, the participant added that crew working in firefighting operations may experience fatigue as result of boredom due to the **prolonged stand-by duties** waiting to be on-call. Lastly, an additional non-scheduled operator indicated that freight or cargo operation may have cause for concern for crew fatigue due to **overnight** and **tight schedule operations**.

Furthermore, the participant added that the operations had to work within the parameters of crew compliment set out by the client further generating cause for concern for crew fatigue.

Outdated regulations and resistance to change emerged as a concern, mainly given that there is limited integration of current science and the active process of amending the current regulations. An industry associate added that they had been working on the fatigue issue and amending the regulations for nearly 25-30 years. A union member further added that ICAO states that the FDP regulations should be more inclusive of science as the participant mentioned *"The current Flight Time Limitations (FTL) are outdated because ICAO stipulates that FTL must be based on scientific evidence. Our existing FTL, were formulated and regulated in the 1970s. Consequently, these regulations predate the latest scientific evidence. Furthermore, they were established before the emergence of low-cost carriers. The operational practices of low-cost carrier operators involve a 'minimum crew, maximum duty' approach. In the past, there was no provision for early sign-on with a consideration for maximum sectors. Our new proposal addresses this issue, as the current flight and duty times inadequately cater to these requirements.".* Thus, by extension, the participants indicated the regulations were generated a long time ago and that operations and science have progressed and adjusted since the generation of the regulations. Thus, the regulations should be adjusted and be inclusive of the latest operational experiences and scientific research.

An industry associate emphasized the challenges posed by the **volatility and unstructured nature of non-scheduled operations**, suggesting that these factors contribute to crew fatigue. In the context of emergency services and firefighting operations, the participant pointed out the unpredictable nature of duties, highlighting instances where crews are called to operate for extended periods with little notice. The participant raised questions about how to address fatigue risks promptly given the urgency associated with such operations. The industry associate elaborated on the differences between scheduled and non-scheduled operations, stating, *"In airlines, it's very structured. In non-scheduled, it's not structured, you can be called to operate for excessive periods of time, at the drop of a hat and at the volatility of your job and the* *volatility of what you do."* The participant cited examples, such as emergency services and firefighting, where operational demands can vary widely, presenting challenges in scheduling adequate rest. The participant also highlighted the diverse nature of the industry, from flying executives to conducting training operations based on weather constraints, underscoring the need for effective fatigue management across different sectors.

4.2.1.1.2 Reasons for why crew fatigue was not a concern within the aviation industry.

Well-managed operations may be a reason for why crew fatigue was not a concern. Participants indicated that crew may be experiencing little to no fatigue risks due to well-run operations and the fatigue management techniques implemented. As an airline and schedule operator mentioned *"Operations as structured are built enforcing FDP regulations, further noting that under pre-covid conditions – crew in operation very rarely flew within 25% to 30% of these limits set. I.e. – average flight hours recorded across crew contingencies was roughly 70% of max totals.".* Although, as another airline and schedule operator acknowledged that managing fatigue can be two-fold for a concern of crew fatigue. The participant mentioned that *"Did we have a lot of fatigue in our company? That was a risk? No, because we had been managing it for quite a while. … Do we have a lot of fatigue in our company at the time? No, not really, because we pretty well managed and we've put in overtime mitigations to try and manage fatigue.".* The well-managed operations experience little to no risk of crew fatigue, however, they're managing them because they understand that it can be a risk to the operation.

An industry associate highlighted that a **focus on revenue generation within operations** may be a cause for why crew fatigue was not a concern. The participant added, *"However, you need to understand that there is a very problematic line between revenue generation – and this comes to the fore with COVID as well revenue generation – and ensuring that you cover the staff or your employees for not getting fatigued having those programs in place.".* While discussing the potential reasons why crew fatigue might not have been a significant concern within the aviation industry, an industry associate pointed out a nuanced challenge. They emphasized the existence of a delicate balance, or what they referred to as a 'problematic line,' between revenue generation and fatigue management. This balance became particularly pronounced in times of crisis such as the COVID-19 pandemic, where maintaining revenue streams while also safeguarding employee well-being became paramount. To elaborate, the associate highlighted the need for robust fatigue management programs to ensure that employees were adequately supported and not overly fatigued, especially given the demanding nature of aviation operations. However, they also noted the inherent tension between prioritizing revenue generation, particularly in highly competitive and financially pressured industries like aviation, and investing resources into comprehensive fatigue management initiatives. In essence, the statement underscored the complexity of the relationship between financial performance and employee welfare. It suggested that while operators may have recognized the importance of addressing crew fatigue, the imperative to maintain profitability could sometimes have overshadowed efforts to implement robust fatigue management strategies. This dynamic warranted further investigation and consideration within the broader context of operational practices.

4.2.1.2 Perceived Contributing Factors to Crew Fatigue Prior to the COVID-19 Pandemic

Figure 10 displays the generated themes and sub-themes from the participants' responses for the interview question: *Prior to the COVID19 pandemic, if you thought that fatigue was a safety concern in your operation / in the stakeholders you represent / regulate, what do you think were the main contributing factors to crew fatigue?* It highlights that the main themes generated were *Person-Related Factors, Environment-Related Factors, Regulation-Related Factors, Roster/Schedule-Related Factors, and Organisation-related factors*. These are unpacked in more detail below.

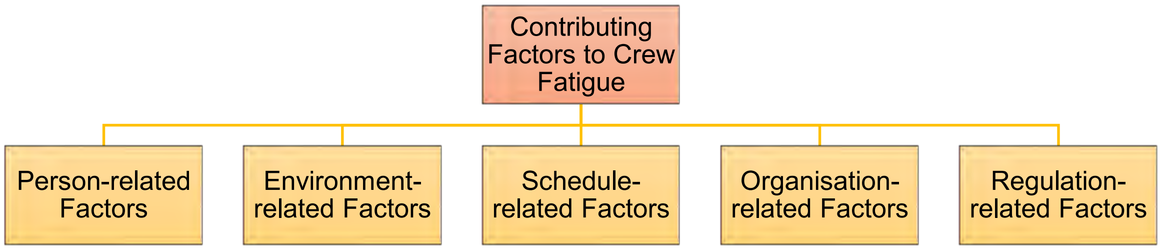

Figure 10: Thematic Map for the Contributing Factors to Crew Fatigue

4.2.1.2.1 Person-related Factors

For the person-related contributing factors to crew fatigue, there were three sub-themes identified: *Economic Induced Stress*, *Limited Understanding of Fatigue*, and *Crew Mentality and Attitude Toward Fatigue*.

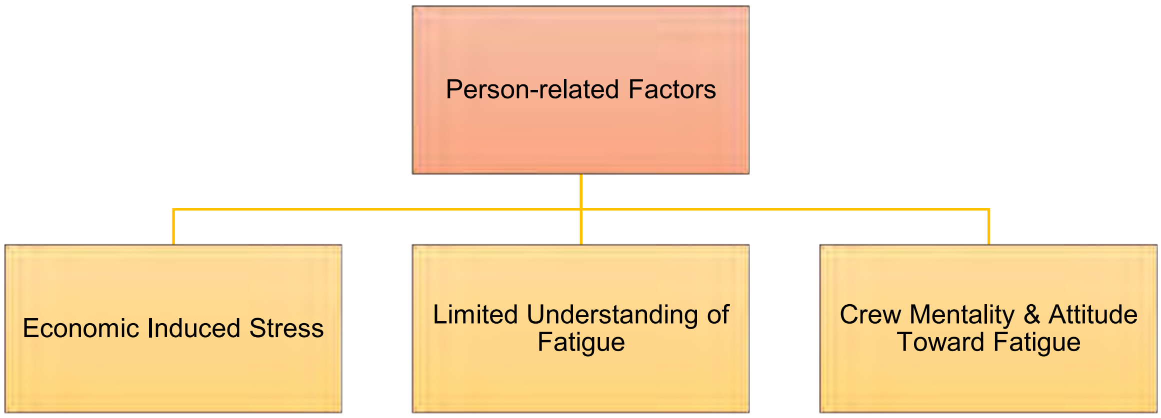

Figure 11: Thematic Map for the Person-Related Contributing Factors to Crew Fatigue

Economic induced stress due to the decrease in career stability and financial security in certain operations at the time of the interview – Late-2020 – may be a person-related contributing factor to crew fatigue. An airline and schedule operator highlighted that stress created by the economic concerns may have impact on crew sleep and ultimately an increase in crew fatigue. An industry associate highlighted crew may be experiencing some form of fatigue but due to concerns surrounding financial issues crew may be hesitant to report that they feel tired or fatigued.

Furthermore, the participant indicated, "*Well, in my company prior to COVID, we had gone into business rescue, so it could've been career stability would have been a main issue, financial security would have been a main issue, and the general economic status of the country would have been an issue but that's only because the stress would have affected the way the crew were sleeping. So, in that regard, I must say even before COVID we were a bit worried about the stress levels of fixing the while crew managing the fatigue."*

An airline and schedule operator highlighted that a **limited understanding of fatigue** as a contributing factor. The participant shed light on a critical aspect of crew fatigue, emphasizing the insufficient understanding prevalent among aviation professionals. The participant explicitly stated, *"Lack of understanding Crew Fatigue (and the scientific principles)."* This insight underscores a gap in knowledge and awareness within the aviation industry, where a limited grasp of scientific principles related to fatigue may contribute to the overall phenomenon.

In exploring the factors contributing to crew fatigue, participants consistently highlighted concerns related to job satisfaction, emphasizing its influence on **crew mentality and attitude toward fatigue**. Multiple support organisations echoed these sentiments, with one industry associate specifically underscoring the impact of job satisfaction on crew fatigue. The participant's observations suggested a correlation between poor job satisfaction and increased crew fatigue during operations. Additionally, insights from an airline and schedule operator revealed that the crew's perception of the operation's destination played a pivotal role in shaping their mentality and attitude toward fatigue. Notably, when the destination was desirable to the crew, they demonstrated a willingness to extend their duties in the event of delays. Conversely, if the destination was not desirable, the crew exhibited reluctance to extend their duties. The participant further elucidated that the crew's perception of the destination influenced layover periods and rest intervals between legs, providing a nuanced understanding of the intricate relationship between job satisfaction, destination preferences, and crew fatigue in operational settings.

4.2.1.2.2 Environment-related Factors

For the environment-related contributing factors to crew fatigue, there were four sub-themes identified: *Weather Conditions, Unfamiliar and Dangerous Environments, Poor Interactions with Air Traffic Control and Passengers and Commuting to Work.*

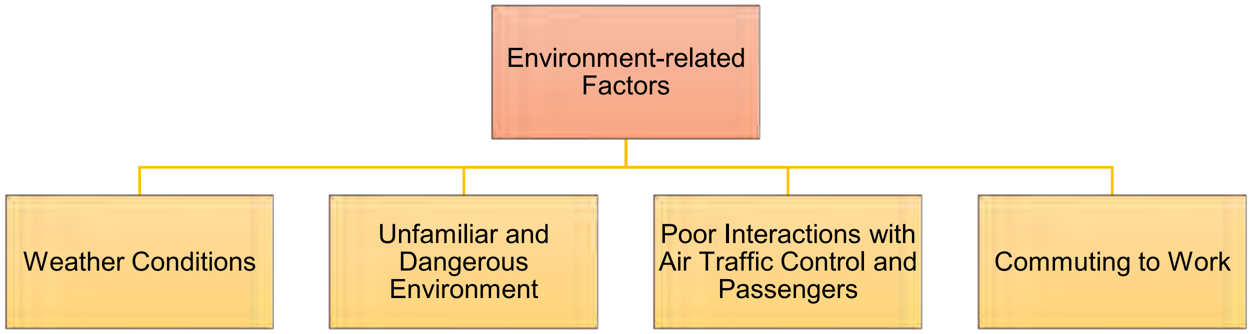

Figure 12: Thematic Map for the Environment-Related Contributing Factors to Crew Fatigue

Weather conditions emerged as a contributory factor to crew fatigue. Specifically, severe rain and thunderstorms often led to operational delays, increasing the crew's workload. This was mainly attributed to the necessity of manually operating the aircraft for extended periods.

Unfamiliar and dangerous operation environments emerged supported by a regulator staff member who reported, *"And then of course, people that are operating in these away from base places. So, I've never been to Baghdad, but a good example, one of my colleagues did an inspection in Baghdad. And she said the most unusual thing was, she had to when she got to the hotel, they did a like a bomb drill. But there was this thing, it was like an armour-type thing she had to put on her. And the thing was so heavy, she could barely lift it, but she had to put this on for shrapnel and stuff. And for her, it was just so unusual. But there are some crews that operate in environments like this. It's not the relaxed environment that we are used to.".* This highlights how some crew members often operate in hostile environments, creating increased stress and anxiety amongst the crew, ultimately resulting in reduced sleep.

Poor Interactions with Air Traffic Control and Passengers were cited as a contributory factor to crew fatigue. A non-schedule operator highlighted that crew experienced increased stress as they would have to think and perform duties on behalf of the foreign air-traffic control which lacked the expertise and most likely had to communicate via a second language. Furthermore, the participant noted that the foreign air traffic control tools/technology that aids with operations did not always work which additionally increased the stress experienced by the crew in operation. The non-scheduled operator provided a first-hand account, stating "*Biggest contributing factor is air traffic control and instrument approach facilities that don't always work. Africa being Africa. [The air traffic control] not necessarily difficult to communicate but more in the sense of not unprofessional but rather inexperienced. You've got to kind of think for them. I guess the inexperience kind of creates a little bit of added stress for the pilots that have to approach.*".

In addition, an airline and schedule operator highlighted that passenger influence may contribute to crew fatigue in an environmental context. Specifically, participants reported instances where operational delays occurred, leading crews to exceed their designated flight and duty schemes. The feedback from participants suggested that crews felt compelled to extend their duty periods to avoid inconveniencing passengers with flight postponements. The airline and schedule operator articulated this complex situation, stating, *"And then, after disembarking 150 passengers, the situation arises where, despite only two minutes having passed, I'm officially off duty. The human element also comes into play as someone might argue, 'I'm ready to go home, and there are 50 more passengers delayed due to a thunderstorm. We're now 30 minutes behind schedule.' These diverse pressures influence the decision to continue the flight.".*

Commuting to work may be an environment-related contributing factor to crew fatigue, as highlighted by an airline and schedule operator. The participant noted, *"You could have a person that's commuted to come to work. And their fatigue levels may already be different when coming to work. And, and that can impact on him saying, Yeah, look, I'm ready to carry on.".* The level of fatigue among crew members can increase based on the strenuous nature of their commute to work.

4.2.1.2.3 Schedule/Roster-related Factors

For the schedule/roster-related contributing factors to crew fatigue, there were two sub-themes identified: *Broad Schedule-related Factors* and *Operations Specific Schedule-Related Factors*. Participants reported that there were three sub-themes identified within broad schedule-related factors. The three sub-themes were *Delays, Incorrect and/or Insufficient Rest Period, and Disruptive Operating Hours.* Participants reported that there were seven sub-themes identified within Operation Specific Scheduled-Related Factors. The seven sub-themes were *Long-haul Operations, Short-haul Operations, Charter Operations, Fire-fighting, Paragliding Operations, Recreational Operations, and Training Operations.*

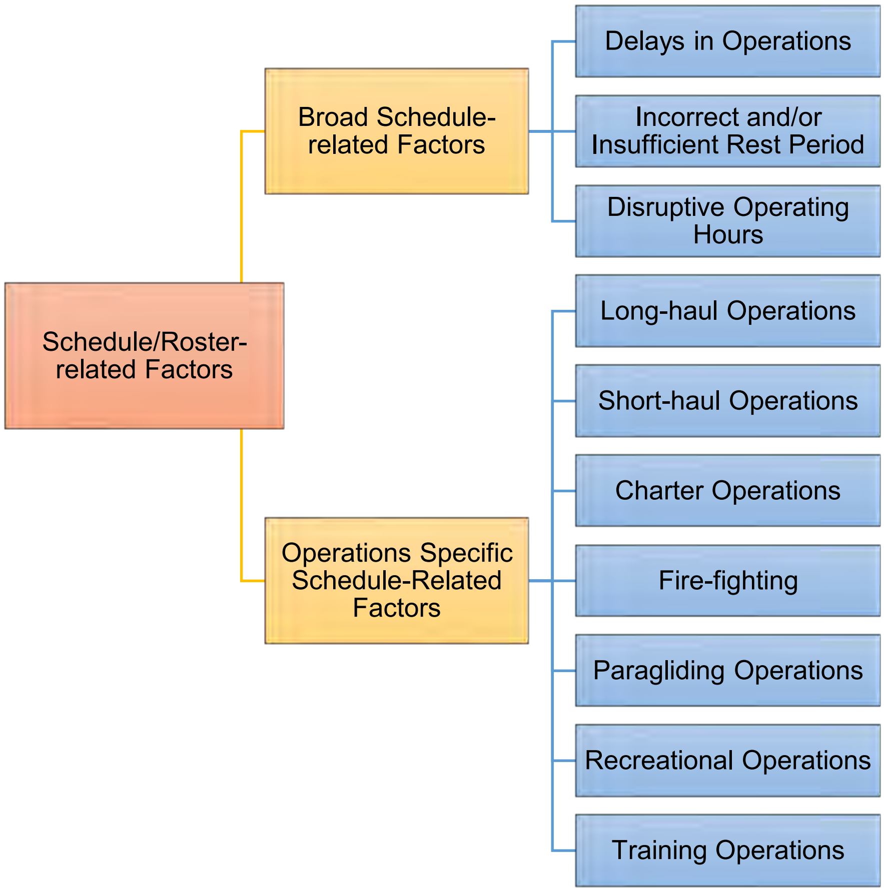

Figure 13: Thematic Map for the Schedule-Related Contributing Factors to Crew Fatigue

4.2.1.2.3.1 Broad Schedule-Related Factors

Delays in operations have emerged as a significant factor contributing to crew fatigue, particularly in the context of schedule and roster management. One notable finding from the participants responses emphasizes the domino effect of delays caused by technical issues. An airline and schedule operator emphasized this point, stating, *“Delays encountered due to technical issues additionally impact on standby requirements, leading to knock-on effects and other related factors.”.* These delays not only result in additional standby requirements but also trigger a cascade of consequences for crew members. Weather-related delays compound this issue, often **extending duty periods beyond prescribed limits**, necessitating standby crews to provide coverage. However, as the situation is far from straightforward, as participants stress. Crew members face multiple pressures urging them to adhere to normal flight operations despite these delays. Notably, the participants responses indicate that operational companies, grappling with the financial burden of accommodating passengers in hotels and rescheduling flights, exert significant influence on crew decision-making. Specifically, the participants highlighted that operational companies often lean on crew members to leverage the captain's discretion in such scenarios. This strategic use of discretion allows companies to avoid shouldering the costs associated with rescheduling flights and providing accommodation for passengers. It is crucial to note that this places an additional burden on the crew, who must collectively agree on the deployment of the captain's discretion.

Incorrect and/or insufficient rest periods may be a schedule/roster-related contributing factor to crew fatigue. Participants emphasized the impact of inadequate layover time on crew members' rest. A union member reported instances where crews were provided with eight hours of layover time, but this period was not solely dedicated to sleep. The time was also consumed by traveling to and from the hotel and preparing for the next flight. This cumulative fatigue poses a significant concern, as the allocated time for rest may not align with the body's natural inclination to rest. The union member provided an insightful perspective: *"You do a night-stop, and you get to the hotel at, let's say, 10 o'clock at night, with a call time of six in the morning. While you technically have eight hours off, it's not a genuine eight-hour sleeping opportunity. After an exciting sector, you still have to change, and the reality is that you won't be able to sleep for a full eight hours. This is why we advocate for longer layover times, depending on whether it's at home or away, to mitigate the risks associated with insufficient rest."* Furthermore, an airline and schedule operator highlighted challenges faced by crews operating short-haul domestic flights, where facilities for proper rest during delays or layovers may be lacking.

Disruptive operating hours and **working within hours of biological rest** emerged as another significant schedule/roster-related factor contributing to crew fatigue. Participants emphasized that a combination of disruptive operating hours and working during hours incongruent with biological rest was a key issue for commercial pilots. An industry associate remarked on the inherent challenges of being a commercial airline pilot: *"It's probably one of the issues you're getting into – disruptive hours. Traveling at different times, working at different times of the evening or night is part of the work, especially on the long-haul side."* Consequently, crews often find themselves needing to sleep or rest during suboptimal times of the day for biological rest, such as operating at night or in the early hours of the morning and attempting to rest during the day.

4.2.1.2.3.2 Operation Specific Scheduled-Related Factors

Long-haul commercial airline operations pose specific concerns related to crew fatigue, potentially influenced by schedule and roster issues. A participant from the regulator noted, *"And then, of course, we've got the obvious one, which is the guys flying overseas, which is the time zone and your circadian rhythms."* Crew members involved in long-haul flights often confront fatigue challenges, such as **jet lag**, as they transition from a familiar time zone to one where their circadian rhythms are unacclimatized.

Short-haul commercial operations raise specific concerns, particularly regarding crew fatigue linked to scheduling and rostering. A participant from the regulator emphasized the challenges faced by crews **operating multiple short-haul legs consecutively** within a day. The participant vividly described the experience, stating, *"Doing a four-sector every day for three days, by the third day you are finished. All you want to do is get home, shut your eyes, and fall asleep. Those short mini sectors are way worse than long sectors. At least with a long sector, you get to sleep five hours in a crew rest."* This first hand insight underscores the intensity and impact of short-haul operations on crew fatigue.

Short-haul commercial operations often involve **early sign-ons and late sign-offs**, leading to reduced rest periods. An industry associate highlighted the operational challenges faced by certain airlines, stating, "*There are airlines that primarily operate during normal daytime hours, but they may extend into early morning and late-night operations. This is especially true for same-day return situations, where business or leisure travellers seek early departures and late returns. The first flights can take off as early as six o'clock or even earlier, and the return flights can arrive back at home bases around 10 o'clock at night or later."* This scheduling dynamic adds strain to crew members' rest schedules.

Participants emphasized the tight scheduling within short-haul commercial airline operations, driven by the competitive nature of the industry. These tightly packed schedules often failed to account for delays, leading to situations where crew members **exceeded their allotted flight and duty periods**. An airline and schedule operator aptly conveyed this challenge, stating, *"Very often, especially on the domestic runs, there might have been a delay. Suddenly, you find that we had a delay. In terms of the flight and duty tables, you probably had just over an hour or even less of leeway to delay. And then suddenly, the reality of life happens. You get to a destination, maybe there's a thunderstorm, and you can't take off; you must delay the take-off. Suddenly, you are now exceeding your flight and duty. If you're going to carry on and come back home, you know, I'm saying so that actually happened a lot more, I think, on the domestic than on the international."* This first-hand account underscores the operational challenges posed by unforeseen delays in short-haul flights.

Firefighting operations often face crew fatigue, with concerns centring on schedule and roster issues. **Extended stand-by times** emerged as a common fatigue-related challenge, affecting rest and leading to boredom. An industry associate succinctly noted, *"You will be on your operation, called up all of a sudden, so you're on standby. You're aware that something might happen. It's fire season. So, you're not getting proper rest; you are under stress. There's psychological stress as well, which fatigues you. Then, all of a sudden, you have to jump into that helicopter or fixed wing plane, entering a challenging, dangerous, visually demanding environment, and you have to perform at 100% or even more due to the nature of the task."*

An industry associate emphasized the **post-operation responsibilities** of the crew, stating, *"And then yeah, and then when you come back, you've got to because it's an emergency craft, you have to ensure that it is prepared for the next call out. So you can't just come like an airline and drop it off and the next crew and the team's sorted out, that aircraft has to be ready, it has to be prepared, the fire stuff that needs to be on has to be there, the slings have to be there, the cleanings, the servicing, everything has to be up to speed, sometimes you're operating at out-of-base places. So, for example, you'll be operating at a farm field, where you actually have to perform the filling of the flame retardants, etc, etc. So, you've got longer hours, more pressure, more jobs that you've got to do, more concerns, more responsibilities, than you would most probably ever find in an aircraft airline environment, and therefore the fatigue is higher, and the demand on you is higher, and the responsibility is possibly higher."* This highlights the extended flight and duty periods faced by firefighting crews.

Charter operations pose specific concerns, particularly related to schedule and roster issues that may contribute to crew fatigue. An industry associate emphasized the **multifaceted nature of crew responsibilities** in charter operations: *"The other contributing factors is you're not considered to be just the pilot; you are the pilot as well as the tour leader as well as various other things. So, when you land at your destination, it's an again, POC, you will be expected to ensure the luggage is on the vehicles you will be injured to ensure that the people get to the reception and possibly any issues that might happen. They're in some of the operations that those are dealt with. So, you're not purely doing a pilot function, you've got very various other responsibilities."* This highlights the additional tasks beyond piloting, underscoring the challenges faced by crew members in charter operations.

The participant emphasized the challenging nature of charter operations crew's **work hours**, stating, *“The other issues that lead to fatigue, or that you might be performing administrative function, safety management functions, dispatch functions, various things, which you don't have in the airlines, and you are basically in charge of doing multiple things. So, you will find that your work hours are more demanding or longer or more challenging. And because of absenteeism and the least number of crew, you often find you on duty more regularly. So that's in your charter environment.”* This multifaceted role, encompassing administrative, safety, and dispatch functions, often leads to longer and more demanding hours, exacerbated by absenteeism and a reduced crew.

Paragliding operations, particularly those involving flipping and training, pose schedule-related challenges that contribute to crew fatigue. An industry associate emphasized the common practice of undertaking extensive **flight take-offs and landings in highly technical conditions** to optimize training. The associate pointed out that such frequent manoeuvres often lead to errors in judgment due to fatigue. Despite concerns being raised by various associations, the participant highlighted the **lack of empirical evidence and regulatory oversight** in this area. The participant stated, *"If I take you to a very different operation, paragliding training, often linked with flipping, involves extensive flights in technical conditions to maximize take-offs and landings. Errors of judgment creep in due to fatigue. Concerns have been raised, but there's no follow-through, no empirical evidence, no studies. It's considered part of the business, both domestically and overseas, as it's not a regulated environment."*

Training operations, with their inherent schedule and roster challenges, may contribute significantly to crew fatigue. An industry associate underscored the distinctions between commercial airline training operations and smaller aircraft operations, such as Private Pilot License (PPL) and Commercial Pilot License (CPL) training. The associate emphasized the less favourable conditions in smaller aircraft training, citing additional expenses on the crew, heightened pre-flight responsibilities, and weather-dependent operations. The participant pointed out that small aircraft training operations come with the added **expectation for revenue generation and maximizing daily training hours**. Moreover, the participant highlighted the **post-flight responsibilities,** mentioning that after signing off from flight operations, the crew is required to prepare theory lectures associated with training operations. The participant added *“And those hours are never registered, the companies don't record them. So, it is an area of serious concern”.* The participant shed light on the challenging nature of small aircraft training, where instructors are pushed to their limits, often experiencing fatigue and making errors. The participant noted the prevalence of accidents in General Aviation (GA) due to instructor fatigue and the **high turnover of**

instructors looking to accumulate hours for career advancement. This detailed insight reinforces the concern about the overlooked challenges in the training sector, where instructors serve as a conduit for building hours before moving up the aviation career ladder.

Recreational operations, with specific concerns possibly contributing to crew fatigue, involve training that typically occurs **outside conventional working hours**, as noted by an industry associate: *"Recreational environment, instruction happens generally when the clients who have to pay for their training are generally involved in other jobs. So when does it happen? After hours, and on weekends, so now you are at the mercy of weather yet again, and even less hours to complete the training that is required."* The participant further emphasizes that instructors often **juggle their recreational roles with regular nine-to-five jobs**, amplifying the fatigue risks. The seasonal aspect also plays a role, with **time constraints during the winter season** intensifying the challenges faced by recreational training operators: *"Then your winter periods, it's even worse because you've got less hours of the day to push those levels."*

Moreover, due to time constraints, these operators encounter challenges such as **reduced breaks**, eating on the go, and **insufficient sleep**: *"Then you link onto it that you are generally the CFI in charge of your own school or they one- or two-men bands. So, there is no oversight system that is in place, to monitor fatigue, to check fatigue, to say hey, listen, it looks like you are tiring. There are also no scheduled breaks. So, you eat on the go you your operator operate on the go. So here are areas where you if you don't have a personal regime, you generally end up not eating properly, not sleeping properly, pushing the hours and this, you know, it's a recipe for serious fatigue."*

4.2.1.2.4 Organisation-related Factors

For the organisation-related contributing factors to crew fatigue, there were two sub-themes identified: *Inadequate Crew and Lack of a Just Culture.*

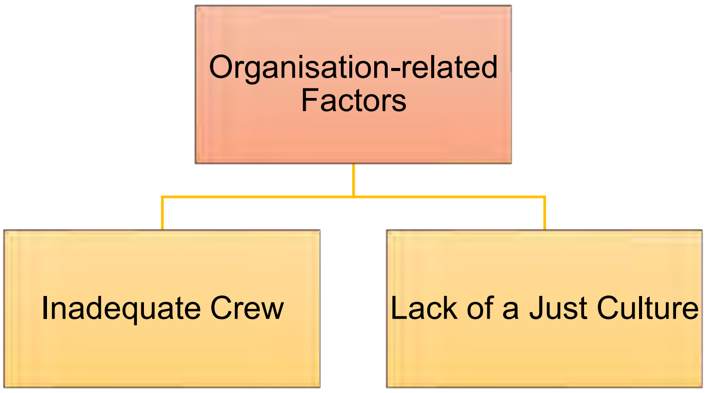

Figure 14: Thematic Map for the Organisation-Related Contributing Factors to Crew Fatigue

A regulator highlighted that the operators were employing an **inadequate crew** to cut costs, which may be an organisation-related contributing factor to crew fatigue. The participant added, *"Operators needing to cost cut, therefore employing minimum pilots, and most times this was fewer than is required to furnish their expanding operations. This resulted in operators using the current FDP to its maximum limits in every way they could find to accommodate their current schedules."* The participant notes that, consequently, operators utilize their current FDP to its maximum limits to accommodate their schedules.

Participants in the study drew attention to the critical issue of the **lack of a just culture** as a significant organisation-related factor contributing to crew fatigue in the aviation industry. From an operational standpoint, an industry associate underscored the prevailing perspective among operators and owners, emphasizing, *"From the operator's perspective, from the owner's perspective, it was, 'Well, you're getting paid for this job, we expect you to do it. We know you might be tired, etc., but it's a job; you must get on with it.'"* This viewpoint highlights a fundamental expectation from operators for crew members to fulfil their duties, even when faced with challenging and potentially fatiguing conditions.

Moreover, considering career stability, insights from an airline and schedule operator shed light on the challenges faced by crew members. The operator pointed out, *"You also find that because jobs are difficult to come by and you're under pressure, that often the staff can feel that they can speak to the captain or the operation executive for the management to say 'listen, I'm tired or I feel that I'm not up to speed' because* *they fear of losing their jobs and the reprisals around that. So, it's a serious problem in the industry."* This revelation underscores the complex interplay between the fear of job insecurity and the reluctance of crew members to report fatigue-related challenges to higher-ups, contributing to a lack of openness and transparency within the organisational culture. Furthermore, an airline and schedule operator pointed out a concerning aspect, noting, *"Certain parties encouraging irresponsible fatigue reporting."* This aspect introduces an additional layer to the lack of a just culture, suggesting that external influences may be exacerbating the issue by promoting a culture that discourages responsible reporting of fatigue, potentially further compromising safety measures.

4.2.1.2.5 Regulation-related Factors

For the regulation-related contributing factors to crew fatigue, there were two sub-themes identified*: Perceived Concerns with Regulations, and Lack of Standardized Sign-on Times.*

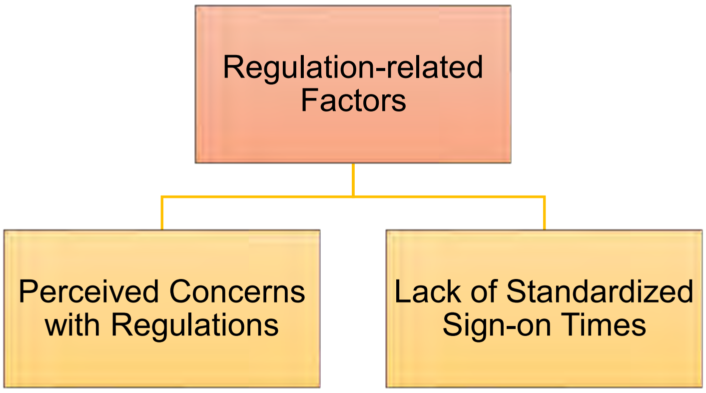

Figure 15: Thematic Map for the Regulation-Related Contributing Factors to Crew Fatigue

Participants highlighted that perceived concerns with regulations were a regulation-related factor contributing to crew fatigue. Participants indicated that lack of local night definition, outdated regulation, and neglecting current science within the regulations were perceived concerns with the regulations. **The lack of local night definition** within the regulations may be regulation-related contributing factor to crew fatigue. An airline and schedule operator highlighted that the current local night definition does not take into consideration sufficient sleep opportunity.

Outdated regulations, reported by participants as a contributing factor to crew fatigue, may stem from obsolete flight and duty period schemes that require amendments. An airline and schedule operator pointed out, *"Aging regulation not in line with current science,"* highlighting the inconsistency between these regulations and the contemporary understanding of crew fatigue.

A potential factor contributing to crew fatigue is a **neglect of current science** within the regulations. According to an industry associate, there is minimal empirical scientific research on the consequences of crew fatigue, highlighting a gap in understanding: "*The other problem is, other than Service Level Agreement (SLA), there haven't been any empirical studies that unequivocally indicate the consequences of not adhering to certain practices. Without such studies, the impact of actions becomes apparent only through absenteeism and health-related issues, leading to operational crew members taking sick leave more frequently."*

An industry associate emphasized a crucial factor influencing crew fatigue: **the lack of standardized sign-on times**. Notably, variations exist among operators in determining when the clock starts for crew members—some only consider work hours from the moment personnel enter the building and prepare for deployment. Conversely, reputable companies adopt a more comprehensive approach by factoring in travel time within the duty period or providing transportation, thereby mitigating mental strain on the crew. The associate succinctly captured the essence of the issue, questioning, *"When do you sign on, when do you sign off?"* The lack of a defined standard and the incomplete application of regulations regarding fatigue become apparent in this variability. Notably, reputable companies prioritize crew well-being by including travel time in duty periods, recognizing the potential fatigue incurred during journeys. Some organisations go the extra mile by offering transport, alleviating mental pressure on staff during active duty, whether in roles such as a pilot, cabin crew, sling operator, paramedic, or any other capacity. These considerations highlight the intricate nature of sign-on practices and their profound impact on crew well-being.

4.2.1.3 Perceived Change in Awareness Around Crew Fatigue (Last 5 Years) Prior to the COVID-19 Pandemic

Figure 16 displays the generated themes and sub-themes from the participants' responses for the interview question: *Do you think that awareness of crew fatigue has changed over the last 5 years in the industry in general and if so, why?* In examining the perceived change in awareness regarding crew fatigue within the industry over the last five years, eight overarching themes emerged. These themes were categorized into either positive or negative responses. Specifically, five positive themes and three negative themes were identified. The positive themes contributing to the perceived change in awareness encompassed the following aspects: *Drive for Fatigue Management, Stakeholder Engagement, Training and Education, Improved Reporting, and Drive for Regulation Adjustments*. On the contrary, the negative themes associated with the change in awareness included *Lagging Behind Other Countries' Regulations and Operational Development, Non-Scheduled Operations Still a Problem, and Responses to Reports*.

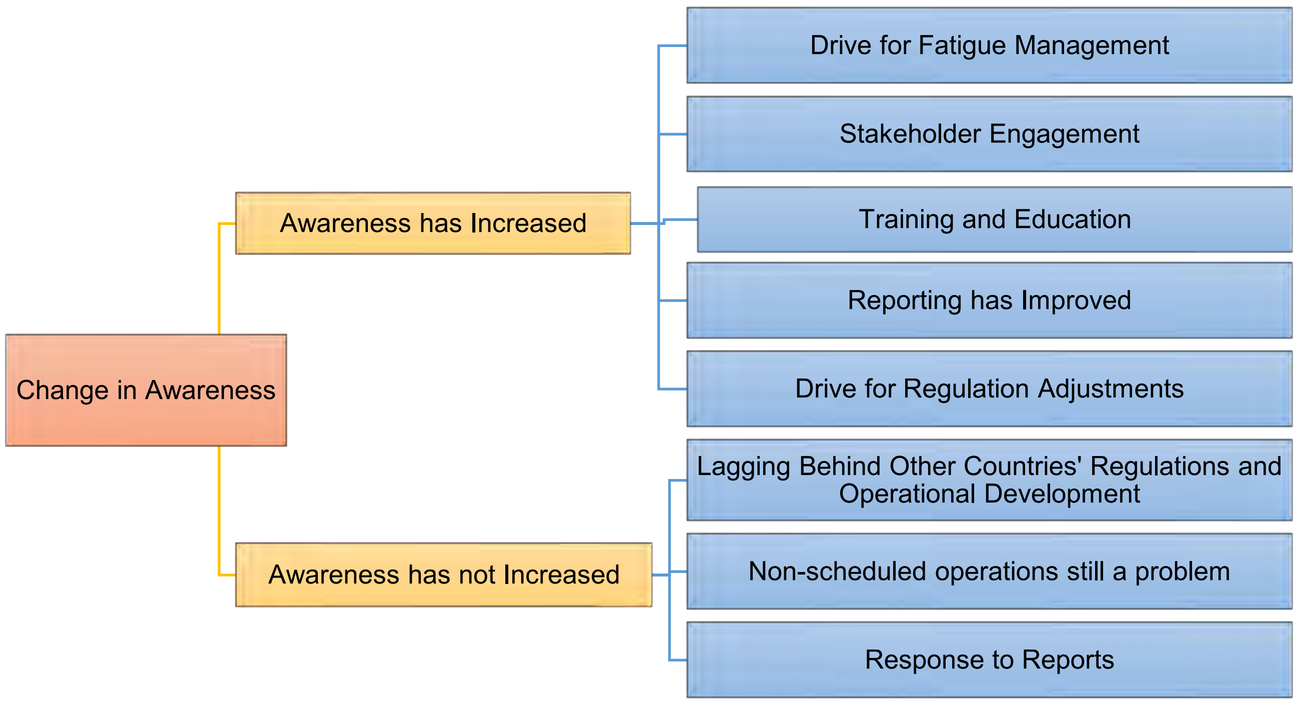

Figure 16: Thematic Map for the Change in Awareness (Last 5 Years)

4.2.1.3.1.1 Why Awareness has Increased.

Participants highlighted that a **drive for fatigue management** in recent years has increased awareness of fatigue. According to the union representative, *"And I think, as I mentioned worldwide, there's an increased awareness of fatigue, particularly management of fatigue, and the science has definitely come to the foreground."* In addition, it was indicated that ICAO's report in 2015 played a significant role in the increased drive for fatigue management. However, a non-scheduled operator pointed out that some organisations in non-scheduled operations had already embraced and enforced fatigue risk management before the ICAO report. According to the participant, *"Previous experience before ICAO actually got hold of fatigue risk management... your oil and gas producing companies, aircraft or aerial support side... want to see your fatigue risk management system. The same with humanitarian organisations like the United Nations World Food Program, the Red Cross Doctors Without Borders, BARS is the basic aviation risk standards. That also became a requirement from them back in 2015, if I'm not mistaken, so there's a little bit ahead of time before ICAO actually published something with regards to a FRMS."* This highlights that certain sectors were proactive in addressing fatigue risk even before the ICAO's involvement. In addition, the participant notes that the rostering system technology has improved, however, the costs of the technology to set-up was high.

Awareness had increased due to an increase in **stakeholder engagement.** An airline and schedule operator highlighted that a drive from international organisations like ICAO and IATA for fatigue management has had a positive change on awareness of crew fatigue. An industry associate reported, *"I don't think that the management of crew fatigue and the possibility of crew fatigue has changed radically. It has moved in awareness slightly due to it coming up on Civil Aviation Regulations Committee (CARCOM) due to a couple of incidents that have occurred due to the awareness that Mayday South Africa has been putting into it. And from the Designated Aviation Medical Examiners (DAME), have they questioned you about it when you do your medicals? Are you feeling tired? Are you feeling fatigued? Do you need any help with it? So, some of the questions that seem to be coming through from requirements by the Civil Aviation Authority,"* highlighting the various channels of communication generating awareness. In addition, an airline and schedule operator noted that awareness had increased due to closer working relationships through unions. Furthermore, a non-scheduled operator noted that in non-scheduled operations there were close working relationships with the operators, clients, and the regulator in the management of fatigue.

Awareness of crew fatigue had increased due to an increase in **training and education** surrounding fatigue. Participants emphasized the growing educational initiatives within certain companies, with training programs specifically designed to enlighten individuals about the risks associated with crew fatigue. In the words of a representative from an airline and schedule operator, *"We've upped the education in our company. So, we added crew fatigue training, discussing aspects such as how you sleep, what happens during sleep, how to sleep better, and what causes sleep issues. At [Company Name], in the past year, we focused on topics like sleep apnea, and before that, we covered insomnia, women's sleep patterns, and a general discussion on how medications can affect sleep. It's an ongoing process. Through continuous education, people are increasingly talking about it."* An industry associate reported that crew perception of fatigue had improved with the crew understanding the science behind it and therefore the way they approach fatigue. Furthermore, concerns have been raised from crew on how and where to fix their ability to perform their duties.

An increase in fatigue reports has led to heightened awareness surrounding crew fatigue. According to an airline and schedule operator, the reporting mechanism implemented operates under just culture and confidential principles. The operator stated, *"And it's definitely reflected in the last five years in the quality of the fatigue reports we've been getting. We've been getting better information, which is showing better awareness of what factors are causing the fatigue. Instead of just saying 'I was tired,' crew would write: 'It was a long trip to the hotel took longer than normal. There was noise near the hotel, which affected my sleep. I couldn't get my eight hours of sleep; I only got six hours, normally asleep.' This also provides much better information."* Furthermore, participants emphasized that the improved quality of the reports signifies an enhanced awareness of crew fatigue among the crew. In addition, participants highlighted that the technology behind reporting fatigue had improved.

However, as a non-schedule operator indicates, crew can have hesitancy in the reporting system, and creating awareness around the availability and utilization of the fatigue reporting system is crucial in tackling the issue. The participant shared their experience, stating, *“We had an issue specifically on our oil and gas contracts which popped up — they reduced the aircraft to one aircraft, kept the same crew, but they kept the same schedule. So, these guys were literally running on the limit for every single time. And that was one thing that came up and we eventually took up with the client. We asked the guys, please file a fatigue report, so we can actually take evidence to the client to say, 'Listen, this is not going to work.' The problem was that the crew didn't have faith in the system. They believed that they were not going to file any reports because we were just going to penalize them for it.”*

The increased drive for changes in flight and duty regulations around crew fatigue has heightened awareness and interest in addressing crew fatigue issues. An industry associate emphasized this, stating, *"Um, I think certainly the work that we've done over the last five years, particularly in the industry, and the request from ALPA to amend the Flight and Duty Regulations has certainly highlighted the issues of fatigue and some of the science that has become involved*." Furthermore, an airline and schedule operator noted, *"Fatigue awareness has definitely improved in the industry over the last 5 years. The International Regulatory Bodies have been instrumental in creating awareness and driving legislation around Fatigue Risk and Management."* Participants indicated that ongoing communication between various stakeholders within the industry is focused on amending the current flight and duty regulations to address these concerns. A regulator highlighted that the regulatory body – the CAA – had previously worked on a baseline regulation adjustment. In addition, a regulator reported that it is important that regulations allow for a non-punitive platform unless gross negligence is proven. Furthermore, a non-schedule operator emphasized the rigorous audit process they undergo, stating, *"And every single audit we got from all the oil and gas to give you an idea, we get audited probably like 20 to 30 times a year different client, plus CAA plus worldwide operations. So, we get audited a lot, and the same question pops up. Where's your key risk management program?"* This underscores the significance of having a fatigue risk management strategy in place for non-scheduled operations as required by the regulatory body and proficient clients.

4.2.1.3.1.2 Why Awareness has not Increased.

Awareness had not changed due to **South Africa being behind times** in relation to fatigue and fatigue management when compared to other countries. In addition, participants indicated that fatigue was not in the foreground of policy development when compared to countries such as Australia, the United States of America, and European countries. According to an industry associate, *"we definitely don't have it closer to the forefront of thinking and incorporated into our policy developments or our operational developments as you would find in Europe or in America, for example."* A participant from the regulator highlighted that adjustments to regulations have been developed, however, the adjustments were not agreed upon by the industry. The participant added that some of the mentioned countries' fatigue policy development stems across a wide array of transport sectors displaying their commitment and understanding that fatigue management plays an important role in risk mitigation which contrasts to South Africa. Shedding light on this disparity, the participant added, *"Yeah, look, we are behind on a bit of things because one of the things we picked up on doing these, these workgroups is international workgroups, you look at I think it was Australia to do your driver's license is actually a short thing on fatigue in the in the driver's license exams. And I think the same goes for Europe, they they're very strict just on truck drivers, for instance, every five hours, pulling it off onto the side of the road. So, a lot of this stuff is instilled in day-to-day activities. I don't think South Africa is there yet. I mean our truck drivers drive like 20 hours and make accidents because they are tired. You know, they get really fatigued, they haven't slept in days. Yeah.".*

An industry associate highlighted that awareness had not changed as fatigue remained a **significant issue within non-scheduled operations**. The participant emphasized, *"And definitely not down in the lower echelons, the lower echelons, it continues to be an absolute problem."* The participant pointed out a prevalent ideology within emergency medical services (EMS) and firefighting operations, where operators and owners of companies perceive that having numerous days off implies sufficient rest, thereby minimizing the impact of fatigue. The industry associate argued, *"If we average it out over the month, then you shouldn't be fatigued, you shouldn't be, you know, under pressure. And I don't believe that that holds true."* The participant expressed concern that this perspective overlooks the nuanced nature of fatigue, stating, *"If you really look at these things, fatigue doesn't work that way, not in my opinion, and not in my knowledge of it. So, I think there's not enough checking over it and notice of it."*

A non-schedule operator highlighted that the **responses to the reports** suggest that awareness has not changed as the participant adds that nothing gets done after filing report. The participant added, *"I filed a fatigue report, and the part that got my blood pressure boiling, was that I received feedback from the safety manager and said that, yeah, it's legal. So, I'm like that's not the point. I physically sit in the airplane. I'm flicking switches. And the captain says to me, what are you doing? I've got no clue what I'm doing. I don't know, let's just start over again, this is at half past ten, eleven o'clock at night. And you've now got to do another leg to go and fly. So, you've exhausted past anything.".* The participant drew attention to their experience of airline operations and crew being worked very hard for short period of time, however, only the average hours in a calendar month was being observed. Regardless, the participant suggested that the operators processed and responded that what was reported was legal rather than understanding that the crew was fatigued. The participant continued to state that crew had to build a case after filing a report for some sort of response.

4.2.2 Perceptions Surrounding the Current Flight and Duty Period Regulations

Below, some relevant answers to research question 2, '*What are their thoughts on current flight and duty period regulations and possible recommendations to amending the flight and duty period regulations?'.*

4.2.2.1 Perceptions of the Current FDP Regulations

In Figure 17, themes and sub-themes derived from participant responses to the interview question regarding the South African Flight and Duty Period regulations are presented. Eight overarching themes – reflecting a negative perception on the current flight and duty period regulations – emerged among the blunt-end stakeholders' perspectives on these regulations: *Rest Periods, Scheduling, Outdated Regulations & Poor Regulatory Support, Lack of Stakeholder Engagement, Lack of Specificity in Regulations Catering to Different Operational Scenarios, Lack of Current Science,* and

Intercountry Operations and the Law. While one positive sentiment was expressed, the prevailing themes reflected negative perceptions on the current flight and duty period regulations. The one positive theme emerged among the blunt-end stakeholders' perspectives on the regulations was: *Regulations are Performing*.

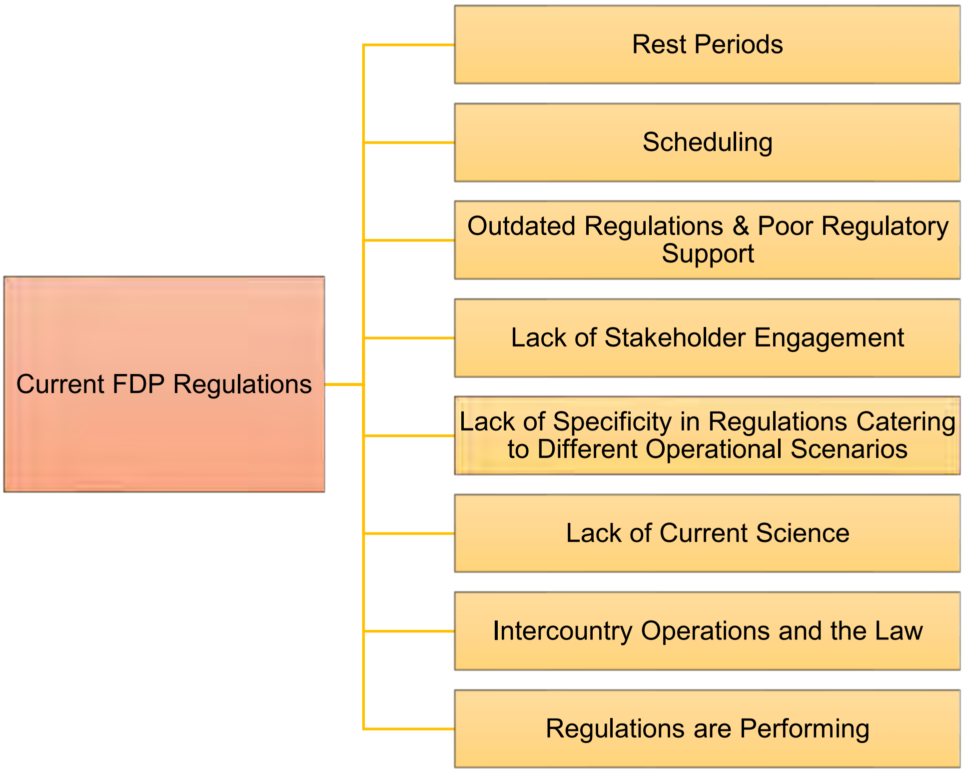

Figure 17: Thematic Map for the blunt-end stakeholders' thoughts on current Flight and Duty Period Regulations

4.2.2.1.1 Rest Periods

It was reported that **rest periods** were a perceived concern within current regulations. An airline and schedule operator expressed their concerns, stating, *"Yeah, so the minimum time off you get between flights is eight hours, that is from the time you finish until the time you start again. It's just not enough time for somebody to get home, wind down, have a good eight hours of sleep opportunity, and then head back to work. That's the first one. So, the rest time is not long enough."* This perception contrasts with what the regulations state, emphasizing that *"each flight duty period, as well as flight watch and home reserve, shall be preceded by a rest period of at least – (i) nine consecutive hours, including a local night."* Furthermore, the participant continued by stating, *"The second one is the definition of a local night is wrong. So, it doesn't protect* *the sleep opportunity sufficiently. So, they call the local nights any eight hours between nine and seven where industry norm is a local on any items between 10 o'clock at night and 8 o'clock in the morning to try to take that opportunity. It's too early. It's the early wake up risk. That's a problem. Just to highlight what I mean. When somebody gets up early, the manager likes to say well just tell him to go to bed earlier. But you know, you can't because you can't just fall asleep earlier. So, the risk is really wake-up well the risk is the fact somebody can fall asleep early enough. So, they are locked in on a cumulative fatigue."* The participant adds that the industry norm defines the local night as any eight hours between nine o'clock at night and seven o'clock in the morning, emphasizing that it is not as simple as going to bed earlier and waking up earlier.

4.2.2.1.2 Scheduling

Concerns have been raised about perceived scheduling practices within current aviation regulations. Participants emphasize the lack of clarity in the existing rules, citing instances where operations manipulate schedules for financial gains. An airline and schedule operator expressed dissatisfaction with the current **maximum monthly flight hours** for pilots, stating, *"He can do 120 hours in a month. That's unacceptable in a 28-day cycle. I'd like to see closer to 90, but the industry norm is about 100."* The participant suggests revising the norm to 100 hours and proposes considering daily limits, pointing out potential issues with the current system: *"For two pilots, you can fly up to 14 hours on a one-sector day, which I think is too long. There should be a 24-hour limit as well."* Furthermore, the participant disagrees with the industry norm allowing seven consecutive working days, advocating for a reduction due to potential fatigue from early starts and late finishes. In addition, another airline and schedule operator emphasized the need for flight and duty hours to conform to labour regulations, advocating for a weekly cap of 45 hours. The participant expressed, *"I think that flight and duty hours should be combined and align with the labour act, and be capped at 45 hours a week, rather than defining a 'flight' cap at 40 hours a week, which leaves duty hours exposed."*

Participants highlighted concerns about **sign-on and sign-off times** within the current regulations. An industry associate highlighted the challenges of early morning sign-on times, stating, *"Early morning start-ups, like a 6:00 or 5:30 flight, require waking up around 2:30-3:00 in the morning to get going."* The participant indicated that these early morning sign-on times encroaches on the natural rest period of the crew. Likewise, a union member emphasizes the cumulative impact of concurrent early sign-ons or late sign-offs on a crews' overall sleep and rest. Highlighting the issue, the member states, *"The most important thing we need regulation on is the number of days that you can have early sign-on or late sign-off. For instance, if guys are flying five early sign-ons, starting at five o'clock in the morning and signing off at four o'clock in the afternoon, they still have to go home and wake up at three o'clock in the morning for the next five days. This repetitive schedule can lead to fatigue. We need limitations on the consecutive days of early sign-ons or late sign-offs because it significantly affects your sleep, even if you have enough available rest. The period in which crew can utilize their rest is often outside the biological rest period."* This underscores the need for regulations to address the challenges faced by the crew.

In addressing concerns about **standby times**, a regulator emphasized, *"Especially the one regarding standby times in our technical standard, where it actually allows you to be on standby for the whole day or something like that."* The participant reported issues with crew members being placed on standby for extended periods, potentially an entire day.

A non-schedule operator highlighted that in the non-scheduled operations depending on the context of operation and standby, **flight and duty period schemes should be trialled and tested**. The participant continued to state that when operations are running normally crew will be rostered for six weeks on and two weeks off, however, if the operations are limited during this time rosters should be able to adjust to lengthen the six weeks on to eight weeks on. Although, if operations are busy during this period, rosters should be able to adjust to reduce from six weeks on to four weeks on.

4.2.2.1.3 Outdated Regulations & Poor Regulatory Support

Another emergent theme was that the regulations were outdated and that amendment discussions had been ongoing. However, as the participants mentioned, nothing had come to fruition regarding the amendments. In addition, an industry associate highlighted concerns, stating, *"And our pilots are pretty good. I think they have managed to ward off possible accidents, etc. Due to probably good training, that when they have been fatigued, they've managed to snap out of it or attend to the dilemma at hand. So, I don't think we've seen as many cases that they could actually be, and it's not measured anyway. So, in my personal opinion, I don't think the regulations are up to speed,"* emphasizing the need for regulatory updates, particularly in addressing fatigue issues. Moreover, an airline and schedule operator highlighted that the way regulations dealt with circadian disruptions, through the unacclimatized table, is outdate and development needs to occur to put these mitigations in place.

Furthermore, a non-schedule operator highlighted that for non-scheduled operations, the regulations allow for deviation away from the prescribed limits within the regulations – part 91, part 121, Part 135, or part 137 – although, the operation had to develop a fatigue risk management strategy to accommodate for the deviation. According to the operator, *"it's lacking. There's no guidance material, first of all available, you know, with the regulation stating that you can deviate from the requirements of FDP, from all parts from Part 135, 121, 137, 91, etc. And they refer to a fatigue risk management system, but there's no guidance material on how you need to establish FRMS. So, the current FDP regulations are severely outdated. If you look at if you compare it to the rest of the world, IASA or you go to FNA, we are severely lacking in terms of our FDP schemes."* This underscores the need for clearer guidelines and updates in the regulations pertaining to fatigue risk management strategies.

4.2.2.1.4 Lack of Stakeholder Engagement

Participants expressed concerns related to stakeholder engagement within the current flight and duty regulations. The overarching theme identified was a perceived lack of involvement of key stakeholders in the regulatory processes. Participants highlighted that the current regulations exhibit minimal engagement with relevant stakeholders. Specifically, the amendments previously discussed were cited as an example where stakeholder engagement broke down. The participants pointed out that the regulatory body responsible for making adjustments to the flight and duty period had not directly experienced the challenges associated with these amendments. This lack of first-hand experience, as emphasized by an airline and scheduled operator, contributed to the perception that the regulatory decision-making process might benefit from increased stakeholder engagement. The airline and scheduled operator expressed this concern by stating, "*actually the authority when they made this, what did they base it on? And have they experienced it? You know, and that is what I believe the people who are going to be involved in setting up flight and duties they need to fly those routes. They need to experience those routes and feel what it is. Because, you know, you can be at home, on your duty free days, and you be busy at the house to do whatever now you suddenly go to work in the evening."* The disconnect between those crafting the regulations and those affected by them was a recurring concern raised by participants, underscoring the need for a more inclusive approach in regulatory decision-making.

4.2.2.1.5 Lack of Specificity in Regulations Catering to Different Operational Scenarios

It was reported that regulations not targeting different operations was a perceived concern within current regulations. Participants highlighted that the regulations were not targeted to specific operations but rather a one-size-fits-all approach. An industry associate expressed this sentiment, stating, *""I think they are missing some clarity; I do not think they are correctly targeted. I think it's a one shoe fits all approach that has been put in there because there was never really any concern on that."* Moreover, participants highlighted that there was no delineation between operations. An industry associate reported, *"Yeah, look, I think, if I talked to a lot of the airlines, a lot of them don't see significant problems with some of the regulations. I think there are probably areas that definitely need attention. And I think that's what we've highlighted, and probably needs a review."* This perspective suggests that while airline operators may not perceive significant issues with the regulations overall, there are specific areas requiring focused attention and potential revision.

4.2.2.1.6 Lack of Current Science

It was reported that a lack of current science within regulation was a perceived concern within current regulations. Participants highlighted that there had been limited empirical research and evidence within the current flight and duty regulations. In addition, a regulator emphasized that there was a lack of scientists within the aviation industry and regulatory body, stating*, "But of course, because there's a lot of science* *behind it, then we don't have a lot of scientists in aviation."* Furthermore, an airline and scheduled operator highlighted that there was limited ability to utilize science to modify and vary the prescriptive limits of flight and duty period regulations. According to the operator, *"The ability to utilise science to modify and vary prescriptive limits is lacking."* This underscores the challenges faced in adapting scientific advancements to current regulatory constraints.

4.2.2.1.7 Intercountry Operations and the Law

A non-schedule operator raised concerns about the challenges faced within non-scheduled operations, particularly the perceived complexity of adhering to multiple aviation laws. The participant emphasized the unique working conditions in non-schedule operations that spanned various countries, leading to difficulties for the crew in navigating different sets of regulations. The participant explained, *"So, for our operations, now, here comes the small, small problem. So, we have got four different AFCs we operate on. South African law, then we've got Gabonese law, Rag Ops, Ivory Coast Law, and we have got Mozambique law...".* The participant further pointed out the lack of information on transitioning crew between these laws, prompting the non-schedule operations to err on the side of caution and adhere to the stricter laws when faced with such uncertainties.

4.2.2.1.8 Regulations are Performing.

Conversely, it was reported that current regulations were performing well. Participants expressed satisfaction, stating that the current flight and duty period regulations were fit for the purpose. An industry associate emphasized, *"It conforms to international standards; it has been working. I am not aware of any major challenges to the current Flight and Duty regulations,"* highlighting the alignment of South Africa's regulations with international standards.

4.2.2.2 Recommended Amendments to the Current FDP Regulations

Figure 18 displays the generated themes and sub-themes from the participants' responses for the interview question: *Based on your answer, what recommendations would you make around amending the current FDP regulations in South Africa in relation to your operation / in the stakeholders you represent / regulate?* With respect to the blunt-end stakeholders' recommendations on current flight and duty period regulations, there were six broad themes identified, some of which were positive, while others were negative responses. The six broad themes identified for recommendations on current flight and duty period regulations were *Rest Periods & Rest Facilities, Scheduling, Stakeholder Engagement, Fatigue Risk Management Strategies, Crew Health and Safety, and Maintain Current Regulations*.

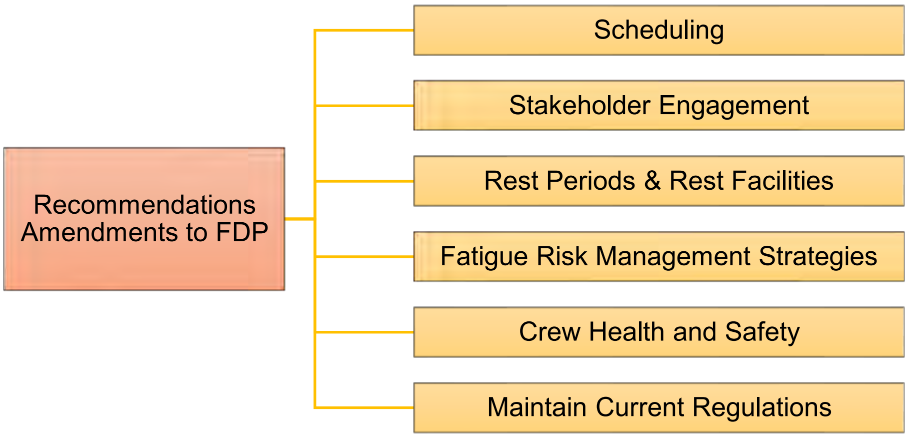

Figure 18: Thematic Map for the Recommended Amendments to the current Flight and Duty Period Regulations

4.2.2.2.1 Scheduling

Recommendations were highlighted for scheduling in the current flight and duty periods. An airline and schedule operator recommended amendments to **reduce the maximum number of hours** within a 28-day cycle. The participant recommended that the maximum number of hours be reduced from 120 hours to 100 hours per a 28-day cycle.

Participants emphasized the necessity for changes in **sign-on and sign-off times**. A union member explained, "*Well, that was our proposal to have it amended. And it's Yeah, that was done four years ago. Well, we want regulation early sign-on, and late sign-off."* The participant's proposal, made four years ago, aimed at implementing regulations for early sign-on and late sign-off. The participant highlighted the impact of the current system on sleep patterns and the resulting cumulative fatigue: *"Now, let's say you've got an early sign-on, let's call it six in the morning. So, you probably* *have to wake up at four o'clock. Okay, so that the first night you're not getting a good sleep. Now you go work, you fly, let's say you sign up at four o'clock in the afternoon. And then the next day, you get a decent night. And the next one is a late sign-off. So, you've got day one was not a good sleep, Day two you maybe got some sleep, and day three was not a good sleep. And the longer these carry on the result is cumulative fatigue, which we are seeing."* Despite the highlighted concerns, specific amendments were not suggested by the participants.

An airline and schedule operator, shed light on regulatory considerations related to **duty stipulations before and after flight operations**. The participant emphasized the need for greater inclusivity in regulations, particularly concerning aspects such as documentation review, briefing requirements, and pre/post-flight activities. The participant suggested a tangible approach to address these concerns by proposing specific time allocations. According to the participant, a well-defined timeframe of 45 minutes prior to chocks off and 30 minutes after chocks on should be designated for duty stipulations. These timeframes encompass crucial activities associated with flight operations, ensuring that regulatory frameworks adequately account for the various tasks involved in the pre- and post-flight phases.

Participants highlighted that **stand-by times** – also known as home reserve or flight watch – required amendments within the current flight and duty period regulations. Participants emphasized the need for clearer regulations in this regard, citing instances where operators exploited vagueness for their own advantage. The recommended amendments include establishing a maximum allowable duration for crew members to be on stand-by. If this prescribed time is exceeded, operators would be precluded from calling on the affected crew. Additionally, an airline and schedule operator, advocated for empowering authorities to approve responsible deviations from prescriptive limits.

4.2.2.2.2 Rest Periods & Rest Facilities

An airline and schedule operator recommended that the **minimum amount rest between flight operations** be extended from 10 hours of rest to 12 hours of rest. In addition, the participant highlighted that the **definition of local night** should be amended. The participant suggested that the local night be extended later, as the participant notes that morning sign-on times can be too early, and the crew cannot simply go to bed earlier to accommodate the offset. An airline and schedule operator reported that long-haul operations lacked **adequate rest facilities** – one aircraft bunk rather than two bunks – for adequate rest for crew between rotations and required amendments. The participant continued by stating that although operators provide relief crew for the long-haul operation it lacked the facilities to cater for adequate rest. Additionally, the participant reported that operations to Lagos required crew to have night stop due to inadequate rest facilities which placed additional costs on operation – such as hotel costs, transport, etc. In addition, the participant noted on the placement and the environment that the bunk was situated within the aircraft which did not cater for adequate rest due to the noise and space.

A union member raised the concern that, despite a mandated 48-hour rest period between operations, **sign-off times are often scheduled during sub-optimal rest periods**. This observation suggests a potential discrepancy between the official rest period regulations and the practical implementation by operators. The participant emphasized the importance of scheduling sign-off times earlier to enable crews to experience a more effective period of rest. The argument presented suggests that adjusting the timing of sign-offs could contribute to optimizing the rest period and, in turn, enhance overall crew well-being. Additionally, the participant suggested that if sign-off times were adjusted, operators might not necessarily need to allocate a full 48-hour rest period. Instead, a 40-hour rest period could suffice if it falls within the optimum rest period. This perspective challenges the conventional approach to scheduling rest periods and opens possibilities for more flexible and tailored solutions.

4.2.2.2.3 Fatigue Risk Management Strategies

Participants emphasized recommendations for **fatigue risk management strategies** in the current flight and duty periods. A participant from the regulator proposed, *"I would take a compulsory fatigue risk or fatigue management program. If I could choose what I wanted it to look like, I would want South Africa's regulations to make it compulsory for every operator to have a fatigue management program. In that, you could have a prescribed FDP and then a provision for unusual circumstances, which* *we do kind of, but the fatigue management program is not really forced or prescriptive as yet. Then, the fatigue risk management system, especially for those who have these unusual operations like firefighting or long-haul operations and those types of things. I also think that possibly the fatigue risk management system could be compulsory as part of that safety system because everyone has a safety system. This means the system is just having one more module to it. It's just a matter of making sure people capture that data."* The participant elaborated that these fatigue risk management strategies should integrate seamlessly within the operational safety system. Furthermore, they stressed the importance of leveraging crew data through available technology.

In addition, an airline and schedule operator emphasized, *"Additionally, guidance surrounding the approval of Fatigue Risk Management Systems must be provided by the SACAA, especially in relation to the approval of Flight and Duty Schemes for individual operations."* This underscores the importance of incorporating guidelines into the regulations concerning the approval of fatigue risk management, particularly with respect to flight and duty period schemes. Furthermore, a non-schedule operator recommended that regulations adopt their current practice of fatigue risk management strategy. However, the participant indicated that operations must learn from experiences and adapt to deal with the challenges within that specific operation.

4.2.2.2.4 Crew Health & Safety

A non-schedule operator highlighted concerns regarding crew health and safety within the current flight and duty periods, emphasizing the need for a comprehensive examination of the impact of fatigue on pilots' health. The participant shared a personal experience, stating, *"And that's eventually I also had a problem with my colon that perforated while I'm flying. So, well not while I was flying. So, I decided to let's start looking at health here and decided to go back to the desk job."* The participant suggested conducting research to understand the prevalence of medical conditions among pilots attributed to various factors, including fatigue. They pointed out common reports of medical issues within a small pool of colleagues, noting a recurring pattern of colon-related problems. The participant observed that pilots engaged in repetitive tasks might neglect basic health practices, such as staying hydrated, due to operational constraints like the requirement to have someone in the cockpit during bathroom breaks. The feedback from participants underscores the need for research into the relationship between fatigue, operational pressures, and crew health. The proposed amendments to flight and duty period regulations should consider these insights to mitigate potential health risks associated with extended and demanding operational duties.

4.2.2.2.5 Stakeholder Engagement

Recommendations were highlighted for more stakeholder engagement in the current flight and duty period regulations It was highlighted that the regulatory body should develop as fast as possible comprehensive and targeted empirical studies through liaison with the different sub sectors of the industry. Although, participants continued to state a certain responsibility should fall on the operators to generate awareness around the duty of care to the company and to the passengers, as well as develop a self-integrated system of managing the risk of fatigue. Thus, participants indicated that stakeholder engagement should be implemented rather than having a prescribed top-down approach from the regulator that does not take into consideration certain aspects within operations. In addition, an airline and schedule operator recommended *"What I would like to do is to is to create an environment where the regulator, the people who amend the FDP, first of all get to experience what is really experienced by pilots, both in the summertime and in the wintertime too. So, they know what you can go through and what the challenge will be. And know how well you how much you'll be taxed. Because they don't."*. In addition, an industry associate stated, *"I think it needs to be a targeted amendment in terms of understanding exactly where the problems are and getting agreement and consistent consensus amongst all the parties."*. Moreover, participants highlighted the need to incorporate science and scientists within the amendments to regulations. Furthermore, participants indicated that the amended regulations should be concisely integrated with the new global guidelines.

4.2.2.2.6 Maintain Current Regulations

Conversely, an industry associate emphasized, *"Maintain the current regulations,"* stating that there are no recommendations to alter the current flight and duty periods.

According to their perspective, the existing regulations are performing effectively and should be retained.

4.2.3 Emerging Risks and Fatigue Management During the COVID-19 Pandemic

Below, some relevant responses to research question 3, *'What are their thoughts on the impacts of the COVID-19 pandemic on the emerging risk and proposed management of fatigue in the industry during the first year of the pandemic?'*.

4.2.3.1 Main Impacts Since the Start of the Pandemic

Figure 19 displays the generated themes and sub-themes from the participants' responses for the interview question: *Since the start of the pandemic, what have been the main impacts on your operation / on the stakeholders you represent / regulate?* With respect to the blunt-end stakeholders' perceptions on the main impacts since the start of the pandemic, there were three broad themes identified. The three broad themes identified for the main impacts since the start of the pandemic were *impact on crew, impact on regulations*, and *impact on operations*.

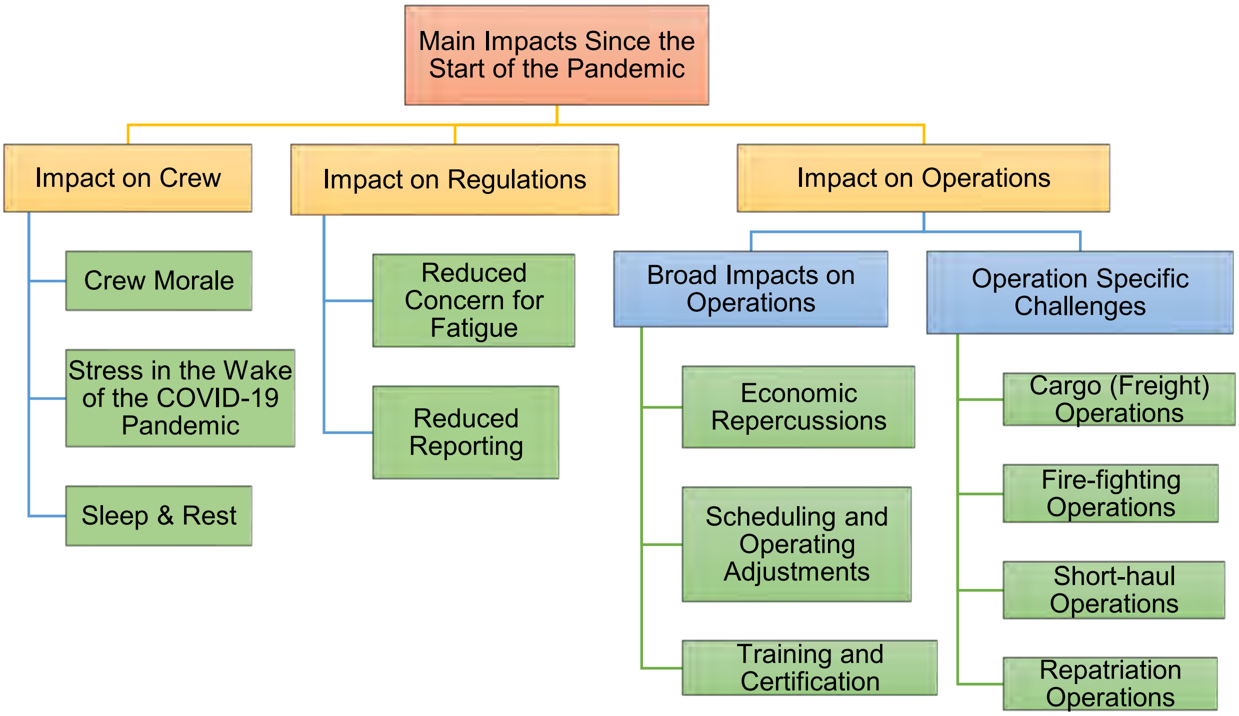

Figure 19: Thematic Map for the Main Impacts Since the Start of the Pandemic

4.2.3.1.1 Impacts on Crew

For the main impacts on crew since the start of the pandemic, there were three sub-themes identified: *Crew Morale, Stress in the Wake of the COVID-19 Pandemic, and Sleep & Rest.*

4.2.3.1.1.1 Crew Morale

Participants reported that crew morale was one of the main impacts on crew since the start of the pandemic. It became apparent that the aviation industry's reduced operations during the pandemic significantly influenced the morale of crew members. Participants emphasized that the diminished flight activities led to a collective eagerness among the crew to resume work. This enthusiasm, however, had implications for concerns related to crew fatigue and adherence to flight and duty regulations. Crew members, eager to return to work and restore normalcy, exhibited reduced apprehension regarding these regulatory aspects.

4.2.3.1.1.2 Stress in the Wake of the COVID-19 Pandemic

Participants reported that **stress in the wake of the COVID-19 pandemic**, a primary concern for crew, was exacerbated by the economic impact of the COVID-19 pandemic and impact of COVID-19 mitigation measures on crew members.

Participants reported that **economic induced stress** was exacerbated by the economic impact of the COVID-19 pandemic. The participants expressed heightened stress about job security, reduced income, and the broader implications for the industry's operations and crew demand, ultimately fearing the loss of their livelihoods. According to an industry associate, *“Some of the pilots were desperately looking for work elsewhere around the world because they're not sure about the future of the industry and whether they will have a job. They've had to reduce numbers, so they're obviously not going to have work. So, I think, from a perspective of other COVID-19, it's not a Flight and Duty issue. It's more another issue related to work satisfaction, psychology of not having a job, and which is, I think, impacting a lot of people across the entire industry.”* This sentiment aligns with participants' broader concerns over a saturated job market resulting from reduced operations and increased crew retrenchments in South Africa and beyond.

Participants emphasized that stress stemming from financial situations had a more significant impact on sleepless nights and crew fatigue than roster or schedule-induced fatigue. According to a regulator participant, *"I think that it's more financial and personal stress that people are going through that's keeping them awake. It's so rare that they wouldn't run into fatigue issues, even in the short term, but it could push over into captain's discretion out of the prescriptive FTL regulations. I definitely think it's not enough to be roster-induced fatigue."*

In addition, an industry associate emphasized the profound **impact of COVID-19 mitigation measures on crew members**, attributing increased stress levels to factors such as reduced airport availability, mandatory mask usage, disinfection protocols, and frequent testing procedures. According to the participant, these measures introduced new stressors, as highlighted *"And you, traveling with these people, you're complying with all these new regulations, you've now got to have masks on and various paraphernalia that you've never had to fly with, which is quite stressful. So, you will find them probably developing a bit more fatigue in the operational environment. Also, the constant checking in every time you have a COVID test, and you have that flipping nine-inch earbud shoved up your nose is also slightly stressful. And those have to be done fairly regularly."*

Furthermore, the industry associate pointed out additional stressors related to the uncertainty of foreign travel, especially in countries requiring essential services or during repatriation flights. The psychological toll was exacerbated by the fear of job loss upon testing positive for COVID-19, adding to the myriad challenges faced by pilots. The participant elaborated, *"And then when you did say you did test positive for COVID the status came around is that you may lose your employment, you may, you know, all the various other stressors that were on. So, there were all the psychological stresses and the solid psychological fatigue that comes with COVID that was lumped on the pilots."* The absence of normal outlets, such as the inability to interact with friends and family, further intensified the strain on pilots, particularly those in older age categories who faced additional restrictions and preferences regarding flight operations.

4.2.3.1.1.3 Sleep & Rest

Participants reported that disruption to sleep and rest was a significant challenge for crew. An airline and schedule operator emphasized how COVID-19, reducing flight frequency, affected crew sleep patterns. The participant noted, *"The crew were not flying a lot. So, they were getting into the local time and used to sleeping at night. So, it was difficult."* This shift in operations created pressure during overnight flights, as crew members were accustomed to resting during that period.

Furthermore, a union member pointed out the lack of available facilities for rest during layovers and delays, attributing it to COVID-19 restrictions. Specifically, short-haul commercial crew members faced challenges in accessing adequate rest facilities between legs. The participant emphasized the impact of changed rosters on local flights, explaining, *"The rosters have also changed, for instance now... you're doing a duty then back, and then you are sitting around for six hours, and then you are doing another duty. So, in that time, you would be sitting around with no rest facilities? Because everything's like a semi-lockdown. The company doesn't want you to hang around, so what do people do? They go sit in the car. What kind of rest is that?"*

4.2.3.1.2 Impacts on Regulations

For the main impacts on regulations since the start of the pandemic, there were two sub-themes identified: *Reduced Concern for Fatigue, and Reduced Reporting*.

4.2.3.1.2.1 Reduced Concern for Fatigue

A regulator reported that a **reduced concern for crew fatigue** was one of the main impacts on regulations. The participant from the regulator pointed out, *"Reduced flying schedules with the start of the industry and an influx of employed pilots made it difficult to address something that is a very minor concern now."* The impact of the COVID-19 pandemic on flying schedules, coupled with a limited workforce, presented challenges in addressing fatigue issues amidst the broader context of working under demanding circumstances.

4.2.3.1.2.2 Reduced Reporting

Participants highlighted that **reduced reporting** was one of the main impacts on regulations. According to an industry associate, *"Lots of threats given by the authorities that if you don't comply, you will have your licenses removed, and your operations will be curtailed, and you could get fined. So, there's a lot of extra pressure that COVID brought about for those that were able to operate."* The participants' responses suggest that the fear of repercussions led to hesitancy among the crew to report incidents. An airline and schedule operator noted a shift in the number of "nuisance" reports – instances where crew members, not genuinely fatigued, sought to excuse themselves from duty - in response to the COVID-19 pandemic. The reduced operations during the pandemic created an environment where crew members were eager to return to work, diminishing the occurrence of fatigue-related reports. As expressed by the participant, *"Enthusiasm to get 'back to work' has reduced nuisance fatigue reports."*

4.2.3.1.3 Impacts on Operations

For the main impacts on operations since the start of the pandemic, there were two sub-themes identified: *Broad Impacts on Operations* and *Operations Specific Challenges*. Participants reported that there were three sub-themes within broad impacts on operation. The three sub-themes were *Economic Repercussions, Scheduling and Operating Adjustments,* and *Training and Certification Challenges.*

4.2.3.1.3.1 Economic Repercussions

Participants emphasized the profound **economic repercussions** on operations since the onset of the pandemic, noting the abrupt halting of activities and the resulting revenue loss for operators. An industry associate indicated that there was a 50% decline in their market. In addition, participants continued to state that operations had to sell their aircrafts due to high cost of their lease and subsequently a loss in fleets and services. An industry associate explained, *"A lot of the companies sold off their aircraft, because if you can't operate and you've got a 23 million Rand aircraft, which you have leased, a lot of the company sold these aircraft off, so there weren't a significant fleets and service."* This underscores the impact of operational challenges on both the leasing decisions and overall fleet and service availability.

The participants emphasized that fleet reductions and diminished operations compelled operators to undertake crew retrenchments, liquidation, or enter business rescue. Concerns were raised about the overall business continuity and industry survival. Reflecting on the challenges, an industry associate stated, *"No flying. That's the problem. So, the pandemic has been a disaster for the industry, an absolute disaster. Both airline management and crew are grappling with a really tough situation. Flights plummeted from the 26th of March, going down to zero overnight. Domestic operations resumed in June, gradually scaling up with the addition of more airports. International flying began on the first of October. However, from a South African perspective, the international impact is limited, as South African Airways no longer operates international flights. The broader impact is on the ability to work and fly, affecting pilots who may not have opportunities to fly again due to the reduced demand."*

Conversely, a non-schedule operator highlighted the increased firefighting operations within the non-schedule sector since the onset of the pandemic. According to the participant, *"We actually did a lot of flying during COVID-19—quite a few fires down in the cape and later on during the free state. So, yeah, we were fortunate enough to be very busy during that period. Salaries, there's not too much. It's sad for other people, but it's good business for us."*

4.2.3.1.3.2 Scheduling and Operating Adjustments

Participants emphasized the broad impact of scheduling and operating adjustments on operations since the onset of the pandemic. Initially, there were limited operations due to travel restrictions imposed to mitigate the transmission of COVID-19. An industry associate highlighted, *"There was not very much support that was, you would have to, a normal operation would be quite difficult. So, to give you an example, only certain airports were open. So, you would have to relocate an aircraft before you could operate the aircraft on its standard deployment to standard operation. So, you would find longer hours awake, longer distances travelled by car, etc., and those sorts of things in place. So, yeah, those things need to be thought about."* This relocation requirement resulted in extended operating hours for the crew.

In addition, an airline and schedule operator indicated that the state implemented curfew to reduce the transmission of the COVID-19 pandemic resulted in shorter operating days and thus resulted in reduced fatigue. An airline and schedule operator emphasized its impact on operational hours: *"The curfew meant shorter operating days, thus reducing fatigue."* Moreover, another airline and schedule operator noted that since the start of the COVID-19 pandemic there were *“Scheduling irregularities requiring alignment to passenger demand”.*

4.2.3.1.3.3 Training and Certification Challenges

Amidst the onset of the pandemic, there was a profound and widespread impact on training and certification processes within the operational landscape. Participants perceived crew members encountered challenges as they were unable to undergo training for an extended period. An industry associate highlighted this, noting, *"Then the other thing that came in is on the training side. Because nobody could train for so long, etc. Suddenly, the requirements to try and complete licenses do a whole lot of skill tests, etc. Because a lot of the ratings and licenses were lapsing, you suddenly found trying to force these things to happen in a very short space of time. So that was also a problem."* As operations resumed, crew members found themselves grappling with the imminent expiration of ratings and licenses due to the hiatus in training activities. In addition, the participant highlighted that there was an excess of 320 air operator certificate (AOC) holders from various operations in the industry being handed back to the CAA as they were unable to continue with operations.

Furthermore, an airline and schedule operator highlighted the challenge of limited classroom capacity for training, attributing it to COVID-19 restrictions. The participant emphasized, *"Training impacts in terms of restrictions enforced in classroom capacities, etc."* Moreover, participants indicated the lapses in licences and ratings had resulted in limited available crew to perform the operations and operators were pushing the available crew to the limits. As a union member expressed, “T*he training had fallen behind because of lockdown. And the companies are saying ‘Hang on. We can have one crew. We can pay them less and we can push them to the limits.’*” This underscored the strain on available crews and the need for addressing training deficiencies.

4.2.3.1.3.4 Operation Specific Challenges

Participants reported that there were four sub-themes within operation specific challenges since the start of the pandemic. The four sub-themes were *Cargo/Freight Operations, Fire-Fighting Operations, Repatriation Operations, and Short-haul Operations.*

4.2.3.1.3.4.1.1 Cargo/Freight Operations

Participants emphasized the unique challenges faced by cargo/freight operations since the onset of the pandemic. An industry associate underscored the **impact of quarantine** on these operations, stating, *"The only industry that's really been holding the aviation industry up. It has been the non-scheduled operators. We have been continuing with cargo, moving essential services. We have been moving politicians. And so, we've had quite a lot of work that happens there. And it is quite immediate work."* The participant further explained that upon completing operations, the crew couldn't return home immediately, facing a mandatory quarantine period. During this time, they were unable to reunite with loved ones and had limited activities to prevent fatigue. Notably, the participant also highlighted the increased prevalence of alcohol abuse among the crew during this challenging period.

A non-schedule operator highlighted the **challenge of crew swaps** in cargo/freight operations during the pandemic: *"So, the start of the pandemic. For us, the biggest thing has obviously been we couldn't do the crew swaps. So, the guys have been in the field for extended periods. And the opposite problem of that is that we obviously had to place some of the crew on unpaid leave to save costs due to the reduction of contracts that we've had. Then the guys who were supposed to come home weren't able to come home."* This underscores the dilemma faced by non-schedule operators, with crew members either stranded in the field for extended durations or placed on unpaid leave to cope with the challenges posed by the pandemic.

4.2.3.1.3.4.1.2 Fire-fighting Operations

A non-schedule operator emphasized the unique challenges faced by fire-fighting operations since the onset of the pandemic. Describing firefighting as an essential service during the initial stages of the pandemic, the participant pointed out operational hurdles, particularly in logistics. The participant stressed difficulties in acquiring and deploying equipment and personnel to operating bases, attributing part of the struggle to cumbersome bureaucratic paperwork. Additionally, the participant cited issues related to COVID-19 protocols, such as substantial delays—up to four hours—at roadblocks due to government-imposed testing and verification measures.

Quoting the participant directly, they explained, *"Logistics issues were essential service provider. So, we continue to operate even through the COVID lockdown, since lockdown level five. The challenges that we faced were logistical issues getting equipment or components or personnel to bases. You know, having to have a mound of paperwork to go through at a roadblock. And the guys that needed to get the stuff they ran into the issues because at some point, you would be stranded at a roadblock for three or four hours to be checked and verified and tested, and then be able to continue your journey. So, those are the challenges we faced. There were one or two challenges where one or two of our pilots were in the facility of somebody that had COVID-19; we had to quarantine them for a period of 14 days. So that impacted on the operation a bit. We then obviously made logistical changes for a relief pilot to go and stand-in."*

4.2.3.1.3.4.1.3 Repatriation Operations

The airline and schedule operator emphasized that repatriation operations faced unique challenges amid the ongoing pandemic. The operator noted the impact of COVID-19, resulting in numerous repatriation flights. Crew members, accustomed to sleeping during the local night, were now tasked with **nighttime operations**, posing challenges. Additionally, the operator revealed an attempt to **extend flight and duty periods** beyond the norm, akin to emergency operations, based on operational experience rather than scientific research.

Regarding this, the operator shared, *"So, we did quite a lot of repatriation flights; that was our fault. It was a bit difficult for the crew to stay awake at night because you become conditioned as a local pilot. The more you do it, the better you get at it. I reckon the guys took a bit of strain, although they had no cumulative fatigue since they started these flights fresh, especially with quarantine afterward—some guys had 14* *days off after the flight. I've actually done one; we only did six days. But that's more than enough time to recover from a normal flight. That was a good thing because we were working through the night. The other thing was the operator trying to extend flight and duties beyond what we normally do for emergency operations. We were pushing the limits based on operational experience, not on scientific evidence, and I was quite uncomfortable with the way we were trying to push the limits."*

The operator also highlighted suggestions to counteract the desire to extend flight and duty periods, such as implementing a larger crew complement from four to six. However, as the operator pointed out, there was **insufficient space for a six-crew complement** to obtain adequate rest during these operations. Consequently, the operator stressed that, rather than enhancing operational efficiency, this would result in six tired crew members instead of four. The challenges included pushing the limits to conduct flights into China and the US, where crew limits and quarantine regulations were in place.

4.2.3.1.3.4.1.4 Short-haul Operations

Participants emphasized the unique challenges faced by short-haul commercial operations throughout the pandemic. State-imposed curfews, implemented to curb the spread of COVID-19, significantly impacted the scheduling of these operations. An industry associate remarked, *"But also there was limitations on hours of flying. And it was normally during the daytime, particularly in the operation that was from six to six or six to eight in the evening. So, there was the in pretty much daytime top operations."* This restriction led to **later sign-on and earlier sign-off times** for the crew. An airline and schedule operator reported a notable decrease in crew fatigue, attributing it to later sign-ons and earlier sign-offs. The participant highlighted the impact of state-imposed curfews on the domestic schedule, stating, *"State-imposed curfews affected the Domestic schedule with the limit of operating hours of airports and routes available."* The limitations on airports and routes further underscored the significance of the scheduling adjustments in reducing overall fatigue.

4.2.3.2 Biggest Concerns Since the Start of the Pandemic

Figure 20 displays the generated themes and sub-themes from the participants' responses for the interview question: *What are your biggest concerns for the South Africa aviation industry?* With respect to the blunt-end stakeholders' perceptions on the biggest concerns for the South African aviation industry since the start of the pandemic, there were four broad themes identified. The four broad themes identified for the biggest concerns since the start of the pandemic were *Economic Sustainability of the industry, Regulations and Regulatory Body, Covid-19 Regulations, and Operation Specific Concerns.*

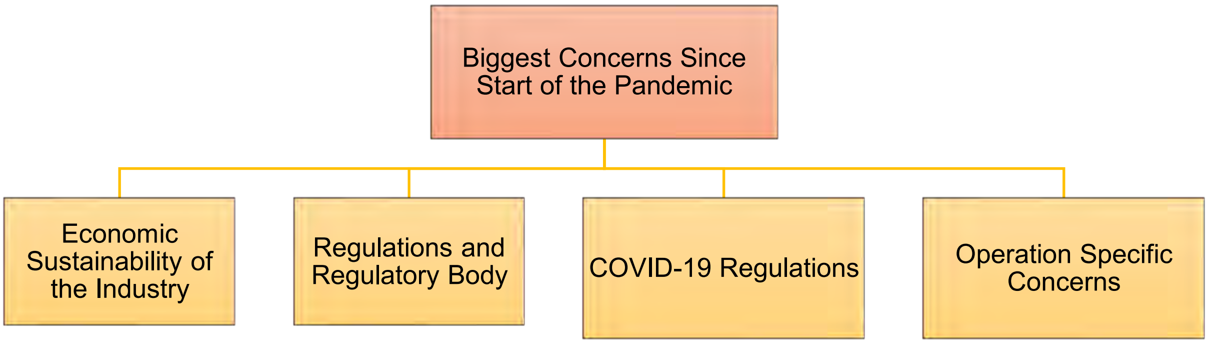

Figure 20: Thematic Map for the Biggest Concerns Since the Start of the Pandemic

4.2.3.2.1 Economic Sustainability of the Industry

Participants expressed significant concerns about the economic sustainability of the industry, emphasizing worries about its recovery and the potential for mass job losses, a flooded crew market, and a future shortfall of crew. As the airline and schedule operator succinctly put it, *"Mass job losses, flooded crew market, crew recency shortfalls, slow return to passenger market, maintenance impacts on aircraft, company sustainability, losing 'wisdom' within the industry."* A union member highlighted IATA's statement on the extended recovery period for the aviation industry, estimating a three-to-four-year timeline to return to pre-COVID-19 levels. Echoing this sentiment, a participant from the regulator emphasized the protracted nature of the recovery process, stating, *"It will take a long time for the industry to recover to even 75% of the capacity that it operated at pre-COVID-19."*

4.2.3.2.2 Regulations and Regulatory Body

Participants expressed significant concerns about regulations and the regulatory body. An airline and schedule operator specifically highlighted the regulator's lack of knowledge and experience in fatigue management, stating, *"It is a lack of knowledge and experience with the regulator to try and manage these and will power to go forward?"* The participant acknowledged the potential of certain individuals within the regulatory body for understanding of fatigue aspects. However, the participant raised concerns about the high turnover of staff at the regulator, impacting their ability to effectively address fatigue issues. The participant emphasized the importance of stable personnel, suggesting that individuals working within the regulatory body should remain in their positions for at least five years to properly manage fatigue concerns. Despite expressing confidence in specific individuals, the participant highlighted the overarching issue of a lack of knowledge and experience within the regulatory body.

A union member expressed concern over fatigue risk management systems and the absence of a just culture during the pandemic, stating, *"Also FRMS, fatigue risk management systems, the whole thing goes on reporting. Um, and if you don't have a just culture, if it's not easy for you to report, and if your report is frowned upon, then it's just not going to happen. Sadly, not just from a fatigue point of view, but pilots are lazy, you know, you tell the guys they're tired. So, I said, well, have you put in a report? Because if you make a report, we've got evidence. But no, they don't do that. So, the various reasons for that they maybe they are too tired to report, so he says he has only got 10 hours sleep, so now I must still for half an hour go sit down and write a report. So yeah, that's it. Yeah, there's various things to consider when it comes to why aren't pilots reporting."* The participant highlighted the impact on fatigue risk management systems, emphasizing the reluctance to report due to the perceived negative consequences in an industry already grappling with economic challenges.

4.2.3.2.3 COVID-19 Regulations

Participants expressed significant concerns about COVID-19 regulations, with a particular emphasis on the challenges posed by state-implemented lockdowns to curb the pandemic's transmission. An airline and schedule operator underscored the government's lack of expertise in providing guidance on COVID-19 regulations. The participant conveyed apprehension within the aviation industry regarding the virus's transmission. However, the participant debunked the prevailing fears, stating, *"Well, my concerns are that we don't necessarily have expertise...poor communications, and also have very poor understanding of what aviation can do...aviation still one of the biggest sufferers because of a lack of understanding."* The participant elaborated on the misconceptions surrounding COVID-19 transmission in aircraft, highlighting the effectiveness of pressurization systems, HEPA filters, and the potential for better-managed protocols. In retrospect, the participant emphasized the need for proactive measures from the outset of the pandemic, expressing regret over the negative impact on various industries and livelihoods.

In addition, an industry associate pointed out concerns regarding the constant redundant testing imposed on the crew for the virus every time they leave the country, irrespective of whether they disembark or not. The participant stressed that this testing regimen was causing heightened stress and anxiety among the crew, stating, *"The crew are currently, and we're pushing for change, under pressure to undergo COVID-19 tests if they cross the border. For instance, if a crew member does a quick Johannesburg-Harare-Johannesburg round trip, departing at 9 o'clock in the morning, arriving in Harare by 10:30, spending just an hour on the ground, and returning by 12 o'clock, they are required to obtain a COVID-19 test certificate. This certificate is needed to prove their eligibility to re-enter South Africa. We find this requirement unreasonable, and we're advocating for an exemption for the crew. The Department of Health is currently reviewing this issue, but it's a source of strain for those who frequently fly."*

4.2.3.2.4 Operation Specific Concerns

Participants reported that operation specific concerns were one of the biggest concerns. An industry associate expressed concerns over long-haul commercial operations, emphasizing the evolving landscape due to technological advancements in newer aircraft. The participant highlighted, *"I think that the risks that you're going to have, most of the operators are now trying to ensure, and you'll see in the regulations, we've just moved ETOPS based on the potential of your aircraft from what used to be 60 minutes to one hour and 20 minutes, now it's gone to 180 minutes. So, in the pursuit of constant economic use and the flight trajectories that we employ, we end up taking longer flights and legs if we can. All of that, and then we would, so we end up having other things. Yes, granted, the aircraft are sometimes faster."*

This increased speed and capability, according to the associate, enable longer flights and expanded operational possibilities. *"So, I think the aircraft have got more potential to stay in the air longer. So, you find that, especially for individuals using it in the commercial environment for business purposes, they will have their pilots flying longer legs and staying in the air longer. Now they can easily do transatlantic trips and cover distances like Cape Town to Reykjavik efficiently—something that was challenging for older aircraft."*

The associate pointed out a shift in the dynamics of flight and duty, particularly in the commercial segment (Part 93) that lacks robust monitoring. *"I don't think it's properly documented. So, I think we're going to see challenges without decent regulation of manipulating the flight and duty tabs by operators, especially in the commercial segment that's not well monitored in the charters, where you're paying for a ticket that will be quite different. Those are easier, you know, better monitored."*

A non-schedule operator expressed concerns about the impact of the COVID-19 pandemic on charter operations in South Africa. The participant emphasized, *"Related to COVID, the continuation of the companies that was hit the hardest. I think, you know, your charter companies, it's operating charter services out of some of the hubs like the interior and even Nelspruit, Kruger, Mpumalanga, all of those. They were the hardest hit because they base their operations on tourism and until such time that tourism returns to a similar level in South Africa, they will continue to face significant challenges.".* This underscores the severe challenges faced by charter companies reliant on tourism for survival.

A non-schedule operator raised concerns about flight school operations, emphasizing a dependency on foreign students for training in South Africa. The operator cited examples such as IFA, a flight school in George and Oudtshoorn, stating, *"Some flight schools, like IFA, rely on Chinese students for training. Due to the lockdown, there hasn't been an influx of students since its beginning. They are completing the last batch by December's end, and it appears they may have to close their doors."*

4.2.3.3 Additional Fatigue Risks Since the Start of the Pandemic

Figure 21 displays the generated themes and sub-themes from the participants' responses for the interview question: *Do you think that the COVID-19 pandemic and the challenges you have outlined above will present different or additional fatigue risks in your operation / for the stakeholders you represent / regulate? If so, what do you think these would be?* With respect to the blunt-end stakeholders' perceptions on the additional fatigue risks since the start of the pandemic, there were five broad themes identified. The five broad themes identified for the additional fatigue risks since the start of the pandemic were *Increased Crew Stress, Additional COVID-19 Safety Measures, Training & Certification Issues, Regulations, and Changes in Workload.*

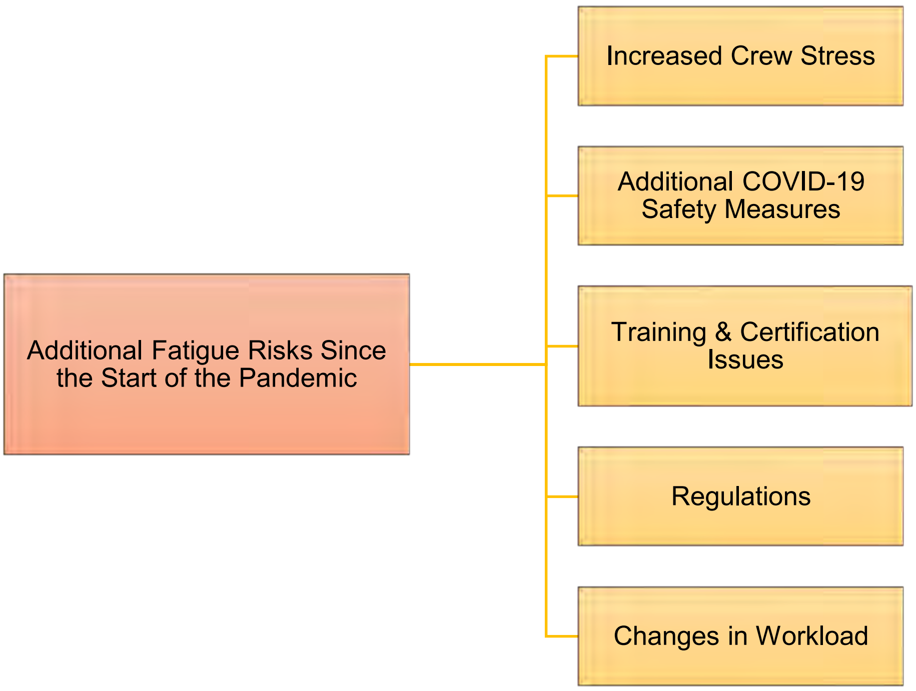

Figure 21: Thematic Map for the Additional Fatigue Risks Since the Start of the Pandemic

4.2.3.3.1 Increased Crew Stress

Participants reported that since the onset of the pandemic, increased crew stress has become an additional fatigue risk. The financial implications of the COVID-19 pandemic, including job losses, have heightened stress levels among crew members. An industry associate succinctly captured this sentiment, stating, *"Yes, absolutely. Job losses are coupled with anxiety, depression, and added pressures to one's family life."* The concerns revolve around income, stability, the ability to provide, and uncertainty for the future.

Participants suggest that the heightened stress levels among the crew due to the COVID-19 pandemic may lead to sleepless nights and contribute to fatigue. According to an industry associate, *"I don't necessarily see the COVID-19 pandemic as a fatigue-related issue, other than the fact that the only one with one exception probably, and that is that. As I mentioned, I think a lot of the pilots are going through a lot of hardship in terms of not understanding when the next flight is going to come and whether they're going to fly again. Any normal person would probably react by being unable to sleep because they're continually worried, and the psychological impact on your whole well-being can be affected by the fact that you're unable to sleep. If, for example, they are fatigued because of that, and then they're asked to fly, does that fatigue impact their operation that they're expected to conduct the next day or within the next two days? So, I think that's probably the only area where I would see fatigue based on the impact of COVID-19, but not necessarily related to the operation itself."*

An airline and scheduled operator emphasized the profound impact of increased stress on the well-being of their crew, leading to elevated fatigue levels. According to the participant, *"Absolutely – Covid-19 has drastically affected company revenues and income streams. This, in turn, is shouldered by employees at all levels, impacting households and the way crew members are able to provide. Stress factors in this regard substantially increase, affecting physical and mental well-being and resulting in increased fatigue."*

4.2.3.3.2 Additional COVID-19 Safety Measures

Participants reported that the government's implemented COVID-19 safety measures were an added fatigue risk since the pandemic's onset. An industry associate underscored the impact of state-imposed quarantines on operational duties: *"And yes, they will be longer operations for the various quarantines your operation. So, ways, basically those going to places outside of the country, I think will be extended. So yes, on there, there may be less operation. So, if you average it out, there may be on average, less fatigue, but then you've got the other factors coming into it. So, I don't know how that will balance out."*

The COVID-19 safety measures have impacted various aspects of airline operations, as noted by an airline and schedule operator: *"Additional safety measures in place potentially increase workload for crew members and constant vigilance, especially on the part of Cabin Crew, may add to fatigue factors."* This underscores the correspondence between safety protocols and heightened fatigue risks among the crew.

4.2.3.3.3 Training & Certification Issues

Participants reported that training issues were an additional source of fatigue risk since the start of the pandemic. They highlighted the COVID-19 pandemic's impact, which led to a backlog of licenses for crew and operators—an issue emphasized by an industry associate: "*And the other thing that we can add there is because of COVID over 4000 licenses that are backlogged in the system. So, you as a pilot or an operator, you don't know if you actually going to get your license in time to actually do your operation. And this is also creating a challenge and a stress. And I don't know if it's fatigue, but it's a contributing contributor to the fatigue and to the stress of being a pilot, of being a license holder in South Africa*." This backlog, according to participants, introduced challenges and stresses within the crew, compounding the factors contributing to crew fatigue.

In highlighting the challenges faced during the first six months of the pandemic, a union member emphasized the constraints posed by a limited trained crew. The member noted that, initially, the available crew operated under tight conditions. Expressing concerns, the member touched upon the apprehensions of those crew members who were not available at the pandemic's onset. The member conveyed, "*As the flying picks up, obviously, the more the crew availability is going to pick up, so they'll be able to spread all those duties over more pilots, I reckon. Maybe for the next, I'd like to say, six months, it's going to be pretty tight. But as more pilots come online and they start being trained, then it's going to be alright. My other concern, not really a fatigue concern, is that there are crews that have not flown—kid you not—flown for six months? And now you're coming back? You're not really up to speed; there are confidence issues*." This underscores the dual challenge of crew availability and the need for reintegration and training.

The training duration for crew members, as reported by a regulator, is approximately six weeks. However, concerns have been raised regarding the pressure placed on crew members to meet their training requirements. In the words of a participant from the regulator, "*Yeah, because it takes about maybe six weeks to train up just the cabin crew member, that's excluding a pilot, you know, and all your other stuff. I just speak from a cabin side, it will take you six weeks to get through your initial training, induction training, your familiarization flights, all the legal requirements, which may lead some people into being just pushing the limits on our roster, we, we they might end up being a little fatigued. But that's if the industry picks up*." This situation may lead to potential fatigue issues, particularly if the industry experiences increased demand.

4.2.3.3.4 Regulations

Participants reported that regulations have introduced additional fatigue risks since the onset of the pandemic. An industry associate emphasized the impact of **the altered auditing process during the COVID-19 pandemic**, stating, *"During COVID, the CAA started doing what's called desktop audits. Now, it sounds fantastic, you're going to be like we're doing on this virtual platform now that you can have virtual meetings. So, you'll find you've got a lot more meetings."* The associate pointed out that regulatory authorities were now requesting evidence before on-site inspections, undermining the just culture of reporting systems. The participant explained, "*They are asking for information before they would come and look. So, have you got an SMS system or safety management system? Have you got a dispatch procedure in place? Can you* *show it to me? Can you show me how it works? It was a show and tell? What is happening now is they asking for evidence. So, what the operators now do is you have to furnish your system to them, which the CAA is now taking that and using it as evidence against you."*

This change has led to a significant decline in trust between crew/operators and the regulatory body. The participant continued, *"So what has started happening is most of the operators, most of the pilots do not trust the CAA for a minute. And they are no longer reporting. So, they are not reporting excessive hours flow, and they are not reporting hazards."* This fear of retribution, as expressed by the participant, has resulted in a reduced number of safety reports, negatively impacting the concept of a just culture that took a decade to establish within the industry. The participant concluded, *"They're not reporting all of those things, for fear of retribution by the CAA, and they are absolutely destroying the whole concept of just culture, which we've spent 10 years getting the industry to sort of trust with the CAA, the CAA, in the last five months has decimated the safety management system."*

An airline and schedule operator emphasized the **impact of stringent lockdown regulations on fatigue**, stating, *"No unless we go into more stringent lockdown again."* This underscores the potential contribution of such measures to increased fatigue levels.

4.2.3.3.5 Changes in Workload

Participants reported that changes in workload were an additional fatigue risk since the start of the pandemic. An airline and schedule operator emphasized the concern over pushing crew limits without empirical evidence from scientific research ensuring operational safety, presenting an additional fatigue risk. The participant remarked, *"Yeah, the additional fatigue risk is that I think managers are going to want to keep pushing the limits, because they've done it before, without the required scientific research that can say, well, we did it safely. But I mean, you can do something safely 100 times, but you got to worry about the hundred and first time when the risk does present itself. So, I'm worried that the airlines and the stakeholders are going to say, well, we've done it, we did it during COVID, why can't we keep doing it. So that's my* *biggest worry. I also may be concerned that with the airlines having struggled so much, they really going to push the crew to the limits, the starting is going to be right on the limit and the crew are going to work even harder, once they start, like to try to keep the cost down."* The participant added that operators were attempting to reduce costs by pushing the remaining limited available crew to the limit.

A regulator participant highlighted the potential risks posed by the current operational challenges in the industry. Emphasizing the impact of reduced schedules on operators, they noted, *"It may present additional risks because with our operators that are battling, remember, they've had these schedules cut, which means they're not as active, they're not as busy. They're going to reduce stuff. So, the few stuff that they do have, they will try and put not for now, because I think a lot of people have tried to keep on as much as possible, hoping that it would bounce back. But I think, eventually, maybe in the next year or so, you're going to find a small, very small crew complement. And as it picks up, that crew complement will be sitting on a very fatigue induced roster, ultimately, you know, if the industry picks up all of a sudden, and they've already reduced staff."* The participant also observed that, since the start of the pandemic, the limited available crew has been dealing with fatigue due to the increased demands on their reduced numbers.

An industry associate emphasized the operational challenges stemming from COVID-19, noting a downsizing trend among operators. Consequently, the remaining staff and crew members were compelled to take on multiple roles, escalating their workload and potentially extending duty times. The associate highlighted this multifunctional demand, stating, *"Yeah, absolutely. And because a lot of them have downsized and now you're getting staff members doing multiple functions. So, you will find a dispatcher is also doing a safety job and this of that, just to keep the wheels rolling, and a lot of CEOs that would never find them dead on the floor during the day in duties. Back on the floor. And, when you've got your CEO, checking up on you as a pilot, etc, it brings another level of stress, you know, to me. So, he saw and consequential and thought of issues that COVID has thrown into the mix. And it's all about survival."* This integration underscores the heightened workload and stress faced by the staff and crew due to the operational changes brought about by the pandemic.

4.2.3.4 Plans to Manage Risks Going Forward

Figure 22 displays the generated themes and sub-themes from the participants' responses for the interview question: *How are you planning to manage these risks in your operation / in the stakeholders you represent / regulate?* With respect to the blunt-end stakeholders' perceptions on the plans to manage risks going forward, there were six broad themes identified. The six broad themes identified for the plans to manage risks going forward were *Regulation Consideration, Scheduling and Operations Consideration, Training and Awareness, Crew Health and Well-being, Stakeholder Engagement, and Economic Management*.

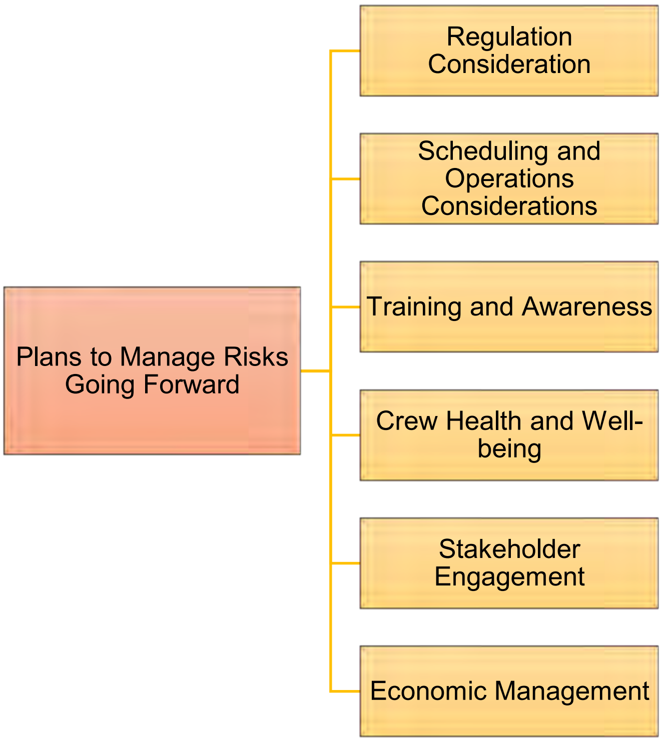

Figure 22: Thematic Map for the Plans to Manage Risks Going Forward

4.2.3.4.1 Regulation Considerations

Participants emphasized the integral role of regulations in risk management plans. A non-scheduled operator stressed the necessity for regulatory amendments to address fatigue risks. The operator highlighted concerns about flight and duty limitations, the number of sectors, and the availability of rest, stating, *"Yeah, I looked at some of the proposals for the new duty periods and rest for the airline industry. It's a requirement for the industry; something must change. Even if it's just the number of sectors or more* *off time, something has to change. It doesn't affect us as much, but when I was there, the system was being abused, and the limitation became a target. Crews run hard, especially now, and with the backlog of licenses at the CAA, crew will be flying themselves to stupor to make the schedule work. More fatigue issues are likely. We need to look after the crew better. We need new procedures because the old policies are going out the window. We're making decisions on the fly without policies, relying on empathy. It creates a vicious circle. Companies are rewriting policies, but they can't keep up with what's happening, leading to an unstable environment. That's the problem."*

The airline and schedule operator emphasized the operators' opposition to the proposed regulation amendments, asserting that the changes would render operations less economically viable. According to the participant, *"We were just picking up momentum to try and get the CAA to update some of its regulation. And this might put us back a bit, because companies are going to use the argument that the suggested changes are going to make them less economically viable. Yeah, but I think we need to, we still need to push forward, even if we can just get one or two things changed. But the landscape has changed."*

A regulator stressed the pivotal role of continuous inspection and oversight by the regulatory body. The participant emphasized the need to actively manage and monitor fatigue risks within operations. Expressing concern about a decline in reports from crew members, attributed to the financial impact of the COVID-19 pandemic and job security uncertainties, the participant underscored the industry's recent challenges. The participant elaborated on the potential reluctance of cabin crew and pilots to report incidents, citing the industry's economic hardships as a deterrent. This sentiment was captured in the participant's words: *"Well, for one, inspection, and oversight, that's the only way we can manage it is the inspection and the oversight and just basically keeping tabs on it."* The participant highlighted the impact of industry trauma on reporting, noting a decrease in incident reports due to job losses. The participant conveyed apprehension about relying solely on anonymous reporting and proposed a shift towards increased surveillance during audits and inspections. The emphasis would be on scrutinizing rosters and flight details to mitigate fatigue risks effectively.

The participant articulated the shift in approach, stating*, "So we wouldn't be able to rely on the reporting that will come into us through our anonymous means, which means we'd have to apply surveillance and during our audits and inspections, constantly check out the rosters constantly scrutinize the flights and the flight times as we do our audits and stuff."*

Furthermore, the airline and schedule operator emphasized the necessity of constant computer modelling in mitigating fatigue risks: *"Constant use of computer modelling."*

4.2.3.4.2 Scheduling and Operations Considerations

Participants reported that scheduling and operational considerations were integral to risk management plans. An airline and scheduled operator emphasized the **need for a more cautious approach**, stating, *"I was going to be forceful about—you've got to go back to what we know, we've got to go, in fact, we need to be maybe even more cautious. Personally, I just pushed back against trying to extend anything without a proper understanding of what the risks are."* This underscores the commitment to avoid pushing crews to their limits and extending flight and duty periods without careful evaluation.

An industry associate emphasized the need to **align the workforce with operational capacity** and suggested, *"Curtailed working week, matching work force/equipment with operational capacity."*

The non-schedule operator emphasized **maintaining the current fatigue management approach** within their safety management system, relying on computerized alert meters and Air-Maestro. They stated, *"We will continue the way that we are currently managing it. Through our safety management system and the systems we've been using to monitor that—your alert meters and Air-Maestro—we would like to test the effectiveness of our FRMS with real-time data. This is what we've discussed with the CAA, with you guys coming on board to test and evaluate these systems. We aim to assess their effectiveness, make any necessary small adjustments as we proceed."*

Furthermore, a non-schedule operator emphasized plans to **increase crew rotation** for those involved in non-scheduled operations, aiming to mitigate fatigue. The operator pointed out, *"For the crew specifically, the fatigue is becoming less and less because we can actually rotate them now more frequently. So, the opening of international borders has made a massive, positive impact for us because we can change the crew frequently. However, financially, it's a significant burden initially. We don't want them to change as often as they used to because it's now costing us double due to the impacts of the COVID-19 pandemic on the industry."*

4.2.3.4.3 Training and Awareness

Participants emphasized the incorporation of training and awareness into their risk management plans. A participant from the regulator stressed the approach of raising awareness through discussions in safety meetings, seminars, and webinars, particularly addressing personal challenges during the COVID lockdowns. The participant stated, *"What we are doing is raising awareness. In safety meetings, we discuss how individuals cope during COVID, addressing stresses and relationship problems. It's done through awareness; I don't think you can regulate this."*

A union member highlighted their efforts in supporting pilot mental health through seminars and webinars, advising individuals to manage their lives and take care of themselves. The participant stated, *"From the Mayday side or the pilot support side, all we can do is look after yourself. It's a matter of managing your life and taking care of yourself."*

An airline and schedule operator mentioned their focus on increased awareness of fatigue risks and the continuation of recurrent training and mitigation processes. The participant succinctly stated, "*Increased awareness of fatigue risks and countermeasures. Continuation of recurrent training and mitigation processes already in place."*

An industry associate emphasized their intention to enhance crew training through the implementation of *"multiskilling."*

4.2.3.4.4 Crew Health and Well-being

Participants consistently emphasized the pivotal role of crew health and well-being in their strategies for managing risks. A prominent airline and schedule operator outlined their comprehensive approach to mitigating fatigue-related risks, specifically addressing financial considerations for the crew. One representative stated, *"In addition, our strategy focuses on compensating for health concerns and accommodating family responsibilities. We have identified available crew resources to meet reduced operational needs without adversely affecting their financial resources. Negotiations are undertaken to provide compensation for those unable to operate during this period, ensuring a balance that considers both the well-being and financial stability of our crew."*

Furthermore, participants underscored the integration of crew mental health within the broader fatigue management plan. Support services, such as health-line counselling, were highlighted as crucial elements to aid crew members in their return to work. An airline and schedule operator further reinforced this commitment, stating, *"Health-line counselling has been made available to our crew during this period. Return-to-work conditions are designed to facilitate a gradual reintroduction to duty, allowing ample time for the re-familiarization with work-related training, tasks, and equipment. Importantly, these measures are implemented without compromising the financial stability of our crew members."*

4.2.3.4.5 Stakeholder Engagement

Participants reported that stakeholder engagement was integral to the risk management plans. According to the airline and schedule operator, *"open communication channels and procedures implemented to bring attention to fatigue elements that may be encountered,"* **open communication channels and procedures** measures are essential components of the ongoing risk management strategy.

In addressing the management of fatigue, an industry associate emphasized the significance of **collaborative initiatives with the regulatory body**, exemplified by projects like the Association of Non-Scheduled Operators (ANSO) project. Providing insight, the associate stated, *"We have a project with CAA called the 'ANSO project,' where we are raising industry concerns with the CAA. They could ease and lighten the regulatory requirements."* This underscores the proactive approach to mitigating fatigue within the industry.

An industry associate emphasized the **accessibility of fellow professionals for insights and recommendations** regarding fatigue and the economic impact of COVID-19, stating, *"Look, I think this is probably an area where the airlines themselves are having to deal with us directly. We certainly haven't gotten involved in trying to influence how the airlines should manage the operation during the COVID-19 situation. I think that they've all had to deal with various aspects, and it's very much been related to the financial viability of what they do."*

Moreover, a non-schedule operator emphasized that **effective coordination** within the operation is crucial for future management plans. They candidly expressed the challenges they face in prioritizing the well-being of the crew, stating, *"That's the biggest challenge for management because we've got to look after the crew at the end of the day. But the sad part about it is the further you go, the more you know that simple saying about give them the pinkie and grab the whole hand. That's generally what has happened. It's sad because you've gone out of your way to help the crew, but they've just said sorry, that's it. No, and now's not the right time to take a stance. It's let's work together and get things done. Yeah, I've burnt my fingers sadly on that a little bit and like I said, get hidings from management about that."*

4.2.3.4.6 Economic Management

Participants reported that economic management, including salary restructuring, was a key component of risk management plans. According to an airline and schedule operator, *"The Company realizes that the root cause (job security and income) of these stress factors needs particular attention. Instead of job cutting, negotiations are ongoing for salary structuring considerations that allow for the continued sustainability of the Company. This includes the flexibility for adjustment and claw back as business improves and operations return to normal."*

Participants reported that operations severely affected by the COVID-19 pandemic had resorted to crew retrenchment as a strategy to alleviate financial burdens and ensure company survival. An industry associate remarked, *"I mean, we know that a lot of airlines have had to lay people off, either temporarily or permanently. Some have gone through the process of retrenchments, others have cut salaries, and others have forced employees to take paid or unpaid leave. I think that's obviously also impacted directly onto the crew side. It's been dealt with on an individual basis; there's not been a general, industry-wide decision made. In general, though, I think airlines have dealt with it fairly similarly. They've had to reduce costs due to a liquidity and cash crisis, and unfortunately, one of the biggest casualties has been their employees, including the crew."*

An industry associate emphasized the importance of cost reduction in economic management plans, stating, *"eradicating unnecessary expenditure, removing 'nice-to-haves,' reviewing office space requirements, and implementing a work-from-home policy for those who can."*

CHAPTER 5 - DISCUSSION

The focus of the study is to shed light on the self-reported challenges of fatigue and its contributing factors from aviation blunt-end stakeholders, commonly referred to as the "blunt-end stakeholders", who play pivotal roles in shaping and overseeing operational procedures within the South African aviation industry. Additionally, the research also aimed to investigate the implications of the unprecedented COVID-19 pandemic on the prevalence of fatigue and its associated management strategies within the industry. To achieve these overarching aims, three specific research objectives were established. The following paragraphs summarise the objectives alongside some key findings from the study.

The first objective of the study focused on examining the experiences and insights of aviation blunt-end stakeholders regarding the challenges of fatigue and the factors contributing to its manifestation. Participants universally reported concerns around crew fatigue in the South African aviation industry. These concerns encompassed the recognition of crew fatigue as a well-established safety risk within the South African aviation industry. Participants highlighted the significant role of crew mentality and attitude in exacerbating this risk, noting instances where a lax approach towards fatigue management or a culture of pushing through fatigue prevailed, thereby posing a risk to safety. Moreover, participants highlighted the compounding effect of outdated regulations on the challenge of fatigue management, particularly in their varied impact across different operational contexts within the aviation industry. For instance, several respondents cited specific regulatory limitations that hindered the optimization of crew rest periods or the adoption of modern fatigue mitigation technologies. These limitations were found to manifest differently depending on factors such as the type of operation (e.g., short-haul vs. long-haul flights), the nature of the aviation sector (e.g., commercial airlines vs. cargo operations), and regional regulatory differences. In certain contexts, regulatory hurdles were observed to disproportionately affect certain segments of the aviation workforce or specific operational practices, further complicating efforts to address fatigue effectively. Contributing factors to crew fatigue were identified across individual, regulation, environment, and operational demands-related categories, each exerting unique influences on crew fatigue across various operational contexts. Change in awareness over the past five years had predominately increased for the majority of the participants. This heightened awareness was attributed to an increased drive for fatigue management, a rise in the number and quality of fatigue reports, and a push for changes in regulations to mitigate crew fatigue.

The second objective focused on delving into the perspectives of these crucial stakeholders concerning the efficacy of the current Flight and Duty Regulations in addressing and mitigating fatigue-related concerns. Participants expressed concerns about the outdated regulations and poor regulatory support, lack of current science and stakeholder engagement, uniform application of regulations across different operations, short rest periods, and scheduling issues. Recommendations for amendments emerged, including extending rest periods, reducing maximum hours, and incorporating stakeholder engagement.

The third objective focused on examining the ramifications of the COVID-19 pandemic on emerging risks associated with fatigue and the proposed management strategies within the aviation industry. Impacts on crew, regulations, and operations were observed, including changes in crew morale, increased stress, and economic-induced stress. Concerns were raised regarding economic stability, regulatory challenges, and limitations imposed by COVID-19 regulations. During the pandemic, additional fatigue risks were identified, such as increased crew stress, changes in workload, and challenges in training and certification. Proposed risk management plans encompassed adjustments to regulations, scheduling practices, increased training, and improved stakeholder engagement.

5.1 Perceived Concerns of Crew Fatigue and Contributing Factors Prior to the COVID-19 Pandemic in the South African Aviation Industry

5.1.1 Perceived concerns around fatigue in the South African aviation industry.

When asked "*prior to the COVID 19 pandemic, do you think that crew fatigue was a concern in your operation / in the stakeholders you represent / regulate and if so, why?",* all thirteen participants indicated that crew fatigue was a concern within the operations, stakeholders represented, and stakeholders regulated within the South

African aviation industry. The most prominent reason crew fatigue was, and remains, a perceived concern was attributed to the operating organisations' understanding that crew fatigue was a significant risk to operation safety and that these operating organisations were mandated by law to manage fatigue. These findings are consistent with previous research outside of South Africa showing that fatigue is a recognised hazard that predictably degrades various aspects of human performance and has contributed to, and continues to contribute to, aviation accidents or incidents (Caldwell, 2005, 2012; Coombes, Whale, Hunter, & Christie, 2020; ICAO, 2016; National Transportation Safety Board, 2019; Roach, Sargent, Darwent, & Dawson, 2012; Wilson, Caldwell, & Russell, 2007). Similarly, Tambala (2017) found that participants from management within the aviation industry emphasized the necessity of treating fatigue as a core safety issue. For instance, one participant noted that *"all parties involved in this work generally must deal with fatigue for what it is—as a question of aviation safety,"* underscoring the strategic prioritization of fatigue management (Tambala, 2017). Another participant highlighted the continuous challenge posed by fatigue, emphasizing that airlines must actively monitor and mitigate fatigue by planning schedules accordingly, as operational departments are typically the first to observe its consequences (Tambala, 2017). This emphasis aligns with the observation and active management of crew fatigue as required by the ICAO's Manual for the Oversight of Fatigue Management Approaches (ICAO, 2016). Furthermore, operator observation and active management of crew fatigue is required by ICAO and the SACAA (ICAO, 2016; CAA, 2009). Thus, the participants understand that crew fatigue is a risk (which has been highlighted in the past and currently being made aware of) and requires observation and active management (which has been increasingly focused on).

Crew mentality and **attitude towards fatigue** was another notable concern as it was perceived by the participants that there was a tendency towards persevering through the fatigue to 'seek heroism or recognition', or due to the obligation to continue working to avoid repercussions while crew may be experiencing fatigue. These observations may be associated with three of the five hazardous attitudes in aviation mentioned by FAA in the Pilot's Handbook of Aeronautical Knowledge (FAA, 2016). Firstly, the 'anti-authority attitude', which refers to individuals who do not like anyone telling them what to do as the crew continue to operate. However, the crew are informed of regulations and policies that are put in place by the regulatory body and operators, mandating crew to cease operating if fatigue is experienced (FAA, 2016). Secondly, the 'invulnerability attitude', which refers to individuals who falsely believe that accidents happen to other individuals, but never to themselves, as the crew continue to operate while being fatigued as the crew believes that an incident or accident will not occur during operation (FAA, 2016). Thirdly, the 'macho attitude', which refers to individuals who are always trying to prove that they are better than anyone else and think, "I can do it - I'll show them", as crew continue to operate under fatigue conditions trying to prove to others around them that they are able to continue to perform operational duties although they may be at risk (FAA, 2016).

In addition to these hazardous attitudes, and unaccounted for in the Pilot's Handbook of Aeronautical Knowledge (FAA, 2016), the participants indicated that crew may be experiencing fatigue and persevering through the fatigue due to the obligation to continue working to avoid repercussions. However, this is ironic as the participants (management and decision makers) are in a position to take action over the concerns of failing to report due to repercussions. It is interesting to note that managers and blunt-end stakeholders are aware of this issue and have the ability to address it, yet there seems to be a gap in their actions towards mitigating crew fears of repercussions for reporting fatigue. Furthermore, to note these observations stemmed from participants who represented the regulator, an industry association, and an airline and scheduled operation. Thus, the participants perceive that there is a systemic concern regarding the crew's attitude towards fatigue. The prevailing environment or system may compel crew members to persevere through fatigue to avoid potential repercussions, rather than this behaviour being inherently hazardous due to their personal attitudes. This systemic pressure places the crew in an increased position of risk for experiencing fatigue-related issues, potentially leading to incidents or accidents. It is crucial to recognize that these behaviours are a result of the broader organisational culture and operational context, rather than solely individual choices or attitudes. The implications of these attitudes suggest a potential cultural aspect within the aviation industry. The concern revolves around the possibility that the prevailing culture may not foster appropriate responses to fatigue, potentially leading to hazardous attitudes among the crew.

Outdated regulations and **resistance to changing regulations** were cause for concern for crew fatigue as participants perceived limited integration of current science. Despite proposed amendments to regulations over several years ago, no concrete actions have been taken to implement these changes. This concern aligns with findings from Blair (2022), where participants advocated for bringing South African regulations up to date with global standards or aligning them with the FDP regulations of other countries or regions, such as those established by the European Union Aviation Safety Agency (EASA). According to the International Civil Aviation Organisation’s (ICAO) recommendations (2015), the development of FDP should incorporate the latest studies and operational experience. Consistent with Blair's (2022) study, participants in this research emphasized the need for incorporating more scientific insights and operational experience into the development of FDP laws. They observed that existing regulations, formulated years ago, do not reflect current scientific understanding of crew fatigue. Despite advancements in knowledge, the regulations have not evolved accordingly. Consequently, participants perceive the current regulations as insufficient in protecting the crew against fatigue, underscoring the urgent need for adjustments. Furthermore, Tambala (2017) highlights similar concerns from the perspective of management, particularly in the context of balancing operational profitability with safety considerations. A participant from Tambala’s study noted that while European Flight Time Provisions (FTL) set maximum allowable limits, these regulations often fail to consider the broader operational realities that impact fatigue, such as the specific nature of tasks performed. The participant observed that focusing solely on flight hours does not adequately capture all the variables contributing to fatigue, emphasizing that the regulations provide a general framework but might not be suitable in addressing fatigue comprehensively: *"It sets limits, it sets a max frame, but it is not said that the max frames are appropriate when it comes to fatigue. It does not look at what you're really doing - it just says how long you fly"* (Tambala, 2017). This insight reinforces the argument that while regulations are designed to protect against fatigue, they may be overly rigid or too narrowly focused, missing critical operational factors that contribute to crew fatigue. While blunt-end stakeholders at the operational level are intimately familiar with the day-to-day challenges posed by existing regulations, their perspective may be influenced by operational priorities and organisational interests. It is essential to recognize that stakeholders, including crew members and operational staff, often prioritize operational efficiency and company objectives. Therefore, their perspectives on regulatory reform may be nuanced, considering factors beyond crew welfare alone. While acknowledging this, it is crucial to emphasize that blunt-end stakeholders possess invaluable insights into the practical implications of existing regulations, particularly regarding crew fatigue management. Their experiences provide critical context for understanding the limitations of current regulatory frameworks. However, it is also important to consider that their views may be shaped by operational imperatives and company objectives. Therefore, while stakeholders may recognize deficiencies within existing regulations, their perspectives must be interpreted within the broader organisational context. In subsequent sections, these multifaceted perspectives are explored in greater detail, aiming to present a comprehensive understanding of the motivations and challenges surrounding regulatory reform in the aviation industry.

Conversely, **well-managed operations** may be a reason for why crew fatigue was not a concern as five participants (two airline and schedule operators, two non-schedule operators, and one industry associate) perceived that the prevalence of crew fatigue was minimal due to well-run operations and the operations’ fatigue management techniques implemented. The small compliment of participants indicated that the low prevalence of crew fatigue was the reason why it was not a cause for concern in their business or with the individuals they represent or regulate. However, the perception of a low prevalence of crew fatigue within these well-managed operations does not imply that it is immune to risks or that fatigue cannot potentially slip through the control measures in place. As ICAO’s Manual for the Oversight of Fatigue Management Approaches has highlighted, fatigue in aviation is an inevitable risk that cannot be eliminated but needs to be managed as part of a broader safety management system (ICAO, 2016). Because of the low reported prevalence of crew fatigue by the participants, it can be deduced that fatigue was less of a concern in well-managed operations. However, due to the inevitable nature of crew fatigue, continued observation and management of crew fatigue is required to ensure that fatigue does not become an increased risk in operations, thus increasing concern. Tambala (2017) similarly observed this cautious optimism in his study of Norwegian civil aviation, where a participant from the NCAA acknowledged that while crew fatigue is indeed a challenge, it is not perceived as a significant issue due to the high standards of fatigue management in Norwegian companies. The participant emphasized that although fatigue is 'not necessarily a big problem,' it is a challenge that must be taken seriously and continuously monitored, reinforcing the idea that even in well-managed operations, vigilance is crucial (Tambala, 2017).

5.1.2 Perceived contributing factors to fatigue in the South African aviation industry.

When asked "*prior to the COVID 19 pandemic, if you thought that fatigue was a safety concern in your operation / in the stakeholders you represent / regulate, what do you think were the main contributing factors to crew fatigue?",* the participants perceived contributing factors to crew fatigue before COVID-19 were systemic and included various person, regulation, environment, and operational demands-related factors.

5.1.2.1 Person-Related Factors

Economic-induced stress was the most commonly cited person-related factor contributing to crew fatigue perceived by the participants. Prior to the COVID-19 pandemic, certain operations within the South African aviation industry were affected financially and as a result, crew experienced a decrease in career stability and financial security. It is important to note that the interviews were conducted as the COVID-19 pandemic was impacting the globe and the aviation industry, but in some cases, certain airlines were already in economic trouble, which may have contributed to this particular theme. The decrease in career stability and financial security caused an increase in economic-induced stress experienced by crew, potentially impacting crew sleep quality and quantity. Stress (economic and other types) has been associated with poor sleep and fatigue development, which may increase crew fatigue and threaten performance ability (Bennett, 2003; Venus & Grosse Holtforth, 2021; Young, 2008b). However, this requires further research. This finding was also consistent with the findings by Blair (2022), where crew members (cabin and cockpit) reported that over a quarter of the participants perceived financial stress as contributing to fatigue.

Crew's perception and **attitude towards crew fatigue** was another commonly cited person-related contributory factor highlighted by the participants. Firstly, participants conveyed concerns about their interacting crew feeling overworked, highlighting the potential association between feeling overworked and an increased risk of fatigue among the crew. Specifically, the narrative suggested that crew members, when feeling overworked, might exhibit an elevated perception of fatigue throughout the operational duty. This implies that the crew's perceived level of fatigue during the operation could surpass what would be experienced under normal working conditions when they are not overworked. Similarly, Ozel & Hacioglu (2021) stated that after a given amount of time, crew operating in a demanding atmosphere where the same activities are continually performed may get mentally and physically fatigued and bored. Furthermore, the study by Ozel & Hacioglu (2021) added that future job dissatisfaction and burnout may result from crew operating in a demanding atmosphere. Thus, the perception of being overworked may influence crew to have an increased perception of experienced fatigue by crew during operation. Secondly, participants indicated that the crew's decision to persevere and willing to extend their duty to fulfil the operation requirement, regardless of whether they were fatigued or not, was impacted by how desirable the destination was to the crew. This places crew in an increased position of risk for fatigue as they continue to extend their duty even though they may be tired from periods of extended wakefulness.

5.1.2.2 Operational Demands-Related Factors

Inadequate rest periods emerged as the predominant operational demands-related factor contributing to crew fatigue, as perceived by study participants. The significance of insufficient rest, encompassing both appropriate durations and well-timed intervals, has consistently surfaced as a prominent fatigue risk factor in global research (Elliott & Lal, 2016; Jehan *et al.*, 2017; May & Baldwin, 2009). This pattern is evident not only in broader research contexts but also within specific industries such as aviation, both globally (Caldwell *et al.*, 2009; Dawson & McCulloch, 2005a) and within the South African aviation sector (Blair, 2022). The structuring of working time in these contexts can either constrain or infringe upon the crew's ability to obtain sufficient sleep or rest. The literature emphasizes the essential role of adequate sleep or rest in recovering from fatigue, mitigating stress, and sustaining alertness and performance during duty hours. In addition, the literature underscores the cumulative nature of sleep loss, forming a sleep debt that detrimentally affects various cognitive functions beyond the scope of knowledge retention, decision-making, and overall performance (Belenky *et al.*, 2003; Davy, 2014; Durmer & Dinges, 2005; Federal Aviation Administration, 2012; Folkard, Lombardi, & Tucker, 2005; Noy *et al.*, 2011; Rogers, Dorrian, & Dinges, 2003). Moreover, a proper rest period not only contributes to professional well-being but also enables the crew to fulfil personal and domestic needs (Caldwell *et al.*, 2019). Furthermore, existing literature highlights the importance of considering the timing of rest periods. For instance, Rudari *et al.* (2016) and Efthymiou *et al.* (2021) emphasize how the timing of rest can be crucial, especially if it falls between duties, exposing the crew to external factors like daytime noise. It is important to recognize that the rest period is not solely about sleep but also about fulfilling basic physiological needs and spending time with family.

Participants in the study indicated that crew fatigue was a result of a combination of factors, including a reduced duration of the crew's rest period and crew **operating during disruptive hours** that conflicted with their biological desire to rest. This resulted in the crew working within hours when their bodies naturally sought rest, such as at night or in the early hours of the morning, forcing them to sleep or rest during suboptimal times of the day for biological rest. Operating during disruptive hours has been linked with night flights, early starts, and late finishes, however, these will be discussed in detail below. The concerns raised by participants extended to both the adequacy of rest and the timing of rest in connection to operational duties. To further contextualize these findings, studies, such as the one conducted by Gander *et al.* (2014), underscore the impact of flight timing, circadian phase, and flight duration on in-flight sleep and fatigue levels, particularly in the context of augmented crew flights. Planning for different flights must carefully consider these factors to mitigate the risk of crew fatigue. Additionally, Van den Burg *et al.* (2019) draw attention to the extended duty periods for cabin crew, where their responsibilities may extend beyond the apparent 12-hour rest period due to attending to passengers even after the aircraft's engines are turned off. This extension can significantly impact the available time for cabin crew rest.

Night flights and **nighttime duty** significantly contribute to crew fatigue in long-haul operations within the South African aviation industry. One crucial aspect influencing fatigue in aviation is the timing of operational demands, particularly during nighttime flying. Nighttime duties are defined as occurring from 15 minutes after sunset to 15 minutes before sunrise, with variations across countries (SACAA, 2009). Crew operating during the night face the challenge of working against their natural sleep inclination, necessitating wakefulness during the night and sleep during the day (Gundel *et al.*, 1995; Samel *et al.*, 1997; Ingre *et al.*, 2014; Sallinen *et al.*, 2020; Sallinen *et al.*, 2021). Night FDP are particularly associated with extended on-duty periods and are significant predictors of fatigue, especially when they overlap with the Window of Circadian Low (WOCL) (Sallinen *et al.*, 2021). Night flights disrupt the crew's natural circadian rhythm, compelling them to resist the urge to sleep at night and subsequently sleep during the day, leading to cumulative sleep loss and sleep debt (Van Dongen *et al.*, 2003). This disruption has cascading effects on crew alertness and concentration in subsequent duties (Caldwell, 2005; Ingre *et al.*, 2014). Additionally, Sallinen *et al.* (2017) found that both short-haul and long-haul FDP covering the early (00h00-03h00) and late (03h01–06h00) parts of the domicile night (00h00–06h00 at home base) consistently result in reduced sleep sufficiency and subjective alertness. The study indicates that FDP overlapping with the domicile night led to reduced sleep-wake ratios and decreased subjective alertness, suggesting a need for effective on-duty alertness management strategies during such periods. Moreover, Bourgeois-Bougrine *et al.* (2003) emphasize the role of sleep loss in pilot fatigue, citing night flights and jet lag as primary contributors. Their findings reveal that the poor quality and quantity of sleep, especially after night flights, increase fatigue levels. For long-haul flights, consecutive night flights within a short timeframe further exacerbate fatigue. Similarly, for short-haul flights, multi-leg flights and early wake-ups are identified as factors contributing to increased fatigue.

The operational demands placed on aviation crew members, particularly concerning the timing of duty periods, significantly influence fatigue levels. **Early sign-ons** and

late sign-offs within the same consecutive string of jobs contribute to irregularities in the roster, exacerbating fatigue among crew members. This is consistent with observations made by Co *et al.* (1999), Bourgeois-Bougrine *et al.* (2003), and the European Cockpit Association (ECA) in 2012, who highlighted the disruptive nature of early starts. Akerstedt *et al.* (2021) discussed that excessively early starts lead to shortened, poor-quality sleep, resulting in increased reports of fatigue during duty. Vejvoda *et al.* (2014) further supported these findings, indicating that early starts often lead to lengthier duty times and an increased likelihood of fatigue at the end of the duty. Conversely, late finishes of the FDP pose their own set of challenges. Studies by Jackson and Earl (2006), Vejvoda *et al.* (2014), and van den Burg *et al.* (2020) found that short-haul crew members self-reported moderate to severe fatigue when the FDP concluded late at night. The interplay of frequent early starts and disruptive rostering procedures with extended work hours could potentially lead to insufficient rest for the crew.

Notably, early starts and late finishes tend not to coincide, with crew members starting early being less likely to finish late, and vice versa. Arsintescu *et al.* (2021), Sallinen *et al.* (2021), and Vejvoda *et al.* (2014) highlighted that the final landing following a late finish FDP is associated with the crew being awake for an extended period and reporting higher fatigue compared to those with early starts. Late finishes, especially those extending beyond midnight, often require crew members to attempt sleep during the day, presenting a challenge due to societal noise, light, and the circadian-modulated drive for wakefulness, as observed in studies by Caldwell (2005), Jackson and Earl (2006), and Powell *et al.* (2007). Moreover, the literature review underscores that short-haul crew fatigue tends to be moderate to severe when the FDP concludes late at night, aligning with the findings of Jackson and Earl (2006), Vejvoda *et al.* (2014), and van den Burg *et al.* (2020). However, there’s a need for empirical data in South Africa on early starts and late finishes.

Jet lag, resulting from the disruption of the circadian rhythm during long-haul flights, significantly contributes to fatigue among crew members. The literature consistently highlights the adverse effects of rapid time zone changes on sleep in crew working long-haul operations (Anne Eriksen & Åkerstedt, 2006; Bendak & Rashid, 2020;

Caldwell, Caldwell, & Schmidt, 2008; FAA, 2013). Furthermore, Bourgeois-Bougrine *et al.* (2003) emphasize the role of sleep loss in pilot fatigue, citing jet lag as one of the primary contributors. Despite the well-established concern regarding the negative impact of jet lag on crew members' sleep, it is noteworthy that the inadequate layover time at the arrival location does not seem to significantly influence their sleep patterns upon returning to their departure point (Anne Eriksen & Åkerstedt, 2006; Bendak & Rashid, 2020; Caldwell, Caldwell, & Schmidt, 2008; FAA, 2013). However, misalignment of crew members' sleep/wake cycles with the destination time zone can affect their sleep and rest during layovers. This common issue leads to crew members experiencing alertness during their biological night and encountering sleepiness and exhaustion throughout the day (Drake & Wright, 2010). Research by Drake & Wright (2010) indicates that disrupted and/or diminished sleep before and during travel exacerbates jet lag symptoms, including daytime tiredness, drowsiness, and sleeplessness. Understanding why this occurs is crucial for addressing the challenges faced by long-haul pilots.

The participants in the study underscored the impact of **extended standby times** on crew rest and boredom levels, contributing significantly to fatigue during firefighting operations. This prolonged downtime resulted in heightened boredom levels, leading to the neglect of small procedural tasks, like neglecting to fill-up the fuel after they have landed and the completion of paperwork such as sign in and out. The consequences of boredom-associated fatigue were evident in various detrimental ways, including diminished vigilance, impaired decision-making, heightened stress, and lowered morale, as highlighted by previous research (Loukidou *et al.*, 2009). Boredom in the firefighting context could trigger risky or counterproductive behaviours, potentially compromising safety and efficiency (van Tilburg & Igou, 2017). The dissonance between the demanding expectations of firefighting roles and the often-mundane reality of low-stimulation situations was identified as a significant factor contributing to boredom. Furthermore, it is important to note that firefighters, operating within the emergency services realm, are obligated to prepare aircraft for subsequent operations after completing a mission. This additional duty extends their flight and duty periods, adding further strain to an already demanding scenario. The emotional toll of boredom, encompassing dissatisfaction, irritation, and anxiety, intensifies crew fatigue by depleting crucial energy and resources (van Hooff & van Hooft, 2014). This impact extends indirectly through altered behaviour and motivation, with bored crew members engaging in non-task-related activities like informal conversations, device use, or daydreaming, thereby risking distraction and increasing the likelihood of errors or accidents (Fisher *et al.*, 2018). Alternatively, boredom may undermine crew commitment and task interest, resulting in reduced performance and satisfaction (van Tilburg & Igou, 2017). More research is necessary in this context.

In the non-scheduled aviation space, unique challenges emerge, significantly impacting crew fatigue. Participants emphasized the diverse challenges faced by crew engaged in firefighting, charter, paragliding, training, and recreational operations in South Africa. These challenges were reported as contributory factors to crew fatigue, with participants frequently highlighting the performance of multiple responsibilities during operational duty as the most commonly cited contributing factor. Crew operating in non-scheduled operations often find themselves working extended duties, facing increased workloads, and dealing with challenging early sign-ons and late sign-offs. These demanding conditions arise due to heightened client or employer expectations, necessitating the need for future research to comprehensively understand the impact of these challenges on fatigue risk.

5.1.2.2.1 Workload-Related Factors

Operating multiple sectors in a day has been consistently identified as a significant contributor to fatigue in short-haul commercial operations. Participants in our study emphasized that the workload for pilots is particularly intense during take-offs and landings in each flight sector. Previous research supports this observation, establishing a direct relationship between the number of flight segments undertaken during a workday and the resulting fatigue experienced by pilots (Bendak & Rashid, 2020; Gawron, 2016; Honn, Satterfield, McCauley, Caldwell, & Van Dongen, 2016; Reis *et al.*, 2016; Van Dongen, 2015). Numerous studies have underscored the demanding nature of take-offs and landings, with Bor *et al.* (2016) asserting that these phases account for 65% of the total workload for pilots and 55% for cabin crew. The increased frequency of performing these demanding tasks during multiple flight sectors amplifies the mental and physical stress on the crew, subsequently diminishing their performance and alertness. Additional pre-flight and post-flight duties, such as briefing, checking, loading, unloading, and paperwork, further contribute to the overall workload. Specifically, short-haul schedules involving four to five sectors per day have been recognized as particularly fatiguing, leading to changes in alertness and performance. The influence of the South African context on short-haul operations introduces an additional layer of complexity. Blair's (2022) research indicated that the prevalence of short flight sectors (not exceeding 2 hours) in South Africa necessitates crew to operate between three to four sectors per day at times. This unique context exacerbates the workload challenges faced by pilots and emphasizes the need for targeted interventions in this specific operational environment.

The participants in this study emphasized that **working consecutive days** is a significant contributor to fatigue for crew members operating short-haul commercial flights. The impact of consecutive workdays is influenced by the nature of their responsibilities, involving disruptive and lengthy duties with high workloads (O'Hagan *et al.*, 2016; Marqueze *et al.*, 2017; Pellegrino and Marqueze, 2019). This highlights the intricate interaction of various work elements that collectively contribute to fatigue (Bourgeois-Bougrine *et al.*, 2003; Yuliawati *et al.*, 2015). The challenges associated with consecutive workdays include disruptions to crew rest periods affecting the quantity and quality of sleep, compounded by another significant concern - insufficient rest.

A study conducted by Roach *et al.* (2019) investigated the risk of fatigue among airline crew during four consecutive days of flight duty, incorporating multiple sectors. The findings revealed an increase in self-reported fatigue levels, particularly after the third day. However, despite the heightened fatigue, there was no deterioration in neurobehavioral test scores, suggesting that cabin crew may have developed coping strategies to maintain performance under such conditions. While Roach *et al.* (2019) did not explore cumulative sleep loss, it is well-documented in the literature that prolonged sleep deprivation as a result from working consecutive duties that involved disruptive duties can lead to increased fatigue and decreased alertness levels during duty (Goffeng *et al.*, 2019; Gillet and Tremblay, 2021), potentially impacting crew performance, particularly toward the end of an extended period of work.

In the context of short-haul flights in South Africa, where crew may work up to four to five consecutive days, the short sectors allow for the theoretical possibility of working more days to attain the limit. Conversely, for long-haul flights, the daily and weekly flight limits are often reached after a single outbound and return flight. It is noteworthy that South African pilots are legally permitted to work up to five or six consecutive days without a day off (SACAA, 2011a). his regulation applied universally to all flight crew members, irrespective of their experience or other criteria. The regulation ensured a standard approach to managing crew scheduling and rest periods to promote aviation safety and mitigate fatigue-related risks. Consequently, the short-haul crew's engagement in numerous consecutive days, with early sign-ons, late finishes, and multiple sectors flown, could lead to a cumulative increase in fatigue levels throughout successive days of duty. In response to this challenge, the crew advised against having more than three consecutive early sign-ons per week. Additionally, they proposed implementing a block roster system, as suggested by Novak *et al.* (2020), which may assist in scheduling the working week, taking into account factors that contribute to fatigue, opportunities for recovery, and adequate sleep.

Poor interactions with air traffic control (ATC) and **passengers** were another notable cited environment-related factor perceived by the participants. Where there was a perceived lack of expertise and communication challenges due to the ATC not being first language English-speaking. This likely would have added to crew workload and stress, which is known to contribute in part to fatigue. In addition, an increase stress was placed on crew as foreign air traffic control’s tools/technology that aids with operations did not always work. Moreover, crew members often felt pressured by passengers and airlines to continue operating flights despite delays, leading them to exceed their prescribed flight and duty times in order to avoid inconveniencing the passengers and airlines by postponing the flight.

5.1.2.2.2 Environment-Related Factors

Weather conditions emerged as the predominant environment-related factor influencing crew fatigue, with participants consistently attributing crew fatigue to adverse weather conditions. The repercussions of these conditions were particularly pronounced in terms of extended work hours and heightened crew workload. Notably, adverse weather conditions were identified as a primary contributor to operational delays, leading to the extension of duty periods for crew (Hilditch et al., 2023). Extended duty periods resulting from weather-related delays play a pivotal role in fostering fatigue through prolonged wakefulness and the activation of homeostatic mechanisms. This, in turn, hinders crew members from obtaining adequate rest periods, creating a cascade effect on overall fatigue levels. The encroachment of extended duties due to weather delays onto designated rest intervals further exacerbates the challenge, curtailing the overall available rest time for crew members. In the aviation context, pilots are required to navigate through adverse weather conditions, and this presents a unique set of challenges. They must sustain unwavering focus on complex digital instruments, demanding significant attention and effort (Dawson *et al.*, 2014).

In considering the profound impact of **unfamiliar** and **dangerous environments** on crew well-being, especially in operations centred around aid or medical support, an essential aspect that warrants further investigation is the necessity for additional research on crew operating in such hazardous conditions. While the preceding discussion has shed light on the consequential effects of accommodation within these environments on crew stress levels, it is crucial to acknowledge the gaps in current research pertaining specifically to the unique challenges faced by crew in dangerous settings. Participants in this study consistently emphasized the detrimental effects of hazardous environments on crew stress levels, ultimately leading to a reduction in both the quality and quantity of sleep and resulting in an alarming escalation in crew fatigue. The existing body of literature, as highlighted by studies such as ICAO (2016) and Lee & Kim (2018), has underscored the intricate link between the sleep environment, sleep quality, and crew well-being. However, there is a notable gap in addressing the specific challenges faced by crews operating in dangerous environments and more research needs to be performed in this context. By addressing this research gap, we can better inform interventions and strategies tailored to mitigate the challenges posed by dangerous environments, ultimately enhancing the overall well-being and performance of these crew members.

5.1.2.3 Organisation-Related Factors

Inadequate crew was another notable cited organisation-related factor that participants perceived contributed to crew fatigue, as the number of crew members available to perform the duties was insufficient to complete it efficiently and safely. Participants believed that certain operators were performing maximum duty limits with a minimum crew complement to lower operating costs. According to Dawson & McCulloch (2005), fatigue is a safety hazard that can be influenced by several levels of an error trajectory, such as prior sleep opportunity, prior sleep obtained, and individual differences in vulnerability to sleep loss. Having an inadequate crew can increase the risk of fatigue-related errors by reducing the opportunities for rest breaks, increasing the demands on individual crew members, and impairing the performance of team tasks (Dawson & McCulloch, 2005). Therefore, it is important to consider the optimal crew size and composition for each flight operation, considering the duration, complexity, and environmental conditions of the flight, as well as the availability and quality of sleep facilities for the crew (Dawson & McCulloch, 2005).

A lack of just culture in fatigue reporting was another notable cited organisation-related factor that participants perceived contributed to crew fatigue as it creates a culture of fear and mistrust among crew, which can lead to underreporting and ultimately fatigue-related incidents. These findings are interesting as they are coming from the blunt-end stakeholders who play an import part in a just safety culture. While our findings diverge from those reported by Reader *et al.* (2016) and Efthymiou *et al.* (2021), who noted positive safety culture perceptions among pilots and cabin crew, disparities in viewpoints emerge in their studies. Reader *et al.* (2016) reveals variations in safety culture rankings among pilots based on factors like employment arrangements and airline types. Pilots on atypical contracts and those with low-cost and cargo airlines express more negative evaluations of safety culture compared to colleagues with secure employment and network carrier airlines (Reader *et al.*, 2016). Notably, perceptions of management's commitment to safety, staffing, equipment, weariness, and organisational support, as indicated by Reader's study (2016), were unfavourable. These findings intersect with our research, highlighting an industry concern where crew members may feel compelled to work despite fatigue levels, leading to underreporting. The participants in our study highlighted a concern for the number of irresponsible reporting influenced by fears of job insecurity and external pressures. Establishing a just culture is paramount for effectively managing risks, including fatigue-related concerns among crew members. It is essential to encourage a culture whereby reporting any risks is not only accepted but also valued. By prioritizing open communication and trust within the organisation, barriers to reporting can be minimized, enabling more effective management of critical issues such as crew fatigue.

5.1.2.4 Regulation-Related Factors

Outdated current regulations and **neglecting current science** emerged as key factors contributing to crew fatigue, as highlighted by study participants. The perception among participants was that the existing regulations fall short in providing adequate protection for the crew. This assertion aligns with the findings of Blair (2022), where pilots and cabin crew shared similar concerns, as expressed by participants in their study. The heightened focus on fatigue management, coupled with increased emphasis on education and training, may have contributed to these shared perceptions. Blair's (2022) study also suggested the need for updating regulations to align with international standards, such as those set by EASA, and emphasized the importance of incorporating scientific insights and operational experience into the design of FDP regulations, echoing recommendations from the International Civil Aviation Organisation (ICAO, 2015). The participants' perspective on the inadequacy of current regulations in safeguarding crew well-being will be further elucidated in the subsequent discussion in sub-section 5.3.

The absence of a defined 'local night' in the current regulations was another important concern raised by the participants around regulation-related factors contributing to crew fatigue. A clear definition of the local night is crucial to ensure crew members have adequate rest periods. The inclusion of local night within the rest period is beneficial for preserving natural sleep patterns, including the circadian rhythm and the WOCL period. This, in turn, allows crew members to maintain a healthy sleep balance and prevent sleep debt. Currently, the South African Civil Aviation Regulations (SACAR) lack a specific local night definition, but they do specify rest period requirements. In contrast, other regulations, such as those by EASA and CAA, include a defined local night, offering more flexibility in operation scheduling and improved rest opportunities for crew. The participants expressed concerns that the absence of a local night definition in SACAR does not provide sufficient sleep opportunities. This deficiency contributes to crew fatigue and may increase the risk of accidents. The deficiency needs to be empirically determined.

A lack of standardised sign-on times was another commonly cited regulation-related factor perceived by the participants that contributed to crew fatigue. Discrepancies in sign-on times emerged, with certain operators considering sign-on from the moment of entering the premises and being ready for duty, while others factored in duty time only upon building entry. Variations were observed in risk mitigation practices prior to sign-on duties. Although this diversity meant differing start and end times for crew across various operations, regulating these differences posed challenges due to the varying demands of scheduled and non-scheduled operations. This pattern echoes the findings of Blair (2022), illustrating pilots' and cabin crew's shared feelings of enduring perpetual fatigue due to lengthy commutes. This extended commute duration can be attributed in part to participants often residing in major city centres like Johannesburg, Gauteng, where the primary international airport is situated. Expounding upon the consequences of commuting, as outlined by Brown and Whitehurst (2011), it is plausible that crew commencing duties early may encounter disrupted sleep resulting from the early wake-up times necessitated by their work schedules.

5.1.3 Perceived changes in fatigue awareness in the South African aviation industry

When asked *"Do you think that awareness of crew fatigue has changed over the last 5 years in the industry in general and if so, why?",* participants noted a significant increase, primarily attributed to a **heightened drive for fatigue management**. This surge in awareness was influenced by several key factors. Firstly, participants emphasized the impact of international organisations, such as the International Civil Aviation Organisation (ICAO) and the International Air Transport Association (IATA), whose initiatives and recommendations have underscored the importance of addressing fatigue within the industry. Specifically, the release of ICAO's report in 2015 served as a catalyst for renewed efforts in fatigue management. Moreover, stakeholders within the aviation sector have increasingly engaged in discussions and collaborations aimed at addressing fatigue-related issues. This heightened engagement has fostered a collective commitment to improving fatigue management practices, evident in ongoing communications regarding amendments to flight and duty regulations. Notably, participants highlighted the proactive measures taken by regulatory bodies to implement changes aimed at mitigating crew fatigue, reflecting a growing acknowledgment of fatigue as a critical safety concern. Integral to the bolstered awareness of fatigue has been the implementation of educational initiatives and training programs within aviation companies.

An **increase in training** and **education** around fatigue was identified as a positive development in the aviation industry. Participants highlighted the growing awareness of crew fatigue, emphasizing the positive impact of educational initiatives within certain companies. Training programs were implemented to inform individuals about the risks associated with crew fatigue, aligning with findings from Blair's (2022) study. The participants' recognition of fatigue as a safety concern reflected the effectiveness of fatigue workshops, courses, and the incorporation of science- and risk-based fatigue management strategies. Blair (2022) emphasized the constructive outcomes of these initiatives, attributing the increased awareness to the practical experiences shared by participants. While discussing the effects of fatigue workshops and courses, the reporting capability, and the implementation of science- and risk-based strategies, the focus remains on the positive aspects of heightened awareness rather than the challenges faced by participants, such as increased workload and perceived lack of operator responsiveness in fatigue management. Efthymiou *et al.* (2021) supported the idea of enhancing knowledge about fatigue and its consequences, emphasizing the positive role of education in mitigating long-term impacts during operations. The importance of continued training in response to evolving aviation requirements has been stressed by previous studies (Signal *et al.*, 2009; Davy, 2014; Efthymiou *et al.*, 2021), underscoring the ongoing need for proactive measures to address crew fatigue within the industry.

Increased number and **quality of fatigue reports** was another notable cited change in awareness in the last five years. Participants underscored the significance of the reporting mechanism, emphasizing its alignment with principles of just culture and confidentiality. It is crucial for the industry to articulate these principles more explicitly to ensure a comprehensive understanding of the reporting framework. Moreover, participants observed a substantial improvement in the quality of received reports, suggesting an overall advancement in crew awareness regarding fatigue issues. Additionally, participants noted advancements in the technological aspects of reporting fatigue, reflecting a commitment to staying abreast of evolving industry standards. This improvement in reporting practices aligns with findings by Weines (2016), who highlighted a growing awareness of fatigue among crew members. From a management perspective, the increased awareness necessitates a diligent review of reports generated by the system. As underscored by Weines (2016), a management team that places significant emphasis on addressing crew fatigue plays a pivotal role in mitigating its impact on the crew.

In contrast, a small complement of participants reported that awareness had not changed. The reasons for this are attributed to the **responses to reports**, where nothing gets done after filing reports, and the **slow adaptation and resistance to amending regulations**. Similarly, Blair (2022) supports these findings, indicating that the final negative response stems from a lack of change in the way fatigue is managed. This is attributed to a stagnant legal framework and inadequate responses by management to reports, along with persistent misconceptions surrounding fatigue (Blair, 2022). Firstly, insights from an industry associate, a regulator, and an airline and schedule operator emphasized that awareness had not changed due to South Africa “lagging behind” in fatigue and fatigue management compared to other countries. Participants pointed out that fatigue was not at the forefront of policy development, unlike countries such as Australia, the United States of America, and European countries. Secondly, a non-scheduled operator with prior experience at the sharp end of active flight operations underscored that the responses to reports suggested a lack of awareness. The participant noted that despite crew members being worked intensively for short periods, only average monthly hours were being considered. The participant further highlighted that operator often processed and responded to reported issues as legal rather than recognizing the underlying issue of crew fatigue, echoing Blair's (2022) assertion of continued misconceptions about fatigue.

5.2 Perceptions Surrounding the Current Flight and Duty Period Regulations in the South African Aviation Industry

When asked "*What are your thoughts on the current South African Flight and Duty Period (FDP) regulations in relation to mitigating fatigue risks in your operation / in the stakeholders you represent / regulate?*" and "*Based on your answer, what recommendations would you make around amending the current FDP regulations in South Africa about your operation / in the stakeholders you represent / regulate?*" participants consistently highlighted **perceived scheduling concerns**. The prevailing sentiment among participants was rooted in the perceived lack of clarity within the existing regulations. For instance, an industry associate highlighted a concern that certain operators manipulate scheduling practices for financial gains. Findings from Blair (2022) aligns with these participant perceptions, emphasizing the theme of 'perceptions and attitudes' towards FDP. Participants expressed dissatisfaction with the current state of regulations, noting that flying limits were often treated as targets during high workload periods. One participant criticized the lack of scientific rigor in the current FDP, describing them as "archaic" and "light years behind the latest available scientific data". The consensus among participants was that the FDP section as a whole is inadequate and outdated. However, Blair (2022) indicates a need for more restrictive regulations and a re-evaluation of FDP tables, but emphasizes that these suggestions lack accompanying evidence.

Tambala's (2017) research in the Norwegian aviation sector echoes similar concerns regarding scheduling practices, particularly with the now-phased-out "*split schedule*." a participant representing management in Tambala's study noted a positive reception from staff following the reduction of split schedules, a practice that involved long breaks between morning and evening work shifts. This practice was perceived to exacerbate fatigue, and its removal has been well-received by pilots and cabin crew alike. However, Tambala (2017) also highlights a significant challenge in the form of European Aviation Safety Agency (EASA) regulations, which impose limits on duty hours that management finds difficult to navigate. One participant from the Norwegian Civil Aviation Authority (NCAA) pointed out the dual responsibility in managing fatigue: while the company must ensure that crew members are not overburdened, individuals also bear responsibility for their fatigue levels, acknowledging personal factors such as commuting, lack of sleep, or stress as contributors. This perspective underscores the complexity of fatigue management, where both regulatory frameworks and individual actions play critical roles.

Moreover, Efthymiou *et al.* (2021) shed light on the perceived impact of European FTL changes on safety, alertness, and fatigue, as perceived by cabin crew and pilots. Their study revealed a neutral or negative perception across all three variables, suggesting concerns among those operating under the regulations regarding their effectiveness. This underscores the importance of considering diverse viewpoints when evaluating the efficacy of regulatory changes in managing fatigue within the aviation industry. From a fatigue management perspective, reducing the number of monthly flying hours is pivotal. Literature suggests that prolonged and irregular duty periods contribute significantly to fatigue among aviation professionals, a sentiment echoed by both Blair (2022) and Efthymiou *et al.* (2021). Blair's (2022) critique of the current FDP emphasizes the potential safety risks they pose, aligning with Efthymiou *et al.*'s (2021) findings of dissatisfaction among industry stakeholders regarding the perceived effectiveness of regulatory changes. Therefore, reducing monthly flying hours, when supported by evidence, can contribute to mitigating fatigue risks, enhancing safety, and aligning with the industry's evolving understanding of scientific data and recommendations. In considering operational implications, reducing monthly flying hours may initially pose challenges to operational efficiency. However, the potential gains in safety and long-term operational stability outweigh these challenges.

In addressing concerns about the management of cumulative fatigue, participants emphasized the need for a re-evaluation of the **current maximum flight hours** allowed for pilots within a 28-day cycle, currently standing at 120 hours. The consensus among participants was that this limit is perceived as excessively high, contributing to concerns regarding fatigue management. This sentiment aligns with findings by Blair (2022), where crew members highlighted concerns about the length of duty periods, with comments indicating that extended duty periods, especially late-night duties, contribute to fatigue. To address this concern and strike a balance between operational requirements and crew welfare, a recommendation was made to lower the threshold to 100 hours. This proposed reduction in maximum flight hours is rooted in the literature, as Blair's (2022) study indicates calls for adjusting monthly and daily limits, with participants stating that the industry is currently operating at the limit. The potential implications of this reduction from a fatigue management perspective are crucial to consider, as crew members in Blair's (2022) study noted that the last sector on a long day is subject to fatigue, emphasizing the need for provisions that account for cumulative effects. Moreover, participants suggested aligning flight and duty hours with the Labour Act, proposing a cap at 45 hours per week. This alignment aims to safeguard crew members' well-being, drawing parallels with Blair's (2022) findings where participants called for a re-evaluation and reduction of duty times for both pilots and cabin crew.

However, it is important to acknowledge the unique constraints and operational requirements of the aviation industry. Blair's (2022) study emphasizes the need for a nuanced evaluation of duty durations, with some participants suggesting increased duty period lengths compensated with more time off. While aligning FDP regulations with labour laws could promote fairness and equity for aviation professionals, the practicality of this proposed alignment becomes a critical consideration. Blair's (2022) participants highlighted that the aviation industry is currently running on the limit, suggesting that any changes should be approached with a thorough understanding of the industry's complexities and potential challenges. Balancing the well-being of aviation professionals with operational requirements, economic viability, and safety imperatives, as emphasized in Blair's (2022) study, requires comprehensive evaluation and the involvement of stakeholders from both the aviation sector and labour organisations. It is imperative to ensure that any proposed changes do not compromise safety or hinder the industry's ability to meet its commitments. To further enrich the discussion and provide a broader perspective, Efthymiou *et al.* (2021) conducted a study exploring the perceived impact of changes made to FTL on safety, alertness, and fatigue among cabin crew and pilots. Their findings revealed a mix of neutral and negative perceptions toward these variables, indicating potential dissatisfaction with the effectiveness of the regulations. While this study provides additional insights into the challenges and concerns surrounding FTL, it underscores the need for a holistic approach to fatigue management within the aviation industry, considering diverse perspectives and regulatory frameworks.

Addressing the concerns raised regarding the **adequacy of rest periods** for aviation personnel requires a nuanced exploration that goes beyond the temporal aspects outlined in current regulations (SACAA, 2011). While the existing mandate prescribes a minimum rest period of nine consecutive hours, it is imperative to delve deeper into the alignment of these rest periods with the physiological restorative processes crucial for mitigating fatigue-related risks. Participants highlighted the concern regarding the adequacy of the nine-hour rest period stems from the recognition that while it aligns with the upper end of the recommended sleep duration range for adults, it may not encompass the full spectrum of requirements necessary for effective rest among aviation personnel. The acknowledgment that most adults typically require seven to nine hours of sleep nightly, as supported by Hirshkowitz *et al.* (2015), serves as a foundational basis for this argument. Consequently, while a nine-hour rest period may meet the minimum regulatory standard, it may not afford individuals the opportunity to achieve the requisite amount of sleep, factoring in the time needed for transition and settling into a restful state.

Furthermore, beyond a basic consideration of sleep duration, research consistently highlights the impact of inadequate sleep, sleep deprivation, or interruptions on increased perceived weariness and poor performance (Petrilli, Roach, Dawson, & Lamond, 2006; Reis, Mestre, Canhão, Gradwell, & Paiva, 2016). Insufficient sleep not only manifests in immediate consequences but accumulates in the form of sleep debt, negatively affecting key cognitive functions over time. This includes knowledge retention, decision-making, overall performance, and the growth of fatigue (Belenky *et al.*, 2003; Davy, 2014; Durmer & Dinges, 2005; Federal Aviation Administration, 2012; Folkard, Lombardi, & Tucker, 2005; Noy *et al.*, 2011; Rogers, Dorrian, & Dinges, 2003). Such findings underscore the significance of the nine-hour rest period as a crucial regulatory measure, ensuring that aviation personnel obtain the necessary sleep duration and quality to maintain optimal cognitive functioning, minimize fatigue-related risks, and ultimately enhance safety. While acknowledging the overarching problem of inadequate rest, this section aims to shift the emphasis toward integrating other regulatory changes related to rest periods. Blair (2022) provides insights into participant perspectives, emphasizing the demand for longer rest periods between strings of duty and duties themselves. Participants expressed sentiments such as “Ten-hour rest period. Make it twelve hours, and it would be much better” and identified issues like “Lack of rest between duties” (Blair, 2022). It is crucial to note that participants highlighted the importance of longer rest after disruptive duties, such as early sign-ons and late sign-offs. These disruptions not only impact the quantity but also the quality of rest obtained by aviation personnel. Incorporating these insights broadens the scope of the discussion, laying the groundwork for justifying the need for regulatory adjustments beyond the temporal duration of rest periods.

Participants in the study expressed concerns regarding the early morning sign-on times required for flight preparations in the South African aviation industry. They reported that these early sign-on times encroached upon their natural rest periods and disrupted their sleep patterns. Moreover, the combination of **early sign-on times** and **late sign-offs** was perceived as a potential cumulative threat to crew rest and sleep. To address these issues and safeguard the well-being of aviation crew members, it is crucial to examine the timing of sign-on and sign-off operations in the context of flight and duty period regulations (Roach *et al.*, 2012). Extending the discussion to the broader literature, insights from Blair (2022) supplement our findings. Blair's (2022) study highlights concerns related to "disruptive rostering," where crew members expressed apprehensions about the absence of legal specifications regarding the number of consecutive early starts and late finishes. A crew member interviewed in Blair's (2022) research stated, "*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*."

Moreover, drawing parallels with studies in the commercial aviation industry by Bourgeois-Bougrine *et al.* (2003) and Jackson and Earl (2006), findings of this study align with the identification of duty periods with early-morning starts as significant contributors to pilot fatigue. These studies reveal that pilots experience reduced sleep duration and heightened fatigue levels when their duty periods commence in the early morning hours, typically between 04:00 and 10:00 (Roach *et al.*, 2012). Importantly, Roach *et al.* (2012) further support these findings by emphasizing that the necessity to wake up early for duty results in a restricted amount of sleep, particularly for early-morning start times. The influence of the internal body clock exacerbates this situation, as it generates a stronger drive for sleep in the early morning compared to the mid-morning (Roach *et al.*, 2012). These collective findings underscore the critical importance of considering circadian rhythms when formulating regulations that govern sign-on times and duty periods within the aviation industry. Therefore, the development of guidelines that respect these rhythms and provide adequate rest opportunities is deemed essential for effective fatigue risk mitigation and overall crew well-being.

The participants in the study emphasized the critical need for **regulations** to be meticulously **tailored to suit diverse operational contexts**, encompassing sectors such as airline, firefighting, and charter operations. A universal approach, as highlighted by Blair (2022) and echoed by the participants, may fall short in addressing the unique challenges faced by each operation within the aviation industry. Blair (2022) discusses the theme of "Applicability," emphasizing that current regulations might not be suitable for various segments of the industry, including regional airlines and operations governed by Part 137 (Aerial work). In these cases, the operating times significantly differ from those in scheduled aviation, leading to a misalignment between regulatory requirements and the operational realities. This emphasizes the critical need for further research to explore and address these discrepancies comprehensively. As such, ongoing research endeavours aim to delve deeper into the nuances of regulatory frameworks across diverse operational contexts within the aviation industry.

Conversely, some participants expressed satisfaction with the current regulations, and advocated for **maintaining the existing regulations** rather than proposing amendments. The varying perspectives indicate a need for balanced decision-making, aligning with findings in the literature. Blair (2022) identified a similar sentiment in the aviation industry, highlighting that a crewmember commented, “Keep the current FDP rules in place," suggesting contentment with the existing regulations. This emphasizes the importance of evidence-based decision-making when considering regulatory revisions. Revising regulations should not only be grounded in empirical data but should also take into account diverse stakeholder viewpoints to strike an appropriate balance between operational efficiency, economic viability, and safety.

5.3 Perceived Emerging Risks and Fatigue Management During the COVID-19 Pandemic in the South African Aviation Industry

The COVID-19 pandemic has had profound effects on the aviation industry, causing disruptions in operations and unprecedented challenges for crew members worldwide. This section discusses the thoughts of management and decision makers on the impacts of the pandemic on emerging risks and proposed fatigue management within the industry.

5.3.1 Main Impacts, Biggest Concerns, and Additional Fatigue Risks Since the Start of the Pandemic

The COVID-19 pandemic brought about significant impacts, concerns, and fatigue-related risks within the South African aviation industry at the time of this study. This section explores the multifaceted effects of the pandemic on the industry and the well-being of crew members. Participants were asked: "*Since the start of the pandemic, what have been the main impacts on your operation / on the stakeholders you represent / regulate?",* "*What are your biggest concerns for the South Africa aviation industry?",* and *"Do you think that the COVID-19 pandemic and the challenges you have outlined above will present different or additional fatigue risks in your operation / for the stakeholders you represent / regulate?".* Participants highlighted the pandemic's far-reaching economic consequences on the aviation industry and crew members. The economic-induced stress stemming from concerns over job security and income reduction emerged as a predominant impact. The decline in aviation operations led to a surge in job losses, jeopardizing livelihoods and adding to the crew's financial stress, which was reported by participants in this study and in other media (ICAO, 2023a; Li et al., 2023; Sabaner et al., 2022). IATA's estimates underscore the magnitude of the economic setback, with the South African market experiencing a significant revenue decline and job losses (IATA, 2020b). The reduced flight operations prompted crew members' eagerness to return to work, temporarily shifting their focus from fatigue management to job security. This change in priorities may have implications for long-term well-being and operational safety. Increased economic-induced stress was found to be a contributing factor to crew fatigue. Concerns over financial stability hindered crew members' ability to obtain sufficient rest, aligning with prior research (Little *et al.*, 1990; Mohr, 2000; Young, 2008).

The challenges posed by the COVID-19 pandemic significantly impacted crew members in the aviation industry, leading to disruptions in their sleep patterns and raising concerns about fatigue risks. In this section, we will delve into the factors that accentuated fatigue risks and discuss associated mitigations, drawing upon relevant literature to provide a comprehensive understanding. The reduced flight frequencies resulting from pandemic-induced alterations in flight schedules created notable challenges for crew members. Participants in the study emphasized the connection between reduced flight frequency and altered sleep patterns, particularly for crew members accustomed to the reduced frequency of flights and sleeping during the local night. This shift in operations added pressure during overnight flights, as crew members were accustomed to resting during that local night period. Furthermore, a participant highlighted that the lack of available rest facilities during layovers and delays exacerbated the challenges faced by crew members, especially for short-haul commercial crew members. Previous literature has highlighted similar challenges, including layover restrictions affecting rest periods and uneven workload distribution (ICAO, 2023a). Additionally, recent studies have examined fatigue risks specific to the COVID-19 pandemic. For instance, Sun *et al.* (2022) conducted a study on fatigue risk assessment for international flights under the COVID-19 outbreak response exemption policy, emphasizing the importance of coordinating crew rotations and the overall safety of the exemption policy. Similarly, Sun *et al.* (2023) assessed pilot fatigue risk on international flights under the prevention and control policy of the Chinese civil aviation industry during COVID-19, highlighting the feasibility and safety of exemption policies in reducing pilot fatigue risk. Sabaner *et al.* (2022) evaluated fatigue and sleep problems in cabin crews during the early COVID-19 pandemic period, emphasizing the association between fatigue and sleep disturbances with anxiety, fear, and uncertainty surrounding COVID-19. The study suggests that psychosocial support and physical activity may contribute to reducing fatigue in cabin crewmembers.

The pandemic-induced changes in regulatory priorities, driven by reduced flight frequencies and workforce constraints, elevated operational continuity as a priority. This shift introduced potential implications for flight safety and operational efficiency, with possible consequences for crew fatigue. The change in regulatory technique created an atmosphere of apprehension, resulting in a decline in reported instances of fatigue, potentially hindering effective fatigue management strategies. Literature emphasizes the need for operators to proactively manage safety risks through Safety Management Systems (SMS) in the face of similar challenges (ICAO, 2023a). To address additional fatigue challenges, the literature advises implementing measures such as planning buffers, risk assessments, and monitoring trends in pilot discretion usage (ICAO, 2023b).

The pandemic raised significant concerns within the South African aviation industry, ranging from economic sustainability to regulatory and operational challenges. Participants expressed apprehensions about the government's handling of COVID-19 regulations, redundant testing of crew members, safety measures, and changes in operational duties affecting crew workload and potentially leading to extended duty times. The backlog of licenses for crew and operators was identified as an additional fatigue risk, along with regulatory changes such as virtual audits impacting trust between stakeholders. Mitigations suggested in the literature include assessing layover conditions, encouraging a reporting culture for fatigue-related concerns, and strategic aircraft utilization to minimize crew exposure to COVID-19 (ICAO, 2023b). The careful consideration of crew well-being is emphasized in adapting operations to the evolving aviation landscape (IATA, 2022).

The COVID-19 pandemic has not only disrupted the aviation industry operationally but has also taken a toll on the mental health of crew members, as was reported in this study. Other studies such as those by Sabaner *et al.* (2022) and Hilditch and Flynn-Evans (2022) have highlighted the association between increased stress, anxiety, and uncertainty surrounding COVID-19 with fatigue and sleep disturbances among crew members. Crew members expressed heightened stress about job security, reduced income, and the broader implications for the industry's operations, leading to sleepless nights and psychological fatigue. For instance, the fear of job loss upon testing positive for COVID-19 has added significant strain, exacerbated by the absence of normal outlets due to travel restrictions. This psychological burden, coupled with financial stressors, has not only impacted sleep patterns but has also affected overall well-being, potentially compromising operational safety and efficiency.

The reduction in flight frequencies and crew flying due to the COVID-19 pandemic has introduced unique challenges for crew members. While initially, there were limited operations due to travel restrictions, resulting in extended operating hours for crew members, subsequent adjustments such as state-imposed curfews have led to shorter operating days. While this may seemingly reduce fatigue, it also translates to fewer opportunities for crew members to fly, potentially impacting their job satisfaction and psychological well-being. Crew members accustomed to a certain frequency of flights faced disruptions in their routine, leading to uncertainties about future assignments and financial stability. Additionally, the downsizing trend among operators has compelled the remaining crew to take on multiple roles, further escalating their workload and stress levels.

The implementation of COVID-19 safety measures, including mandatory testing and quarantine protocols, has added significant hassle factors for crew members, further complicating their workload. The constant need for COVID-19 testing, especially for crew members involved in international flights, has introduced additional stress and anxiety. For instance, crew members are required to undergo testing even for short trips, leading to logistical challenges and psychological strain. Moreover, the need to comply with various safety protocols such as mandatory mask usage, disinfection procedures, and adherence to quarantine requirements has increased workload and operational complexities. Crew members have to navigate through these additional procedures while ensuring the safety and well-being of passengers, adding to their cognitive load and potentially impacting their performance during flights. The cumulative effect of these hassle factors, coupled with the uncertainty surrounding the pandemic, has contributed to heightened fatigue levels among crew members, necessitating proactive measures to mitigate fatigue-related risks and safeguard operational safety.

5.3.2 Plans to Manage Risks Going Forward

The outbreak of the COVID-19 pandemic has significantly impacted the aviation industry, raising concerns about the management of fatigue risks among flight crew and operators. In this sub-chapter, we delve into the responses of blunt-end stakeholders within the aviation industry concerning the impacts of the COVID-19 pandemic on emerging risks and the proposed strategies to manage fatigue are discussed. Participants were interviewed on their plans to address these risks within their operations or the stakeholders they represent or regulate. When asked about their plans to manage risks, participants emphasized adjustments to regulations and regulation oversight as a primary approach. The proposed amendments to flight and duty period regulations are a fundamental step towards managing fatigue risks effectively in the post-COVID-19 aviation landscape. These proposed changes, including adjustments to flight and duty limits, the number of sectors flown, and the amount of available rest for crew members, align with the findings of Sun *et al.* (2022) and their simulation of flight plans under different policies. Moreover, industry data and research, as highlighted by Hilditch and Flynn-Evans (2022), have consistently shown that extended work hours and insufficient rest periods are linked to fatigue-related incidents. Therefore, the proposed regulatory changes align with established best practices in fatigue risk management.

Additionally, participants emphasized the importance of discouraging operators from pushing crew members to their limits. This strategy aligns with the evidence presented by Sun *et al.* (2023), which highlights the detrimental effects of longer duty periods and reduced rest on fatigue and performance in aviation contexts. However, it is crucial to note the unique challenges posed by the COVID-19 pandemic, which have significantly impacted operational practices and crew dynamics within the aviation industry. While Sun *et al.'s* findings remain pertinent in illustrating the general principles of fatigue management, the specific implications in light of the pandemic's disruptions warrant further examination and consideration in scheduling and operational decision-making. Enhanced training and awareness for crew fatigue emerged as commonly cited strategies to manage fatigue risks post-COVID-19. These strategies find support in the work of Li *et al.* (2023), who applied Quick Coherence Technique (QCT) biofeedback as an intervention to increase pilots' resilience and mitigate the negative impacts of COVID-19. Their findings suggest that regular practice of QCT significantly improves pilots' psychophysiological coherence, contributing to stress reduction and improved cognitive function.

Participants also highlighted the importance of stakeholder engagement in developing insights and recommendations for fatigue management. This approach, as supported by Sabaner *et al.* (2022), is rooted in research in organisational behaviour and safety culture, emphasizing the importance of open communication channels and procedures to address concerns. Furthermore, industry-led projects, proposed as a significant avenue for managing fatigue risks in the aviation sector, align with the findings of Sun *et al.* (2022), who concluded that an exemption policy during the COVID-19 outbreak is safe and feasible for the risk of pilot fatigue. Lastly, effective coordination within operations was identified as a crucial factor in managing and addressing fatigue. The importance of collaboration among different departments and personnel, as highlighted by Hilditch and Flynn-Evans (2022), is supported by organisational psychology and resource management principles. This collaborative approach optimizes resource allocation, minimizes unnecessary disruptions, and implements fatigue management strategies cohesively.

In addition to implementing measures to optimize resource allocation, minimize disruptions, and ensure cohesive fatigue management strategies, it's imperative for aviation stakeholders to prioritize the mental health and well-being of flight crew members. Recent studies have shed light on the significant impact of the COVID-19 pandemic on pilot mental health, emphasizing the need for tailored support mechanisms. Sun *et al.* (2022) and Sun *et al.* (2023) have highlighted the importance of coordinating crew rotations and assessing fatigue risk under exemption policies, demonstrating the necessity of addressing mental health concerns alongside operational adjustments. Furthermore, interventions like the Quick Coherence Technique (QCT) biofeedback, as studied by Li *et al.* (2023), offer promising avenues for enhancing pilots' psychophysiological resilience and reducing stress levels amid challenging operating conditions. Additionally, insights from Sabaner *et al.* (2022) underscore the association between psychosocial support, physical activity, and reduced fatigue among cabin crewmembers, suggesting similar approaches may benefit flight crew. Acknowledging these findings, industry stakeholders must continue to integrate mental health support services, such as health-line counselling, into their fatigue management strategies to ensure the holistic well-being of flight crew members.

5.4 Limitations and Strengths of the Study

5.4.1 Limitations

The study encountered significant challenges arising from the unique circumstances of the COVID-19 pandemic and the nationwide lockdown. These unprecedented conditions disrupted normal operations within the aviation industry, which significantly impacted the availability and willingness of other aviation stakeholders to participate. The study commenced in January 2020, with data collection taking place from October 2020 to January 2021, encompassing a critical period during the ongoing pandemic. A total of 13 participants from diverse sectors were included in the study. However, the limited number of participants may introduce a potential bias in the representation of the South African aviation industry. Despite efforts to involve a broad spectrum of stakeholders, the study's findings may not comprehensively reflect the typical state of affairs within the industry. Invitations to participate were sent to representatives from four major airlines and two non-scheduled operators. However, some declined to participate, which could affect the study's overall applicability. Furthermore, while the study aimed to encompass all sectors of the aviation industry, limitations in participant recruitment, particularly in the context of non-scheduled operations given the lack of access to these operators, may have hindered full representativeness. This constraint could potentially restrict the generalizability of the findings to a broader range of aviation stakeholders.

In addition to these recruitment challenges, the study faced other significant limitations related to the evolving nature of pandemic-related restrictions and industry adaptations. The rapidly changing regulatory environment, fluctuating airline schedules, and varying operational capacities within the aviation sector during the pandemic posed challenges in obtaining consistent and comparable data. These conditions also contributed to potential variability in participant experiences, which may affect the uniformity of the study's findings. Furthermore, the cross-sectional nature of the study design, while suitable for capturing a snapshot of the industry during a specific timeframe, inherently limits its ability to track longitudinal changes or developments within the industry as the pandemic evolved. The absence of longitudinal data makes it difficult to account for how fatigue and other operational stressors may have shifted over time in response to industry adaptations and the gradual easing of restrictions. Consequently, the study's findings should be interpreted within the specific timeframe of data collection, recognizing the ongoing changes in the aviation landscape prompted by the pandemic.

Another notable limitation is the potential for self-report bias among participants, especially considering the sensitive nature of discussing fatigue within the aviation industry. Given the industry's regulatory environment and the professional consequences that fatigue can have for aviation personnel, participants may have been hesitant to disclose their experiences fully. Although anonymity and confidentiality were emphasized, these factors could still influence the data provided, potentially leading to underreporting or selective reporting of fatigue-related experiences.

Despite these limitations, the study contributes valuable insights within the scope of its participants and timeframe, acknowledging the need for cautious interpretation and consideration of these constraints in the broader application of its findings. Given the data collection timeline, the study sought to capture the evolving impact of the pandemic on the aviation industry. However, due to the cross-sectional nature of the study design, it was unable to fully capture the dynamic and constantly evolving nature of the pandemic's impact on the aviation industry. The findings should be interpreted within the specific timeframe of data collection, recognizing the ongoing changes in the aviation landscape prompted by the pandemic.

5.4.2 Strengths

This study contributes valuable insights into fatigue management within the South African aviation industry. It provides a snapshot of the perspectives and practices of key stakeholders, shedding light on a critical issue that impacts aviation safety. The use of interviews allowed for in-depth exploration of participants' views and experiences. This qualitative approach helped uncover nuanced insights and rich data that would have been challenging to obtain through quantitative methods alone.

5.5 Theoretical Implications and Practical Recommendations of the Findings

5.5.1 Theoretical Implications:

This study has uncovered several key findings that have implications. Firstly, the study aligns its findings with the broader global understanding of fatigue recognition. By emphasizing the need for universal fatigue management strategies, the research underscores the importance of consistency in addressing fatigue-related challenges across different contexts. This highlights the significance of a specific to the operation approach to fatigue management in safety-critical industries. Secondly, the study sheds light on the influence of hazardous attitudes in fatigue management. It identifies psychological factors, such as crew mentality and attitude towards fatigue, that play a significant role in fatigue and underscores the necessity for interventions that target behavioural change among individuals involved in safety-critical industries. This recognition of crew mentality and attitude towards fatigue as key contributors to fatigue provides new insights into the theoretical framework of fatigue management, drawing specifically from the sub-chapters 'Perceived concerns around fatigue in the South African aviation industry' and 'Perceived contributing factors to fatigue in the South African aviation industry.' Thirdly, the research illuminates a significant incongruity between existing regulations in fatigue management and the advancements in sleep and circadian science. While scientific understanding of fatigue, its causes, and mitigation strategies has grown substantially in recent years, regulatory frameworks often lag behind in integrating these insights effectively. Specifically, there is a disparity between the evolving evidence-based approaches recommended by scientific research and the regulatory measures currently in place. This discrepancy underscores the need for regulatory frameworks to adapt to the latest scientific findings promptly. For instance, current regulations may not fully reflect the complexity of fatigue dynamics or adequately address emerging issues such as the impact of long-duration flights, non-traditional work schedules, or individual differences in fatigue susceptibility. Consequently, there is a risk that regulatory practices may not optimally safeguard individuals and operations against the multifaceted challenges posed by fatigue. In essence, this finding emphasizes the importance of aligning regulatory practices with contemporary scientific knowledge to ensure that fatigue management strategies remain effective and responsive to evolving safety concerns within safety-critical industries.

Furthermore, the study recognizes the complexity of the various factors contributing to fatigue. By acknowledging the multifaceted origins of fatigue, it informs the development of holistic fatigue management strategies that take into account not only physical but also psychological and contextual factors, such as crew mentality and attitudes. One notable aspect illuminated by our findings is the presence of vertical integration within the realm of fatigue management. Rasmussen's hierarchy of risk management, as discussed in the literature review, provides a conceptual framework for understanding this integration. According to Rasmussen (1997), safety regulation operates across different hierarchical levels, encompassing societal regulations at the apex and engineering disciplines at the foundational level. Our study resonates with this hierarchical perspective, as we observed a correspondence between overarching regulatory frameworks and their practical implementation within specific workplace contexts. For instance, our findings underscore the alignment between necessary legislative changes and the attitudes towards fatigue observed among those responsible for managing or regulating. The findings also align, in part, with Blair’s (2022) findings, which garnered responses from crew. This alignment suggests a vertical integration wherein regulatory mandates at higher levels influence and shape attitudes and practices at operational levels. However, it's crucial to note instances where vertical integration may encounter challenges or gaps. While our study highlights alignment in certain areas, it also identifies areas where discrepancies or disconnects exist between regulatory mandates and their implementation. These gaps may stem from factors such as varying interpretations of regulations or insufficient enforcement mechanisms.

At the organisational level, our research aligns with the functions of management scientists and occupational sociologists, emphasizing the need for understanding and enforcing rules within specific organisations. Our findings highlight the specific call for adaptive regulatory frameworks. This call goes beyond recognizing the misalignment; it emphasizes the necessity for regulatory systems that are agile and responsive to emerging scientific findings. The highlighted statement emphasizes the dynamic nature of this discrepancy and advocates for regulatory frameworks that actively incorporate new scientific insights. It serves as a pointed reminder that mere acknowledgment of the misalignment is insufficient; proactive steps must be taken to bridge the gap between regulation and scientific progress in fatigue management. Finally, at the fundamental level, fatigue management intersected with engineering disciplines and the establishment of standard operating procedures (SOPs). This aspect underscored our emphasis on recognizing the multifaceted origins of fatigue. In safety-critical industries, engineering disciplines played a crucial role in designing systems and processes that mitigated fatigue-related risks. These disciplines encompassed various aspects, including ergonomic design of workspaces, optimization of shift schedules, and integration of technology to monitor and manage fatigue levels effectively. Moreover, the development of SOPs was essential for ensuring consistency and adherence to best practices in fatigue management across different operational scenarios. SOPs delineated protocols for tasks, breaks, and workload distribution, aiming to minimize the onset and impact of fatigue on operational performance. By acknowledging the involvement of engineering disciplines and SOP development at the fundamental level, our study underscored the holistic approach required for effective fatigue management. It emphasized the need to consider not only psychological and contextual factors but also the structural and procedural aspects that contributed to fatigue dynamics within safety-critical industries. Rasmussen's model emphasizes the importance of considering disruptions and the design of processes and equipment, aligning with our approach to holistic fatigue management. In essence, the study aligns with and extends the applicability of Rasmussen’s hierarchy, illustrating how our findings resonate with the various levels of regulation and control within safety-critical industries. This integration reinforces the importance of our research in contributing to a more effective theoretical framework for fatigue management.

5.5.2 Practical Recommendations:

This section provides specific recommendations based on the study's findings, aiming to offer actionable steps for enhancing operational safety and fatigue management within the industry. The focus shifts from broad implications to concrete recommendations, aligning with the identified challenges and nuances revealed by the research.

Prioritizing risk perception in fatigue management practices is critical. Risk perception involves the ability of individuals within the operational environment to accurately identify, assess, and respond to potential hazards associated with fatigue. Industry stakeholders should make risk perception a central element of fatigue management strategies. This approach encompasses recognizing the presence of risk, understanding its potential consequences, and evaluating its likelihood. Developing a culture that emphasizes the proactive identification and assessment of potential risks in day-to-day operations will enable organizations to address safety concerns and mitigate potential hazards before they escalate. The findings underscore the need for enhanced awareness and responsive measures to address emerging fatigue-related risks.

A regulatory framework that acknowledges the specific challenges faced in operations beyond scheduled aviation is essential. Regulatory reforms should account for the distinctive characteristics of various operational contexts. Comprehensive data collection from diverse operational environments is crucial to inform the regulatory process effectively. Gathering data from different sectors will provide insights into unique challenges and requirements, ensuring that regulatory reforms address the nuanced needs of each sector. This dual approach—targeting individual attitudes and behaviours while aligning with operational intricacies—will promote efficiency and effectiveness in regulatory outcomes. This recommendation addresses the latent themes related to the diverse operational contexts revealed in the study.

Operator responsiveness, in conjunction with technology-driven reporting tools and monitoring systems, is vital. While these tools are valuable, their effectiveness relies on the proactive engagement of operators in reporting fatigue incidents and adhering to recommended interventions. Fostering a culture of open communication and accountability within organizations is necessary. This includes not only discussing the functionalities and benefits of technological tools but also developing strategies for their adoption and optimization in real-world contexts. Comprehensive training for personnel, streamlining reporting processes, and integrating fatigue management protocols into existing safety frameworks are critical steps. Additionally, evidence-based regulatory updates responsive to evolving scientific understanding and operational demands should be considered, such as revising duty-hour limitations or incorporating new biomathematical models for fatigue risk assessment.

The economic impact of the COVID-19 pandemic has compounded fatigue by introducing stressors such as job insecurity and income reduction. Developing targeted interventions to alleviate economic stress among crew members, including financial support programs and stability assurances, is recommended. Enhancing sleep management and rest facilities is crucial. The pandemic has highlighted the need for improved rest environments and accommodations to support altered sleep patterns caused by reduced flight schedules. Upgrading rest facilities at layover locations, with particular attention to short-haul commercial crew members, is advised. Partnerships with airports and accommodation providers should be explored to enhance rest environments and ensure access to adequate facilities.

Mental health concerns, including increased stress, anxiety, and sleep disturbances, have become significant. Comprehensive mental health support should be integrated into fatigue management strategies. This includes implementing counselling and stress management workshops, and incorporating interventions such as Quick Coherence Technique (QCT) biofeedback to enhance resilience and reduce stress. Promoting a supportive work culture that prioritizes mental health and well-being is essential for addressing the holistic needs of flight crew members and improving overall fatigue management.

Strengthening stakeholder engagement and collaboration is vital for developing and implementing effective fatigue management strategies. Involving operators, regulators, and crew members in the development of fatigue management practices will provide valuable insights and foster collaborative approaches. Regular forums should be established for stakeholders to discuss fatigue management and operational challenges. Joint initiatives between operators, regulators, and crew members should be developed to address emerging risks. Encouraging open communication and feedback mechanisms is crucial for continuously improving fatigue management strategies and ensuring they respond to the evolving needs of the aviation industry.

5.6 Suggestions for Future Research

Given the qualitative nature of the current study and the specific research questions aimed at exploring subjective experiences and perceptions surrounding fatigue in the aviation industry, it is important to consider the rationale behind the chosen methodology. While objective measures such as actigraphy, sleep diaries, and psychomotor vigilance tasks offer valuable insights into sleep-wake behaviour, alertness, and performance in crew, they may not fully capture the nuanced and contextual aspects of fatigue experiences among blunt-end stakeholders. Blair's (2022) study, which employed both qualitative and quantitative methods, focused on examining fatigue prevalence and contributing factors among sharp-end stakeholders, namely pilots and cabin crew. In contrast, our study adopts a qualitative approach to explore the perspectives of blunt-end stakeholders, including management and decision-makers within the aviation industry. This distinction highlights the complementary nature of research efforts in addressing the multifaceted issue of fatigue. Blair's research provides quantitative prevalence rates and correlations, while our qualitative study delves into the subjective experiences, perceptions, and contextual factors influencing fatigue among pilots and crew from perspective of the blunt-end stakeholders.

To comprehensively understand fatigue in the aviation industry, future research endeavours should incorporate both sharp-end and blunt-end stakeholders, integrating a mixed-measure approach of qualitative and quantitative methods. Sharp-end stakeholders, such as pilots and cabin crew, offer frontline perspectives, while blunt-end stakeholders, including management and decision-makers, provide crucial organisational insights. This integrated approach ensures greater vertical integration, capturing a holistic view of fatigue within aviation operations. Quantitative measures play a pivotal role in providing statistical validation and broader generalizability to qualitative findings. By triangulating qualitative insights with quantitative data, researchers can not only uncover underlying patterns and trends but also validate subjective experiences reported by stakeholders from both ends of the spectrum. This triangulation not only enriches the depth of understanding but also enhances the reliability and credibility of findings. Such an integrated approach is essential for informing evidence-based interventions and policy decisions aimed at mitigating fatigue-related risks in aviation operations. By considering the perspectives of all stakeholders and employing a mixed-methods approach, researchers can develop more robust strategies to address the multifaceted nature of fatigue in the aviation industry.

Furthermore, to improve precision and comprehensiveness, future research should embrace a mixed-methods approach that delves into the diverse sectors of the aviation industry, encompassing commercial long-haul and short-haul operations as well as non-scheduled operations like firefighting, medical flight operations, training operations, and recreational operations. This pivot in research direction addresses a noted gap in both global and South African aviation research, where previous studies predominantly cantered on self-reported fatigue prevalence among commercial pilots. Exploring these various facets within the industry is imperative as it promises to illuminate previously investigated areas, offering a deeper understanding of the factors contributing to fatigue and proposing effective management strategies. By venturing beyond the confines of commercial aviation, researchers can gain insights into unique challenges and fatigue dynamics present in non-scheduled operations, thereby contributing significantly to the overarching goal of fatigue management within the aviation sector.

Considering the impact of the COVID-19 pandemic on aviation operations, future research should delve into industry-specific pandemic protocols and their implications on an already stretched crew. This aligns with the critical focal point identified in the problem statement, emphasizing the need to understand how the altered operational landscape has affected pilots and crew fatigue. Exploring the delicate balance between safety protocol adherence and crew well-being directly addresses the concerns raised by IFALPA, providing practical insights for managing fatigue under challenging conditions. To address the concerns raised by IFALPA regarding the impact of the pandemic on an already stretched crew, it is essential to consider the constraints posed by a limited trained crew. As noted during discussions with industry experts, the available crew initially operated under tight conditions, with concerns expressed about crew members who were not available at the pandemic's onset.

CHAPTER 6 - CONCLUSION

In conclusion, this study has provided an extensive examination of crew fatigue within the South African aviation industry, focusing on perspectives from those less involved in direct operations. The research has highlighted critical insights into the prevalence, contributing factors, regulatory implications, and impacts of crew fatigue, particularly in the context of the COVID-19 pandemic. The findings reveal a broad acknowledgment of crew fatigue as a pressing issue among industry professionals, with concerns raised about its impact on safety, operational efficiency, and crew well-being. Variations in perceptions of fatigue risks were noted, with some participants emphasizing that well-managed operations were less vulnerable to fatigue-related issues. The analysis of contributing factors reveals the complexity of crew fatigue within the South African context. Key drivers include economic stressors, regulatory inadequacies, adverse environmental conditions, and operational challenges. This underscores the intricate interplay of individual, organizational, and environmental factors in shaping fatigue risk. The study also identifies shortcomings in current flight and duty period regulations, with participants expressing concerns about the effectiveness of existing frameworks. They advocated for reforms to improve crew rest provisions, address scheduling issues, and create a more adaptable and responsive regulatory environment.

The COVID-19 pandemic has introduced significant challenges to managing crew fatigue, amplifying existing stressors and introducing new operational dynamics. Shifts in crew morale, regulatory changes, and operational adjustments in response to the pandemic highlight the necessity for flexible and resilient fatigue management strategies. Future research should continue to explore the complex interactions between individual, organizational, and regulatory factors affecting crew fatigue. Additionally, developing evidence-based interventions tailored to industry-specific challenges is crucial for effective fatigue management. For stakeholders in the South African aviation industry, adopting a proactive and collaborative approach is essential. Leveraging the insights from this study can guide the development of targeted interventions, regulatory reforms, and best practices to mitigate fatigue risks and foster a culture of safety and resilience. Despite the study's limitations, such as a limited participant pool, the qualitative depth provided valuable perspectives. However, it is important to acknowledge the potential biases and constraints that may have influenced the findings. The unique circumstances surrounding the COVID-19 pandemic and subsequent nationwide lockdowns created challenges in participant recruitment, particularly from sectors less directly impacted by pandemic-related operational changes. As discussed in Chapter 5, the study's participant pool was restricted, resulting in potential underrepresentation of certain segments within the South African aviation industry. The challenges of recruiting participants from non-scheduled operators, for example, highlight the difficulties in achieving a fully representative sample during this period. These limitations may have introduced biases in the results, as the study's findings could reflect the perspectives of those more accessible during the pandemic rather than a comprehensive cross-section of the industry.

Additionally, the evolving nature of the pandemic, coupled with fluctuating regulatory and operational environments, introduces temporal constraints that limit the generalizability of the findings. The cross-sectional design, although capturing a critical snapshot during the pandemic, lacks the ability to track longitudinal changes in fatigue risk or operational dynamics. As such, the study's results should be interpreted with an understanding of the temporal specificity of the data collection period. The potential for self-report bias is also a consideration, as the sensitive nature of discussing fatigue in a regulated industry may have led to underreporting or selective reporting, despite measures taken to ensure confidentiality. Another factor to consider is the potential influence of pandemic-related stressors on participant responses, which could have skewed perceptions of fatigue or its impacts. For instance, heightened economic pressures during this period may have exacerbated concerns over job security, potentially amplifying the reporting of fatigue-related issues. While these limitations do not detract from the study's contributions, they do underscore the need for cautious interpretation when applying these findings more broadly across different contexts or timeframes.

Enhancing risk perception in fatigue management practices remains crucial. Organizations should foster a culture of proactive risk identification and assessment.

This includes implementing regular training programs to increase staff awareness of fatigue-related hazards and their potential consequences. Developing and integrating tools for real-time risk assessment into operational procedures is also essential. Establishing feedback mechanisms will facilitate ongoing evaluation and improvement of risk perception practices. Regulatory frameworks must adapt to address the specific challenges faced in various operational contexts. Effective regulatory reform requires comprehensive data collection from diverse environments to inform updates. Regulations should cater to the unique needs of different aviation sectors, including those impacted by economic and operational pressures. Engaging industry stakeholders in periodic reviews and updates of regulatory standards will ensure their relevance and effectiveness.

Enhancing operator responsiveness and integrating technology-driven tools is vital. Operators should adopt and effectively utilize reporting systems and monitoring tools for fatigue management. Comprehensive training on these tools and adherence to fatigue management protocols are necessary. Streamlining reporting processes will enable timely identification and resolution of fatigue incidents, and incorporating user feedback will improve tool functionality. Addressing the economic and operational stressors exacerbated by the COVID-19 pandemic is important. Developing targeted interventions to alleviate economic stress among crew members, such as financial support programs and stability assurances, is recommended. Additionally, enhancing sleep management and upgrading rest facilities, especially at layover locations, will support altered sleep patterns. Exploring partnerships with airports and accommodation providers can further improve rest environments.

Integrating comprehensive mental health support into fatigue management strategies is essential. Implementing counselling services, stress management workshops, and interventions such as the Quick Coherence Technique (QCT) for biofeedback can address mental health concerns. Promoting a supportive work culture through regular mental health awareness campaigns is also necessary. Strengthening stakeholder engagement is crucial for effective fatigue management. Establishing regular forums for operators, regulators, and crew members will facilitate discussions on fatigue management challenges and solutions. Developing joint initiatives to address emerging risks and promoting open communication and feedback mechanisms will enhance collaboration. This study lays a foundation for future research in fatigue management within the South African aviation industry. It underscores the importance of objective measures, a mixed-methods approach, and sector-specific insights for refining fatigue management strategies. As the aviation industry evolves, so must our understanding of crew fatigue risks. This research contributes valuable insights that can inform discussions and decisions regarding fatigue management and other operational risks. By unravelling the complexities of fatigue and offering practical recommendations, this study provides a framework for stakeholders, including regulators, managers, and crew representatives, to navigate the balance between operational efficiency and the well-being of aviation professionals.

For regulators, implementing standardized fatigue management protocols that incorporate objective measures and insights from a mixed-methods approach is imperative. These protocols should be tailored to the unique challenges of the South African aviation industry. Ongoing collaboration with industry stakeholders will ensure the effectiveness and adaptability of regulatory frameworks. Managers should prioritize the implementation of Fatigue Risk Management Systems (FRMS) that allow crew members to report fatigue concerns without fear of reprisal. Proactive scheduling practices based on scientific evidence can mitigate fatigue-related risks while maintaining efficiency. Crew representatives, including unions and professional associations, should advocate for integrating crew input into fatigue management strategies. This includes soliciting feedback on scheduling, workload management, and rest facilities to ensure that measures align with the needs of frontline aviation professionals. The recommendations aim to foster a holistic approach to fatigue management that considers the perspectives of regulators, managers, and crew representatives. By implementing these recommendations, stakeholders can work together to protect the well-being of aviation professionals and uphold industry operational integrity. The ongoing evolution of scientific insights and industry priorities necessitates continuous assessment of regulatory adaptability, particularly in the face of disruptions like the COVID-19 pandemic. The significance of this research extends beyond immediate challenges, highlighting the enduring importance of effective fatigue management in aviation.

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APPENDICES

Appendix A – Civil Aviation Regulation Part 121 Flight time and Duty period

PART 121: AIR TRANSPORT OPERATIONS – CARRIAGE ON AEROPLANES OF MORE THAN 19 PASSENGERS OR CARGO

121.02.13 Flight time and duty period scheme

DIVISION THREE: FLIGHT TIME AND DUTY LIMITATIONS

Flight time and duty period scheme

121.02.13 (1) An air service operator shall –

(a) establish a scheme for the regulation of flight time and duty periods, rest periods and days free of duty as applicable, for each flight crew member, cabin crew member and flight operations officer that –

(i) complies with the flight time and duty period limitations, rest periods and days free of duty, prescribed in Document SA-CATS 121; or

(ii) a system of flight time and duty period limitations, rest periods and days free of duty proposed by the operator where the Director is of the opinion that an equivalent level of safety may be achieved by the operator's proposed scheme; and

(b) publish the scheme referred to in sub-regulation (1)(a) in the operations manual referred to in regulation 121.04.2.

(2) The operator shall not assign and no crew member shall accept an assignment if such assignment is not in compliance with the provisions of the scheme referred to in sub-regulation (1)(a) or if -

(a) the operator or crew member knows or has been made aware that such flight assignment will cause the crew member to exceed the flight time and duty periods referred to in sub-regulation (1)(a) while on flight duty; or

(b) the crew member is suffering from or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from fatigue which may endanger the safety of the aeroplane or its crew members and passengers.

(3) The operator shall not schedule a flight crew member for active flight duty for a period exceeding eight consecutive hours during any given flight time and duty period unless authorised in the scheme referred to in sub-regulation (1)(a).

(4) Where any flight crew member, cabin crew member or flight operations officer is aware of any reason they would be in violation of the scheme referred to in sub-regulation (1)(a), that person shall, without delay, inform the operator. For the purposes of this regulation, the operator shall be taken to mean –

(a) the appropriate management personnel if time permits;

(b) the duty crew scheduler of the operator; or

(c) the duty person responsible for operational control over the flight; and

(d) in the case of a cabin crew member, the PIC or such cabin crew member's immediate supervisor.

(5) The provisions to be included in a flight time and duty scheme referred to in sub regulation (1) shall be as prescribed in Document SA-CATS 121.

Fatigue risk management system

121.02.14 (1) An air service operator who establishes a scheme for the regulation of flight time and duty periods in accordance with subparagraph (*a*) (ii) of sub-regulation 121.02.13 (1) shall establish a fatigue risk management system for the purpose of managing fatigue.

(2) An operator's fatigue risk management system shall contain, as a minimum—

(*a*) a fatigue risk management policy;

(*b*) fatigue risk management processes;

(*c*) safety assurance processes; and

(*d*) fatigue risk management system promotion processes, each described in Document SA-CATS 121.

(3) The operator shall designate a person responsible for the fatigue risk management system who meets the qualifications and experience requirements, and who will be responsible for the functions prescribed in Document SA-CATS 121.

(4) A fatigue risk management system established in terms of sub-regulation (1) shall—

(*a*) be based upon scientific principles, knowledge and operational experience with the aim of ensuring that flight crew and cabin crew members are performing at an adequate level of alertness; and (*b*) be integrated with the safety management system.

Approval of a fatigue risk management system

121.02.15 (1) An operator shall submit to the Director its proposed fatigue risk management system which complies with the requirements of subregulation 121.02.14 (2).

(2) The Director shall approve the commencement of a trial phase for implementation of the proposed fatigue risk management system for a trial period of up to 36 months if the Director is satisfied that the operator has complied with the provisions of sub-regulation 121.02.14 (2).

(3) At any time during the approved trial phase, the Director may withdraw the approval if it becomes evident that the operator does not comply with the provisions of the system or the regulations.

(4) During the trial phase the operator may implement the proposed maximum and minimum flight time and duty values, as determined by the operator and approved by the Director.

(5) After a 24 months period an operator, approved under sub-regulation 121.02.15 (2), may apply to the Director for full approval by providing evidence that the fatigue risk management system is delivering the required safety outcomes.

(6) Where the Director is satisfied that the evidence provided under paragraph (5) is acceptable, the Director shall issue a full approval to implement the fatigue risk management system.

Fatigue risk management system manual

121.02.16 The operator shall draw up a fatigue risk management system manual containing all the information required under this Part, and publish the content in its operations manual, as prescribed in Document SA-CATS 121.

Appendix B – Civil Aviation Regulations Part 135 Flight Times and Duty Periods

PART 135: AIR TRANSPORT OPERATIONS – CARRIAGE OF LESS THAN 20 PASSENGERS OR CARGO

135.02.9 Flight time and duty period scheme

Division Three: Flight time and duty limitations

Flight time and duty period scheme

135.02.9 (1) An air service operator shall –

(a) establish a scheme for the regulation of flight time and duty periods, rest periods and days free of duty as applicable, for each flight crew member that –

(i) complies with the flight time and duty period limitations, rest periods and days free of duty, prescribed in Document SA-CATS 135; or

(ii) is a system of flight time and duty period limitations, rest periods and days free of duty proposed by the operator where the Director is of the opinion that an equivalent level of safety may be achieved by the operator's proposed scheme; and

(b) publish the scheme referred to in sub-regulation (1)(a) in the operations manual referred to in regulation 135.04.2.

(2) The operator shall not assign and no flight crew member shall accept an assignment if such assignment is not in compliance with the provisions of the scheme referred to in subregulation (1)(a) or if –

(a) the operator or flight crew member knows or has been made aware that such flight assignment will cause the flight crew member to exceed the flight time and/or duty periods referred to in sub-regulation (1)(a) while on duty; or

(b) the flight crew member is suffering from or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from fatigue which may endanger the safety of the aeroplane or its flight crew members and passengers.

(3) The operator shall not schedule a flight crew member for flight time for a period exceeding eight consecutive hours during any given duty period unless authorised in the scheme referred to in sub-regulation (1)(a).

(4) Where any flight crew member is aware of any reason they would be in violation of the scheme referred to in sub-regulation (1)(a), that person shall, without delay, inform the operator. For the purposes of this regulation, the operator shall be taken to mean –

(a) the appropriate management personnel if time permits;

(b) the duty crew scheduler of the operator; or

(c) the duty person responsible for operational control over the flight.
Division Three: Flight time and duty limitations

Flight time and duty period scheme

135.02.9 (1) An air service operator shall—

(*a*) establish a scheme for the regulation of flight time and duty periods, rest periods and days free of duty as applicable, for each flight crew member that—

(i) complies with the flight time and duty period limitations, rest periods and days free of duty, prescribed in Document SA-CATS 135; or

(ii) is a system of flight time and duty period limitations, rest periods and days free of duty proposed by the operator where the Director is of the opinion that an equivalent level of safety may be achieved by the operator's proposed scheme; and

(*b*) publish the scheme referred to in subregulation (1) (*a*) in the operations manual referred to in regulation 135.04.2.

(2) The operator shall not assign and no flight crew member shall accept an assignment if such assignment is not in compliance with the provisions of the scheme referred to in subregulation (1) (*a*) or if—

(*a*) the operator or flight crew member knows or has been made aware that such flight assignment will cause the flight crew member to exceed the flight time and/or duty periods referred to in subregulation (1) (*a*) while on duty; or

(*b*) the flight crew member is suffering from or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from fatigue which may endanger the safety of the aeroplane or its flight crew members and passengers.

(3) The operator shall not schedule a flight crew member for flight time for a period exceeding eight consecutive hours during any given duty period unless authorised in the scheme referred to in subregulation (1) (*a*).

(4) Where any flight crew member is aware of any reason they would be in violation of the scheme referred to in subregulation (1) (*a*), that person shall, without delay, inform the operator. For the purposes of this regulation, the operator shall be taken to mean—

(*a*) the appropriate management personnel if time permits;

(*b*) the duty crew scheduler of the operator; or

(*c*) the duty person responsible for operational control over the flight.

Fatigue risk management system

135.02.10 (1) An air service operator who establishes a scheme for the regulation of flight time and duty periods in accordance with subparagraph (*a*) (ii) of sub-regulation 135.02.9 (2) shall establish a fatigue risk management system for the purpose of managing fatigue.

(2) An operator's fatigue risk management system shall contain, as a minimum—

(*a*) a fatigue risk management policy;

(*b*) fatigue risk management processes;

(*c*) safety assurance processes; and

(*d*) fatigue risk management system promotion processes, each described in Document SA-CATS 135.

(3) The operator shall designate a person responsible for the fatigue risk management system who meets the qualifications and experience requirements, and who will be responsible for the functions prescribed in Document SA-CATS 135.

(4) A fatigue risk management system established in terms of sub-regulation (1) shall—

(*a*) be based upon scientific principles, knowledge and operational experience with the aim of ensuring that flight crew and cabin crew members are performing at an adequate level of alertness; and

(*b*) be integrated with the safety management system.

Approval of a fatigue risk management system

135.02.11 (1) An operator shall submit to the Director its proposed fatigue risk management system which complies with the requirements of subregulation 135.02.10 (2).

(2) The Director shall approve the commencement of a trial phase for implementation of the proposed fatigue risk management system for a trial period of up to 36 months if the Director is satisfied that the operator has complied with the provisions of sub-regulation 135.02.10 (2).

(3) At any time during the approved trial phase, the Director may withdraw the approval if it becomes evident that the operator does not comply with the provisions of the system or the regulations.

(4) During the trial phase the operator may implement the proposed maximum and minimum flight time and duty values, as determined by the operator and approved by the Director.

(5) After a 24 months period an operator, approved under sub-regulation 135.02.11 (2), may apply to the Director for full approval by providing evidence that the fatigue risk management system is delivering the required safety outcomes.

(6) Where the Director is satisfied that the evidence provided under paragraph (5) is acceptable, the Director shall issue a full approval to implement the fatigue risk management system.

Fatigue risk management system manual

135.02.12 The operator shall draw up a fatigue risk management system manual containing all the information required under this Part, and publish the content in its operations manual, as prescribed in Document SA-CATS 135.

Cabin crew emergency evacuation stations

135.02.13 A cabin crew member, assigned to perform evacuation duties, shall occupy the seat provided for that purposes during take-off and landing, or when so directed by the pilot-in-command for safety purposes.

Seating of cabin crew members during flight

135.02.14 During take-off and landing, and whenever deemed necessary by the PIC in the interests of aviation safety, cabin crew members shall be seated at their assigned stations or seats, on all decks that are occupied by passengers.

Appendix C - South African Civil Aviation Technical Standards Part 121 Flight Time and Duty Period

121.02.13 FLIGHT TIME AND DUTY PERIODS SCHEME

Note – *CAR 121.02.13 requires each air service operator to establish a scheme for the administration of flight time and duty periods. Operators are reminded that they bear sole responsibility for such schemes being in full compliance with any Acts, laws and regulations that are external to the South African Civil Aviation Regulations, notwithstanding any approvals given by the SACAA.*

1. Definitions

(1) Any word or expression to which a meaning has been assigned in the Act and the Civil Aviation Regulations, bears, when used in this technical standard, the same meaning unless the context indicates otherwise.

(2) In addition, the definition of “duty period” is applicable to flight operations officers employed by an operator.

(3) Time spent on flight watch or home reserve may also be deemed to be part of a rest period as provided in section 8(2)(e) of this technical standard.

2. Maximum flight time

(1) An operator may not exceed the following maximum flight times –

(a) 40 hours during the preceding seven days;

(b) 120 hours during the preceding thirty days;

(c) 300 during the preceding 90 days; or

(d) 1000 hours during the preceding 365 days.

(2) If a flight crew member expects his or her cumulative flight hours projected for a particular operation, to exceed the appropriate limit the flight crew member shall inform the operator accordingly.

(3) Every flight crew member is required to inform the operator of all flying he or she has undertaken if the cumulative amount of such flying and any scheduled duties is likely to exceed the maximum laid down in the Regulations.

3. Operators’ schemes and their approval

(1) An operator shall submit a proposed scheme for the regulation of flight time and duty periods and minimum rest periods to the Director for approval which shall be based upon scientific principles and knowledge, where available, with the aim of ensuring that crew members are performing at an adequate level of alertness.

(2) Any deviation from the approved scheme shall be submitted to the Director for consideration.

(3) Non-availability of auto pilot or auto stabilisation systems requires a reduction in flight time and duty period in respect of public air transport and IFR operations.

4. General principles of control of flight, duty and rest time

(1) The prime objective of any scheme of flight time and duty limitations is to ensure that flight crew members are adequately rested at the beginning of each flight duty period (FDP). Aeroplane operators will therefore need to take account of inter-related planning constraints on –

(a) individual duty and rest periods;

(b) the length of cycles of duty and the associated periods of rest; and

(c) cumulative duty hours within specific periods.

(2) Duties shall be scheduled within the limits of the operator's scheme. To allow for unforeseeable delays the pilot-in-command (PIC) may, within prescribed conditions, use his or her discretion to exceed the limits on the day. Nevertheless, flight schedules shall be realistic, and the planning of duties shall be designed to avoid as far as possible exceeding the flight time and duty limits.

(3) Other general considerations in the sensible planning of duties are –

(a) the need to construct consecutive work patterns which will avoid as far as possible such undesirable rostering practices as alternating day/ night duties and the positioning of flight crews in a manner likely to result in a serious disruption of established sleep/work patterns;

(b) the need, particularly where flights are carried out on a programmed basis, to allow a reasonable period for the pre-flight notification of duty to flight crews, other than those on standby duty; and

(c) the need to plan time off and also to ensure that crew members are notified of their allocation well in advance.

5. Responsibilities of crew members

It is the responsibility of all flight crew members to make optimum use of the opportunities and facilities for rest provided by the operator, and to plan and use their rest periods properly so as to minimise the risk of fatigue.

6. Standard provisions required for an operator's scheme

(1) The standard provisions which the Director regards as the basis for an acceptable scheme of flight time and duty limitations and which, if included in an operator's scheme, will facilitate approval by the Director are contained in sections 7 to 13 below.

(2) Although operators are expected to plan their schemes in accordance with the requirements, it is however, recognised that the standard provisions will not

necessarily be completely adaptable to every kind of operation. In exceptional circumstances therefore, operators may apply to have variations from the standard provisions included in their schemes. However, such variations should be kept to a minimum and approval will only be granted where an operator can show that these proposed provisions will ensure an equivalent level of protection against fatigue.

7. Limitations of single flight duty periods – flight deck crew

Note – *Tables 1-4 referred to in this section may be found at the end of this technical standard.*

7.1 Maximum rostered flight duty periods

The maximum rostered FDP (in hours) shall be in accordance with Table 1 or 2, or Table 3 or 4. Rostering limits in the tables may be extended by in-flight relief or split duty under the terms of sections 7.2 and 7.3. On the day, the PIC may at his or her discretion further extend the FDP actually worked in accordance with section 7.6.

(1) Maximum FDP – Two pilot crews: Aeroplanes

Table 1 applies when the FDP starts at a place where the flight crew member is acclimatised to local time, and Table 2 applies to other times. To be considered acclimatised for the purpose of this technical standard, a flight crew member shall be allowed three consecutive local nights free of duty within a local time zone band which is two hours wide. He or she will thereafter be considered to remain acclimatised to that same time zone band until he or she ends a duty period at a place where local time falls outside this time zone band.

(2) Maximum FDP – Two pilots plus additional flight crew member: Aeroplanes

Table 3 applies when the FDP starts at a place where the flight crew member is acclimatised to local time, and Table 4 applies at other times. To be considered acclimatised for the purposes of this technical standard, a flight crew member shall be allowed three consecutive local nights free of duty within a local time zone band which is two hours wide. He or she will thereafter be considered to remain acclimatised to that same time zone band until he or she ends a duty period at a place where local time falls outside this time zone band.

(3) Limits on two flight crew long range operations

(This paragraph does not apply to cabin crew members)

When an aeroplane flight deck crew comprises only two pilots, the allowable FDP is calculated as follows: A sector scheduled for more than 7 hours is considered as a multi-sector flight, as below:

Scheduled sector times	Acclimatised to local time Sectors	Not acclimatised to local time Sectors
Sector length over 7 hrs but not more than 9 hrs	2	4
Sector length over 9 hrs but not more than 11 hrs	3	4
Sector length over 11 hrs	4	Not applicable

7.2 Extension of flight duty period by in-flight relief

(1) When any additional flight crew member is carried to provide in-flight relief for the purpose of extending a FDP, he or she shall hold qualifications which will meet the requirements of the operational duty for which he or she is required as a relief.

(2) When in-flight relief is provided, there shall be available, for the flight crew member who is resting, a comfortable reclining seat or bunk separated and screened from the flight deck and passengers.

(3) A total of in-flight rest of less than three hours will not count towards extension of an FDP, but where the total of in-flight rest (which need not be consecutive) is three hours or more, the rostered FDP may be extended beyond that permitted in Tables 1 and 2 or 3 and 4 by –

(a) if rest is taken in a bunk, a period equal to one-half of the total of rest taken, provided that the maximum FDP permissible is 18 hours (or 19 hours in the case of cabin crew members); and

(b) if rest is taken in a seat, a period equal to one-third of the total of rest taken, provided that the maximum FDP permissible is 15 hours (or 16 hours in the case of cabin crew members).

(4) The maximum extension allowable is equivalent to that applying to the basic flight crew member with the least rest.

(5) Where a flight crew member undertakes a period of in-flight relief and after its completion is wholly free of duty for the remainder of the flight, that part of the flight

following completion of duty may be classed as positioning and be subject to the controls on positioning detailed in section 7.4.

7.3 Extension of flight duty period by split duty

When a FDP consists of two or more flight duties separated by less than a minimum rest period, then the FDP may be extended beyond that permitted in the tables by the amounts indicated below –

Consecutive hour rest	Maximum extension of the FDP
Less than 3 3 – 10	Nil Period equal to half of the consecutive hours rest taken

The rest period shall not include the time required for immediate post-flight and pre-flight duties. When the rest period is not more than six hours it will be sufficient if a quiet and comfortable place is available, not open to the public, but if the rest period is more than six consecutive hours, then a bed shall be provided.

7.4 Positioning

All time spent on positioning as required by the operator is classed as duty, but positioning as a passenger does not count as a sector when assessing the maximum permissible FDP. Positioning, as required by the operator, which immediately precedes a FDP, is included as part of the FDP for the purpose of section 7.1.

7.5 Travelling time

(1) Travelling time other than that time spent on positioning may not be classed as duty time and may not be included in cumulative totals of duty hours.

Note – *Travelling time from home to departure aerodrome can become an important factor if long distances are involved. If the journey time from home to the normal departure aerodrome is lengthy, flight crew members should make arrangements for accommodation nearer to their bases to ensure adequate pre-flight rest.*

(2) Where travelling time between the aerodrome and sleeping accommodation provided by the operator exceeds thirty minutes each way, the rest period shall be increased by the amount of the excess, or such lesser time as is consistent with a minimum of ten hours at the sleeping accommodation.

(3) When flight crew members are required to travel from their home to an aerodrome other than the one from which they normally operate, the assumed travelling time from the normal aerodrome to the other aerodrome is classed as positioning and is subject to the controls of positioning detailed in section 7.4.

7.6 Pilot-in-command's discretion to extend a flight duty period

(1) A PIC may, at his or her discretion, extend a FDP beyond the maximum normally permitted, provided he or she is satisfied that the flight can safely be made. In these circumstances the maximum normally permitted is calculated according to what actually happens, not on what was planned to happen. The operator's scheme shall include guidance to PICs on the limits within which discretion to extend a FDP may be exercised. An extension of three hours beyond the maximum normally permitted should be regarded as the maximum, except in cases of emergency.

Note – *It is important to note that the PIC discretion shall take into consideration whether or not a ". . . crew member is suffering from or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from fatigue which may endanger the safety of the aeroplane or its crew members and passengers . . ." as provided in CAR 121.02.13*(*2*)(*b*).

(2) Whenever a PIC so exercises his or her discretion, he or she shall report it to the operator and, should the maximum normally permitted be exceeded by more than two hours, both the PIC and the operator shall submit a written PIC's discretion report – extension of flying duty period, to the Director within thirty days.

Notes –

1. Discretion reports either concerning extension of a FDP in excess of two hours or reduction of a rest period shall be submitted in the PIC's Discretion Report form, which is available from the SACAA. Those reports will be used by the Director when assessing the realism of particular schedules.

2. An emergency in respect of an extension of a FDP is a situation which in the judgment of the PIC presents serious risk to health or safety.

7.7 Delayed reporting time

When flight crew members are informed of a delay before leaving their place of rest the FDP starts at the new reporting time or four hours after the original reporting time, whichever is the earlier. The maximum FDP is based on the original reporting time. This subsection does not apply if flight crew members are given ten hours or more notice of a new reporting time.

8. Rest periods

(1) It is the responsibility of the operator to notify flight crew members of a FDP and not to schedule them for duty other than flight watch or home reserve, so that adequate and, within reason, uninterrupted pre-flight rest can be obtained by the flight crew before the commencement of the next FDP. Away from base the operator shall provide the opportunity and facilities for the flight crew to obtain adequate pre-flight rest. It is the operator's responsibility to ensure that rest accommodation is satisfactory. When operations are carried out at such short notice that it is impracticable for an operator to ensure that rest accommodation is satisfactory, it will be the PIC's responsibility to obtain satisfactory accommodation.

(2) The following rest period requirements shall be followed –

(a) each flight duty period, as well as flight watch and home reserve, shall be preceded by a rest period of at least –

(i) nine consecutive hours including a local night;

(ii) ten consecutive hours; or

(iii) if the preceding FDP, adjusted for split duty, exceeds eleven hours, an additional rest period shall be provided for in the operator's scheme to the satisfaction of the Director;

(b) where a flight crew member has completed two consecutive FDPs, the aggregate of which exceeds eight hours flight time or eleven hours flight duty time (extensions by in-flight relief or split-duty disregarded), and the intervening rest period has been less than twelve consecutive hours embracing the hours between 22h00 and 06h00 local time, he or she shall have a rest period on the ground of at least twelve consecutive hours embracing the hours between 22h00 and 06h00 local time or so much longer as to embrace these hours prior to commencing any further duties, but not necessarily longer than twenty-four consecutive hours; provided that this requirement does not apply in respect of consecutive flight watch and home reserve duties;

(c) following fifty hours of duty of any nature associated with his or her employment, except flight watch and home reserve duty, a flight crew member shall have a rest period of not less than twenty-four consecutive hours before commencing further duties;

(d) when a flight crew member has completed a flight time and duty period in excess of eighteen hours, he or she shall receive a rest period of at least eighteen hours including a local night before he or she commences any further duties; and

(e) time spent on flight watch and home reserve duty prior to a FDP shall not be counted when determining the limitations associated with the FDP.

(3) Pilot-in-command's discretion to reduce a rest period

A PIC may, at his or her discretion, reduce a rest period to below the minimum required by sections 8(2) and 12(2)(b). The exercise of such discretion shall be considered exceptional and should not be used to reduce successive rest periods. A rest period shall be long enough to allow flight crew members at least eight hours rest, at the accommodation where the rest is taken. If a rest period is reduced, the PIC shall submit a report to his or her employer, and if the reduction exceeds two hours, a written report shall be submitted to the Director within thirty days. (See note 1 to section 7.6(2)).

(4) For the purpose of calculating the minimum rest period before commencement of flight duty, the required post-flight duties on completion of the previous FDP is added to such FDP.

9. Duty periods

(1) The following limits apply –

Duty	Maximum duration
Flight watch	No limit* Home reserve
No limit* Positioning	No maximum**
Standby	Maximum 12 hours (not necessarily consecutive) in any 24 hour period
Standby + FDP	+20 hours

* However, the provisions of paragraph (2) apply.

** However, the provisions of section 7.4 apply.

(2) For the purpose of calculating duty time, the following applies –

(a) for the calculation of accumulated duty time in terms of section 11, flight watch and home reserve is credited on the basis of eight hours for every period of twenty-four or fewer consecutive hours, or on a one-for-one basis, whichever is the lesser;

(b) standby duty time shall count fully as duty time for the calculation of accumulated duty time in terms of sections 8(2)(c) and (d) and 11; and

(c) see section 7.4 in respect of positioning time.

10. Days off

Flight crew members shall –

(a) not work more than seven consecutive days between days off;

(b) have two consecutive days off in any consecutive fourteen days;

(c) have a minimum of six days off in any consecutive four weeks at the aerodrome from which they normally operate; and

(d) have an average of at least eight days off in each consecutive four week period, averaged over three such periods.

11. Cumulative duty and flying hours

Maximum cumulative duty hours: The average weekly total of duty hours may not exceed sixty hours over seven days, or fifty hours averaged over any four consecutive weeks. All types of duty, flight duty, ground duty, split duty, stand-by and positioning is counted in full for this purpose. Any period of seven or more consecutive days within which the flight crew member is employed on duty other than flight duty, flight watch or home reserve, standby or positioning is not included in calculating the above average weekly total of duty hours.

12. Cabin crew members

(1) The requirements detailed in this section are applicable to all cabin crew members carried as cabin crew members.

(2) The limitations which apply to cabin crew members are those contained in sections 7 to 11 applicable to flight deck crew members, but with the following adjustment –

(a) rostered FDPs may not be more than one hour longer than those permitted to flight deck crew members and contained in section 7.1. In order to remove anomalies which might arise when cabin crew members and flight deck crew members report at different times for the same flight, the maximum FDP for cabin crew members shall be based on the time at which the flight deck crew start their FDP;

(b) rostered minimum rest periods must not be more than one hour shorter than those required by flight deck crew as contained in section 8(2);

(c) for the purpose of a FDP extension following in-flight rest by cabin crew members –

(i) a period of a minimum of two consecutive hours of rest shall allow for the extension of such FDP by half the actual rest period; and

(ii) where in-flight rest is provided for more than three hours, the provisions of section 8(2)(a)(iii) apply;

(d) the combined sum of standby duty and following FDP may not exceed 21 hours;

(e) the average weekly total of duty hours may not exceed fifty-five hours; and

(f) the annual and monthly limits on flying hours need not be applied.

13. Flight operations officer or flight follower maximum duty and rest periods

(1) An operator's flight time and duty period scheme shall also include the requirements detailed in this section applicable to all flight operations officers and flight followers.

(2) The maximum duty period to which a flight operations officer or flight follower may be assigned are –

(a) where the entire duty period falls between the hours of 06h00 and 23h59 local time a flight operations officer or a flight follower may be assigned to a maximum duty period of 10 consecutive hours; and

(b) where any part of the duty period falls between the hours of 00h00 and 05h59 a flight operations officer or flight follower may be assigned to a maximum duty period of eight consecutive hours.

(3) Upon completion of any duty period, a flight operations officer or flight follower shall receive a rest period of not less than 10 consecutive hours.

(4) Where necessitated by unforeseen operational circumstances, any duty period prescribed in paragraph (2) above may be extended by a maximum of two hours provided –

(a) the flight operations officer or flight follower has had a rest period of not less than 12 consecutive hours immediately preceding the duty period; and

(b) the maximum cumulative duty hours in any 6 day period does not exceed, in the case of a duty period prescribed in paragraph (2)(a), 66 duty hours; and in the case of a duty period prescribed in paragraph (2)(b), 54 duty hours.

(5) A duty period shall include the time taken to perform all hand-off procedures as laid down in the operator's operations manual.

(6) Each the flight operations officer or flight follower shall receive not less than one day off in every seven day period exclusive of any earned holidays or allowed sick leave.

14. Records to be maintained

(1) An operator shall retain flight crew member flight time and duty period records as provided in CAR 121.04.6.

(2) An operator shall retain all PIC discretion reports of extended FDPs and reduced rest periods for a period of at least six months.

TABLES to Technical Standard 121.02.13

Table 1 – Maximum flight duty period: Two pilot crews – aeroplanes: acclimatised to local time

Local time of start	Sectors							
	1	2	3	4	5	6	7	8 or more
0500 – 0659	13	12¼	11½	10¾	10	9¼	9	9
0700 – 1359	14	13¼	12½	11¾	11	10¼	9½	9
1400 – 2059	13	12¼	11½	10¾	10	9¼	9	9
2100 – 2159	12	11¼	10½	9¾	9	9	9	9
2200 – 0459	11	10¼	9½	9	9	9	9	9

Table 2 – Maximum flight duty period: Two pilot crews – aeroplanes: not acclimatised to local time

Length of preceding rest	Sectors						
	1	2	3	4	5	6	7 or more

Up to 18 or over 30	13	12¼	11½	10¾	10	9¼	9
Between 18 and 30	12	11¼	10½	9¾	9	9	9

Note – *The reason that available duty times are less following rest periods inside 18 – 30 hours is the aeromedical advice that the quality of rest is less due to the disturbance of the body's natural rhythm.*

Table 3 – Maximum flight duty period: Basic crew consisting of three flight crew members – aeroplanes certified for three crews members: acclimatised to local time

Local time of start	Sectors						
	1	2	3	4	5	6	7	8 or more
0500 – 0659	13	12¼	11½	10¾	10	9¼	9	9
0700 – 1359	14	13¼	12½	11¾	11	10¼	9½	9
1400 – 2059	13	12¼	11½	10¾	10	9¼	9	9
2100 – 2159	12	11¼	10½	9¾	9	9	9	9
2200 – 0459	11	10¼	9½	9	9	9	9	9

Table 4 – Maximum flight duty period: Basic crew consisting of three flight crew members – aeroplanes certified for three flight crew members: not acclimatised to local time

Length of preceding rest (hours)	Sectors						
	1	2	3	4	5	6	7 or more
Up to 18 or over 30	13	12¼	11½	10¾	10	9¼	9

Between 18 and 30	12	11¼	10½	9¾	9	9	9

Note – *The reason that available duty times are less following rest periods inside 18 – 30 hours is the aeromedical advice that the quality of rest is less due to the disturbance of the body's natural rhythm.*

Appendix D - South African Civil Aviation Technical Standards Part 135 Flight Time and Duty Period

135.02.9 FLIGHT TIME AND DUTY PERIOD SCHEME

Note – *CAR 135.02.9 requires each operator to establish a scheme for the administration of flight time and duty periods. Operators are reminded that they bear sole responsibility for such schemes being in full compliance with any Acts, Laws and Regulations that are external to the South African Civil Aviation Regulations, notwithstanding any approvals given by the SACAA.*

1. General

Time spent on flight watch or home reserve may also be deemed to be part of a rest period as provided in section 8(2)(e) of this technical standard.

2. Maximum flight time

(1) An operator may not allow nor may a flight crew member exceed the following maximum flight times –

(a) 10 hours during any duty period of which a maximum of eight hours may be consecutive, except that single-pilot night VFR or IFR operations in an aeroplane without a serviceable autopilot are restricted to 8 hours in a duty period;

(b) during the preceding seven days –

(i) for a single-pilot operation, 35 hours;

(ii) for a multi-pilot operation, 40 hours; and

(iii) for mixed single- and multi-pilot operations, 37.5 hours;

(c) during the preceding thirty days –

(i) for a single-pilot operation, 100 hours;

(ii) for a multi-pilot operation, 120 hours; and

(iii) for mixed single- and multi-pilot operations, 110 hours;

(d) 300 during the preceding 90 days; or

(e) 1000 hours during the preceding 365 days.

(2) If a flight crew member expects his or her projected cumulative flight hours for a particular operation to exceed the appropriate limit, the flight crew member shall inform the operator accordingly.

3. Operators' schemes and their approval

(1) An operator shall submit a proposed scheme for the regulation of flight time and duty periods and minimum rest periods to the Director for approval.

(2) Any deviation from the approved scheme shall be submitted to the Director for consideration.

4. General principles of control of flight, duty and rest time

(1) The prime objective of any scheme of flight time and duty limitations is to ensure that flight crew members are adequately rested at the beginning of each flight duty period (FDP). Aeroplane operators will therefore need to take account of inter-related planning constraints on –

(a) individual duty and rest periods;

(b) the length of cycles of duty and the associated periods of rest; and

(c) cumulative duty hours within specific periods.

(2) Duties shall be scheduled within the limits of the operator's scheme. To allow for unforeseeable delays the pilot-in-command (PIC) may, within prescribed conditions, use his or her discretion to exceed the limits on the day. Nevertheless, flight schedules shall be realistic and the planning of duties shall be designed to avoid as far as possible exceeding the flight time and duty limits.

(3) Other general considerations in the sensible planning of duties are –

(a) the need to construct consecutive work patterns which will avoid as far as possible such undesirable rostering practices as alternating day/night duties and the positioning of flight crews in a manner likely to result in a serious disruption of established sleep/work patterns;

(b) the need, particularly where flights are carried out on a programmed basis, to allow a reasonable period for the pre-flight notification of duty to flight crews, other than those on standby duty; and

(c) the need to plan time off and also to ensure that flight crews are notified of their allocation well in advance.

5. Responsibilities of flight crew members

It is the responsibility of all flight crew members to make optimum use of the opportunities and facilities for rest provided by the operator and to plan and use their rest periods properly so as to minimise the risk of fatigue.

6. Standard provisions required for an operator’s scheme

(1) The standard provisions which the Director regards as the basis for an acceptable scheme of flight time and duty limitations and which, if included in an operator’s scheme, will facilitate approval by the Director are contained in sections 7 to 13 below.

(2) Although operators are expected to plan their schemes in accordance with the requirements, it is however, recognised that the standard provisions will not necessarily be completely adaptable to every kind of operation. In exceptional circumstances therefore, operators may apply to have variations from the standard provisions included in their schemes. However, such variations should be kept to a minimum and approval will only be granted where an operator can show that these proposed provisions will ensure an equivalent level of protection against fatigue.

7. Limitations of single flight duty periods – flight deck crew

Note – *The tables referred to in this section may be found in section 12 of this technical standard.*

7.1 Maximum rostered flight duty periods

The maximum rostered FDP (in hours) shall be in accordance with Table 1, or Table 2 or 3, or Table 4 or 5. Rostering limits in the tables may be extended by in-flight relief or split duty under the terms of sections 7.2 and 7.3. On the day, the PIC may at his or her discretion further extend the FDP actually worked in accordance with section 7.6.

(1) Maximum FDP – Two pilot crews

Table 2 applies when the FDP starts at a place where the flight crew member is acclimatised to local time and Table 3 applies to other times. To be considered acclimatised for the purpose of this technical standard, a flight crew member shall be allowed three consecutive local nights free of duty within a local time zone band which is two hours wide. He or she will thereafter be considered to remain acclimatised to that same time zone band until he or she ends a duty period at a place where local time falls outside this time zone band.

(2) Maximum FDP – Two pilots plus additional flight crew member

Table 4 applies when the FDP starts at a place where the flight crew member is acclimatised to local time, and Table 5 applies at other times. To be considered acclimatised for the purposes of this technical standard, a flight crew member *shall* be allowed three consecutive local nights free of duty within a local time zone band which is two hours wide. He or she will thereafter be considered to remain acclimatised to that same time zone band until he or she ends a duty period at a place where local time falls outside this time zone band.

(3) Limits on two flight crew long range operations

(a) When an aeroplane flight deck crew comprises only two pilots, the allowable FDP is calculated as follows. A sector scheduled for more than 7 hours is considered as a multi-sector flight, as below –

Scheduled sector times	Sectors	
	Acclimatised to local time	Not acclimatised to local time
Sector length over 7 hrs but not more than 9 hrs	2	4
Sector length over 9 hrs but not more than 11 hrs	3	4
Sector length over 11 hrs	4	Not applicable

(b) Table 2 is then entered with the start time of the flight duty period and the “modified” number of sectors, to determine the allowable FDP.

(c) When an additional, current, type rated pilot is a flight crew member, then these limits do not apply and the permissible FDP is determined by entering Table 2 or 3 with time of start and the actual sectors planned.

7.2 Extension of flight duty period by in-flight relief

(1) When any additional flight crew member is carried to provide in-flight relief for the purpose of extending a FDP, he or she shall hold qualifications which will meet the requirements of the operational duty for which he or she is required as a relief.

(2) When in-flight relief is provided, there shall be available, for the flight crew member who is resting, a comfortable reclining seat or bunk separated and screened from the flight deck and passengers.

(3) A total of in-flight rest of less than three hours will not count towards extension of an FDP, but where the total of in-flight rest (which need not be consecutive) is three hours or more, the rostered FDP may be extended beyond that permitted in Tables 2 and 3 or 4 and 5 by –

(a) if rest is taken in a bunk, a period equal to one half of the total of rest taken, provided that the maximum FDP permissible is 18 hours; and

(b) if rest is taken in a seat, a period equal to one third of the total of rest taken, provided that the maximum FDP permissible is 15 hours.

(4) The maximum extension allowable is equivalent to that applying to the basic flight crew member with the least rest.

(5) Where a flight crew member undertakes a period of in-flight relief and after its completion is wholly free of duty for the remainder of the flight, that part of the flight following completion of duty may be classed as positioning and be subject to the controls on positioning detailed in section 7.4.

7.3 Extension of flight duty period by split duty

When a FDP consists of two or more flight duties separated by less than a minimum rest period, then the FDP may be extended beyond that permitted in the tables by the amounts indicated below –

Consecutive hours rest	Maximum extension of the FDP
Less than 3	Nil
3 – 10	Period equal to half of the consecutive hours rest taken

The rest period shall not include the time required for immediate post-flight and pre-flight duties. When the rest period is not more than six hours it will be sufficient if a quiet and comfortable place is available, not open to the public, but if the rest period is more than six consecutive hours, then a bed shall be provided.

7.4 Positioning

All time spent on positioning as required by the operator is classed as duty, but positioning as a passenger does not count as a sector when assessing the maximum permissible FDP. Positioning, as required by the operator, which immediately precedes a FDP, is included as part of the FDP for the purpose of section 7.1.

7.5 Travelling time

(1) Travelling time other than that time spent on positioning may not be classed as duty time and may not be included in cumulative totals of duty hours.

Note – *Travelling time from home to departure aerodrome can become an important factor if long distances are involved. If the journey time from home to the normal departure aerodrome is lengthy, flight crew members should make arrangements for accommodation nearer to their bases to ensure adequate pre-flight rest.*

(2) Where travelling time between the aerodrome and sleeping accommodation provided by the operator exceeds thirty minutes each way, the rest period shall be increased by the amount of the excess, or such lesser time as is consistent with a minimum of ten hours at the sleeping accommodation.

(3) When flight crew members are required to travel from their home to an aerodrome other than the one from which they normally operate, the assumed travelling time from the normal aerodrome to the other aerodrome is classed as positioning and is subject to the controls of positioning detailed in section 7.4.

7.6 Pilot-in-command's discretion to extend a flight duty period

Note – *It is important to note that the PIC discretion shall take into consideration whether or not a ". . . crew member is suffering from or, having regard to the circumstances of the flight to be undertaken, is likely to suffer from fatigue which may endanger the safety of the aeroplane or its flight crew members and passengers . . ." as specified in CAR 135.02.9*(*2*)(*b*).

(1) A PIC may, at his or her discretion, extend a FDP beyond the maximum normally permitted, provided he or she is satisfied that the flight can safely be made. In these circumstances the maximum normally permitted is calculated according to what actually happens, not on what was planned to happen. The operator's scheme shall include guidance to PICs on the limits within which discretion to extend a FDP may be exercised. An extension of three hours beyond the maximum normally permitted should be regarded as the maximum, except in cases of emergency.

(2) Whenever a PIC so exercises his or her discretion, he or she shall report it to the operator and, should the maximum normally permitted be exceeded by more than two hours, both the PIC and the operator shall submit a written PIC's discretion report – extension of flight duty period, to the Director within thirty days.

Notes –

1. Discretion reports either concerning extension of a FDP in excess of two hours or reduction of a rest period shall be submitted to the Director. Those reports will be used by the Director when assessing the realism of particular schedules. The information required to be submitted and an example of the form may be obtained from the SACAA.

2. An emergency in respect of an extension of a FDP is a situation which in the judgment of the PIC presents serious risk to health or safety.

7.7 Delayed reporting time

When flight crew members are informed of a delay before leaving their place of rest the FDP starts at the new reporting time or four hours after the original reporting time, whichever is the earlier. The maximum FDP is based on the original reporting time. This subsection does not apply if flight crew members are given ten hours or more notice of a new reporting time.

8. Rest periods

(1) It is the responsibility of the operator to notify flight crew members of a FDP and not to schedule them for duty other than flight watch or home reserve, so that adequate and, within reason, uninterrupted pre-flight rest can be obtained by the flight crew before the commencement of the next flight duty period. Away from base the operator shall provide the opportunity and facilities for the flight crew to obtain adequate pre-flight rest. It is the operator's responsibility to ensure that rest accommodation is satisfactory. When operations are carried out at such short notice that it is impracticable for an operator to ensure that rest accommodation is satisfactory, it will be the PIC's responsibility to obtain satisfactory accommodation.

(2) The following rest period requirements shall be followed –

(a) each flight duty period, as well as flight watch and home reserve, shall be preceded by a rest period of at least –

(i) nine consecutive hours including a local night;

(ii) ten consecutive hours; or

(iii) if the preceding FDP, adjusted for split duty, exceeds eleven hours, an additional rest period shall be provided for in the operator's scheme to the satisfaction of the Director;

(b) where a flight crew member has completed two consecutive FDPs, the aggregate of which exceeds eight hours flight time or eleven hours flight duty time (extensions by in-flight relief or split-duty disregarded), and the intervening rest period has been less than twelve consecutive hours embracing the hours between 22h00 and 06h00 local time, he or she shall have a rest period of at least twelve consecutive hours embracing the hours between 22h00 and 06h00 local time or so much longer as to embrace these hours prior to commencing any further duties, but not necessarily longer than twenty-four consecutive hours; provided that this requirement does not apply in respect of consecutive flight watch and home reserve duties;

(c) following fifty hours of duty of any nature associated with his or her employment, except flight watch and home reserve duty, a flight crew member shall have a rest period of not less than twenty-four consecutive hours before commencing further duties;

(d) when a flight crew member has completed a FDP in excess of eighteen hours, he or she shall receive a rest period of at least eighteen hours including a local night before he or she commences any further duties; and

(e) time spent on flight watch and home reserve duty prior to a FDP shall not be counted when determining the limitations associated with the flight duty period.

(3) Pilot-in-command's discretion to reduce a rest period

A PIC may, at his or her discretion, reduce a rest period to below the minimum required by section 8(2) and 12(2)(b). The exercise of such discretion shall be considered exceptional and should not be used to reduce successive rest periods. A rest period shall be long enough to allow flight crew members at least eight hours rest at the accommodation where the rest is taken. If a rest period is reduced, the PIC shall submit a report to his or her employer and if the reduction exceeds two hours, a written report shall be submitted to the Director within thirty days. (See note 1 to section 7.6(2)).

(4) For the purpose of calculating the minimum rest period before commencement of flight duty, the required post-flight duties on completion of the previous FDP is added to such FDP.

9. Duty periods

(1) The following limits apply –

Duty	Maximum duration
Flight watch	No limit*
Home reserve	No limit*
Positioning	No maximum**
Standby	Maximum 12 hours (not necessarily consecutive) in any 24 hour period
Standby + FDP	20 hours

* However, the provisions of paragraph (2) apply.

** However, the provisions of section 7.4 apply.

(2) For the purpose of calculating duty time, the following applies –

(a) for the calculation of accumulated duty time in terms of section 11, flight watch and home reserve is credited on the basis of eight hours for every period of twenty-four or fewer consecutive hours or on a one-for-one basis, whichever is the lesser;

(b) standby duty time shall count fully as duty time for the calculation of accumulated duty time in terms of sections 8(2)(c) and (d) and 11; and

(c) see section 7.4 in respect of positioning time.

10. Days off

Flight crew members shall –

(1) not work more than seven consecutive days between days off; and

(2) have two consecutive days off in any consecutive fourteen days; and

(3) have a minimum of six days off in any consecutive four weeks at the aerodrome from which they normally operate; and

(4) have an average of at least eight days off in each consecutive four week period, averaged over three such periods.

11. Cumulative duty hours

The average weekly total of duty hours may not exceed sixty hours over seven days or fifty hours averaged over any four consecutive weeks. All types of duty, flight duty, split duty, stand-by and positioning is counted in full for this purpose. Any period of seven or more consecutive days within which the flight crew member is employed on duty other than flight duty, flight watch or home reserve, standby or positioning is not included in calculating the above average weekly total of duty hours.

12. Tables

Table 1: Maximum flight duty period: Single-pilot crews – aeroplanes certified for single-pilot operations

Local time of start	Sectors				
	Up to 4	5	6	7	8 or more
0500 – 0659	10	9¼	8½	8	8
0700 – 1359	11	10¼	9½	8¾	8
1400 – 2059	10	9¼	8½	8	8
2100 – 0459	9	8¼	8	8	8

Note – *Pilots engaged in repetitive short flights, with an average eight or more take-offs and landings per hour, shall have a break of at least thirty minutes within any continuous period of three hours away from the aircraft; however for the purpose of this technical standard each such series of repetitive flights shall be counted as a single sector.*

Table 2: Maximum flight duty period: Two pilot crews – aeroplanes: Acclimatised to local time

Local time of start	Sectors							
	1	2	3	4	5	6	7	8 or more
0500 – 0659	13	12¼	11½	10¾	10	9¼	9	9
0700 – 1359	14	13¼	12½	11¾	11	10¼	9½	9

1400 – 2059	13	12¼	11½	10¾	10	9¼	9	9
2100 – 0459	12	11¼	10½	9¾	9	9	9	9
2200 – 0459	11	10¼	9½	9	9	9	9	9

Table 3: Maximum flight duty period: Two pilot crews – aeroplanes: Not acclimatised to local time

Length of preceding rest (hours)	Sectors						
	1	2	3	4	5	6	7 or more
Up to 18 or over 30	13	12¼	11½	10¾	10	9¼	9
Between 18 and 30	12	11¼	10½	9¾	9	9	9

Note – *The reason that available duty times are less following rest periods inside 18–30 hours is the aeromedical advice that the quality of rest is less due to the disturbance of the body's natural rhythm.*

Table 4: Maximum flight duty period: Basic crew consisting of three flight crew members – aeroplanes certified for three crew members: Acclimatised to local time

Local time of start	Sectors							
	1	2	3	4	5	6	7	8 or more
0500 – 0659	13	12¼	11½	10¾	10	9¼	9	9
0700 – 1359	14	13¼	12½	11¾	11	10¼	9½	9
1400 – 2059	13	12¼	11½	10¾	10	9¼	9	9
2100 – 2159	12	11¼	10½	9¾	9	9	9	9
2200 – 0459	11	10¼	9½	9	9	9	9	9

Table 5: Maximum flight duty period: Basic crew consisting of three flight crew members aeroplanes certified for three flight crew members: Not acclimatised to local time

Length of preceding rest (hours)	Sectors						
	1	2	3	4	5	6	7 or more
Up to 18 or over 30	13	12¼	11½	10¾	10	9¼	9
Between 18 and 30	12	11¼	10½	9¾	9	9	9

Note – *The reason that available duty times are less following rest periods inside 18–30 hours is the aeromedical advice that the quality of rest is less due to the disturbance of the body's natural rhythm.*

13. Records to be maintained

(1) An operator shall retain flight crew member flight time and duty period records as provided in CAR 135.04.6.

(2) An operator shall retain all PIC discretion reports of extended FDPs and reduced rest periods for a period of at least six months.

Appendix E – Email Recruiting Participants to Partake in the Study

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

HUMAN KINETICS & ERGONOMICS

Tel: (046) 603 7369 • Fax: (046) 603 8934 • e-mail: j.davy@ru.ac.za

Letter to the Participant

Dear ,

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

Background of the study

There has been debate within the aviation industry about whether the current Flight and Duty Periods (FDPs) regulations are in line with latest scientific and operational knowledge relating to fatigue management. Various stakeholders have agreed that these regulations need to be updated, but for this to happen there is a need to carry out research within the entire South African aviation industry.

However, the COVID-19 pandemic has impacted the world and the aviation industry – with various travel restrictions affecting the number of passengers, loss in revenue, and a loss in jobs. In addition, with the restart of the industry, the International Air Transport Association (IATA) and International Civil Aviation Authority (ICAO) warn that the industry needs to continue to manage fatigue because of concerns over its additional risks.

This will serve as an important step to identifying the perceived impact of COVID-19 pandemic towards fatigue and fatigue management within the different parts of the aviation industry, which can assist in the identification of emerging risks and proposed fatigue management in the aviation industry, while allowing the researchers to pinpoint 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 interview that aims to investigate the perceived changes in emerging risks and proposed fatigue management within the different parts of the aviation industry before and after the COVID-19 pandemic.

Who should participate?

Stakeholders in the South African aviation industry that the study wishes to examine and then seeks out research participants who cover that full range of perspectives. The participants include senior members of the ALPA-SA, relevant SACAA management (schedule and fatigue management), and management, the chief executive officer (CEO), and representatives from AASA and CAASA.

Structure of the Interview

The interview is online and administered through ZOOM or any means deemed appropriate by the participants. This will be a secure online platform that only the research team and the participant have access to. The interview consists of (#) sections:

1. Greeting

2. A description of the primary and secondary research questions

3. The personnel involved in the study

4. The process to be followed by the interviewer

5. Consent – Consent to partake in the study and to be recorded.

6. Questions Section:

6.1. Demographic Information – General personal and professional information – (which pat of the aviation industry you work for, experience – questions)

6.2. Understandings and Experiences on Fatigue – Its prevalence and impact it may have on the working environment – (questions)

6.3. Understandings and Experiences on Emerging Risks – Impact of work and non-work-related factors and their contribution to fatigue before and after the impact of the COVID-19 pandemic – (questions)

6.4. Understandings and Experiences on Fatigue Management – comments on fatigue management in the industry before and after the impact of the COVID-19 pandemic – (questions).

Once the interview has been completed, your recorded answers will then be transcribed using Otter.Ai, a software that allows only the research team to have access to the recorded text for further analysis. The interview will take between 15 – 25 minutes.

Ethical Considerations

The completion of this interview is voluntary, and you should only complete the interview once. Upon completion of the interview, your response will only kept and analysed by researchers at the Human Kinetics and Ergonomics Department at Rhodes University. While participation is not anonymous, no data captured will be linked to your any of your personal details and a special code will be assigned to each participant to ensure their anonymity and that of your operation or group you represent. Please note that you may choose to stop participating in the data collection process at any stage should you feel you wish to with no recourse. 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. In addition, gate-keeper's permission was required from each group that was interviewed, as confirmation that the various safety-management stakeholders bodies agree to allow their stakeholders may be part of the study.

Should you have any concerns relating to this project, you may contact the researchers (details below) of the Ethics coordinator at Rhodes University Mr Siyanda Manqele at s.manqele@ru.ac.za.

Thank you for your participation in this study.

Yours sincerely,

Dr Jonathan Davy
Principal researcher and supervisor
Cell: +27 72 226 0430
Email: jonathan.davy@ru.ac.za

Mr. Darryl Clark
BSc.
Cell: +27 79 666 3792
Email: darrylmalcolmclark@gmail.com

Appendix F – The Interview Protocol for the Study

1. Greeting

Good morning/afternoon (participant),

Thank you for joining us today and agreeing to participate in our research project:

FATIGUE AND ITS' CONTRIBUTING FACTORS IN THE SOUTH AFRICAN AVIATION INDUSTRY DURING THE COVID-19 PANDEMIC: PERSPECTIVES FROM BLUNT-END STAKEHOLDERS.

I trust that you are all well and rested. My name is Darryl Clark, and I will be conducting your interview while Jono sits in to ensure everything runs smoothly. The interview process will run according to the interview schedule that was attached in the email invitation to the participant.

Do you have any questions before we begin the informative section of the interview schedule?

2. A description of the primary and secondary research questions

Firstly, let us begin with a quick description of the research project's aim and objectives.

The study will aim to explore the self-reported prevalence of fatigue and its contributory factors from the perspective of management and decision makers in operations in the South African aviation industry, while exploring the possible impact of the COVID-19 pandemic on the fatigue and its contributory factors.

The objectives of this study therefore are:

> 1. To determine aviation management and decision makers' experiences and insights into the prevalence of fatigue and its contributory factors in the South African aviation industry.
>
> 2. To explore this group's perspectives on the current Flight and Duty Regulations in relation to fatigue in the South African aviation industry.

3. To determine the impacts of the COVID-19 pandemic on the emerging risks and proposed management of fatigue in the industry.

3. The personnel involved in the study

In Addition, Dr Davy (principal investigator) and myself, Darryl Clark, (postgraduate student) form part of a larger research team in the department of Human Kinetics and Ergonomics at Rhodes University investigating the fatigue in the South African aviation industry.

4. The process to be followed by the interviewer

Finally, the processes to be followed during the recorded section of the interview schedule includes disclosure of ethical considerations, consent to partake in the study, and finally the questions pertaining to the research project.

During which you the participant will ensure you understand and consent to the ethical considerations of the research project. Following the disclosure of ethics and approval of consent, I will ask you the questions pertaining to the research project. Please answer the questions clearly and rich in detail. Any further questions?

5. Consent – Consent to partake in the study and to be recorded.

The completion of this interview is voluntary, and you should only complete the interview once. Upon completion of the interview, your response will only be kept and analysed by researchers at the Human Kinetics and Ergonomics Department at Rhodes University. While participation is not anonymous, no data captured will be linked to your any of your personal details and a special code will be assigned to each participant to ensure their anonymity and that of your operation or group you represent. Please note that you may choose to stop participating in the data collection process at any stage should you feel you wish to with no recourse. 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. In addition, gate-keeper's permission was required from each group that was interviewed, as confirmation that the various safety-management stakeholders bodies agree to allow their stakeholders may be part of the study. Furthermore, the participant’s answered interview questions will be recorded.

Do you understand what I have just read for you and do you consent to partake in the study and be recorded.

6. Questions Section:

Finally, we come to the questions section of the interview.

Demographic Information

Age?

Sex?

What is your job title?

What part of the aviation industry do you work in?

How long have you worked in your present job?

Are you involved in fatigue management in your role? If so, how?

Understandings and Experiences on Fatigue Questions

Prior to the COVID 19 pandemic, do you think that crew fatigue was a concern in your operation / in the stakeholders you represent / regulate and if so, why?

Understandings and Experiences of Emerging Risks Questions

Prior to the COVID19 pandemic, if you thought that fatigue was a safety concern in your operation / in the stakeholders you represent / regulate, what do you think were the main contributing factors to crew fatigue?

Do you think that awareness of crew fatigue has changed over the last 5 years in the industry in general and if so, why?

What are your thoughts on the current South African Flight and Duty Period regulations in relation to mitigating fatigue risks in your operation / in the stakeholders you represent / regulate?

Based on your answer, what recommendations would you make around amending the current FDP regulations in South Africa in relation to your operation / in the stakeholders you represent / regulate?

Since the start of the pandemic, what have been the main impacts on your operation / on the stakeholders you represent / regulate?

What are your biggest concerns for the South Africa aviation industry?

Understandings and Experience of Fatigue Management Questions

Do you think that the COVID-19 pandemic and the challenges you have outlined above will present different or additional fatigue risks in your operation / for the stakeholders you represent / regulate? If so, what do you think these would be?

How are you planning to manage these risks in your operation / in the stakeholders you represent / regulate?

That concludes the interview schedule. Do you have any more questions or input you would like to add? Many thanks again for participating in the research project your input is truly acknowledge and appreciated. If you have any suggestions of any other possible participants that you are aware of that are available to partake in the study, it will be greatly appreciated.

Appendix G – Ethical Clearance

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Human Ethics Sub-Committee
Rhodes University Ethical Standards Committee
PO Box 94, Makhanda, 6149 South Africa
Email: ethics-committee@ru.ac.za

www.ru.ac.za/research/research/ethics
NHREC Registration No. REC-241114-045

30th September 2020

Dr J. Davy
Department of Human Kinetics and Ergonomics
Rhodes University

Review Reference: **HKE=2018-02: Fatigue in Aviation Research**

Dear Jonathan

Re: Extension and Amendment to the above Project

Principal Investigator: Dr J. Davy
Researcher: Mr D. Clark

New Title: Fatigue and its Contributing Factors in the South African Aviation Industry post the COVID-19 pandemic: Perspectives from Blunt-end Stakeholders

This letter confirms that the above research proposal is renewed for a further calendar year with the **approval** the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

It is also noted that the project is now being widened to embrace the levels of fatigue experienced by persons associated with the managerial functions of the aviation industry, as opposed to the pilots and cabin crews (sharp-end stakeholders), with particular reference to the impact of the COVID-19 pandemic on the entire industry (both sharp and blunt-end stakeholders).

Please ensure that the Ethical Standards Committee is notified should any substantive change(s) be made, for whatever reason, during the continued research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the Ethics Committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the Ethical Standards Committee should be aware of.

Sincerely,

Arthur Webb

Prof Arthur Webb
Chair: Human Ethics sub-committee, RUSEC-HE

Appendix H – Gate Keepers Permission

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PERMISSION TO CONDUCT RESEARCH

Rhodes University
Drosty Road,
Grahamstown,
6139

Department of Human Kinetics and
Ergonomics Upper African Street
Grahamstown/Makhanda
6139

Study: FATIGUE AND ITS CONTRIBUTING FACTORS IN THE SOUTH AFRICAN AVIATION INDUSTRY DURING THE COVID-19 PANDEMIC: PERSPECTIVES FROM BLUNT-END STAKEHOLDERS

Principle researcher: Dr Jonathan Davy

Co-researcher: Darryl Clark

This letter serves to confirm that.. is a willing participant of the above-mentioned study which will be conducted by the principal researchers and co-researcher mentioned above.

Should there be any questions or queries, please do not hesitate to contact me.

Sincerely,

[SIGNATURE]
[NAME]
[DESIGNATION]

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix I – Participant Consent Form

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PARTICIPANT INFORMED CONSENT

INFORMED CONSENT DECLARATION
(Participant)

Project Title: FATIGUE AND ITS CONTRIBUTING FACTORS IN THE SOUTH AFRICAN AVIATION INDUSTRY DURING THE COVID-19 PANDEMIC: PERSPECTIVES FROM BLUNT END STAKEHOLDERS

Darryl Clark from the Department of Human Kinetics and Ergonomics, Rhodes University has requested my permission to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

I am aware that:

1. The purpose of the research project is to explore my thoughts about the prevalence of fatigue and its contributing factors in the South African aviation industry and the proposed fatigue management going forward after the COVID-19 pandemic.

2. The Rhodes University has given ethical clearance to this research project and I have seen/ may request to see the clearance certificate.

3. By participating in this research project, I will be contributing towards further knowledge of fatigue and fatigue management in the South African aviation industry. In addition, the knowledge of fatigue and fatigue management within the context of the South African aviation industry can help with ongoing debates about how to adjust the current flight duty period regulations in South Africa.

4. I will participate in the project by providing my thoughts on the prevalence of fatigue and its contributing factors by answering the carefully formulated semi-structured interview questions.

5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences.

6. I will not be compensated for participating in the research, but my out-of-pocket expenses will be reimbursed.

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7. There may be risks associated with my participation in the project. I am aware that:

   a. the following risks are associated with my participation: anonymity and maintaining anonymity of participants and their companies, particularly if their operations have been negatively affected by the pandemic;
   b. the following steps have been taken to prevent the risks: all interviewers or respondents will be anonymized, and no mention will be made of their operation/employer. Participants will be shown the questions prior to the start of the data collection and may indicate what they would be happy to answer and what they wish to not answer. Any non-disclosure agreement required by the participants will be signed by the research team as well.

8. The researcher intends publishing the research results in the form of Master's Project and Journal Article. However, confidentiality and anonymity of records will be maintained and that my name and identity will not be revealed to anyone who has not been involved in the conduct of the research.

9. I will receive feedback in the form of regarding the results obtained during the study.

10. Any further questions that I might have concerning the research, or my participation will be answered by:

Dr Jonathan Davy

Principal researcher and supervisor

Cell: +27 72 226 0430

Email: jonathan.davy@ru.ac.za

Mr. Darryl Clark

BSc.

Cell: +27 79 666 3792

Email: darrylmalcolmclark@gmail.com

11. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies.

12. A copy of this informed consent declaration will be given to me, and the original will be kept on record.

13. Request to take pictures, video and voice recording for this study

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I, ……………………………………………………………………………… have read the above information / confirm that the above information has been explained to me in a language that I understand, and I am aware of this document's contents. I have asked all questions that I wished to ask, and these have been answered to my satisfaction. I fully understand what is expected of me during the research.

I have not been pressurised in any way and I voluntarily agree to participate in the above-mentioned project.

…………………………………	…………………………………	…………………………………
Participants signature	**Witness**	**Date**

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix J - Number of individuals' responses seen in relation to the total codes in a node

Table vii: Number of individuals' responses seen in relation to the total codes in a node.

Number of Individuals with responses in specific nodes (total coded in node)					
	Airline and Schedule Operations	**Industry Associates**	**Regulator**	**Union**	**Non-scheduled Operations**
Challenges of Fatigue and Its Contributing Factors Prior to the COVID-19 Pandemic					
Perceived Concerns About Crew Fatigue Prior to the COVID-19 Pandemic Reasons for why crew fatigue was concern within the aviation industry.					
Crew Mentality and Attitude Towards Fatigue		2(2)	1(1)		
Individual Variability	2(2)	1(1)	1(1)		
Lack of Knowledge and Awareness	2(2)				
Maintenance Delays	1(1)				
Managing Fatigue	2(3)	1(2)			
Operation Specific Challenges		1(1)	1(1)	1(1)	2(2)
Outdated Regulations & Resistance to Change	1(1)	1(1)	1(1)	1(1)	
Volatile and Unstructured Nature of Non-schedule Operations		1(1)			
Reasons for why crew fatigue was not a concern					
Focusing on Revenue Generation within Operations.		1(1)			
Well Managed Operations	3(4)				2(2)
Perceived Contributing Factors to Crew Fatigue Prior to the COVID-19 Pandemic					
Person-related Factors	4(6)	2(3)			
Environment-related Factors	1(4)	1(1)	1(1)		1(3)
Schedule-related Factors	3(7)	3(8)	1(2)	1(1)	1(1)
Organisation-related Factors	1(1)	1(1)	1(1)		
Regulation-related Factors	2(4)	1(2)			

Perceived Change in Awareness Around Crew Fatigue (Last 5 Years) Prior to the COVID-19 Pandemic					
Why Awareness has increased					
Drive for Fatigue Management				1(1)	2(4)
Stakeholder Engagement	2(2)	1(1)	1(2)	1(1)	2(3)
Training and Education	3(3)	1(1)	2(2)	1(1)	1(1)
Reporting has Improved	2(2)	1(1)	1(1)		2(3)
Drive for Regulation Adjustments	2(2)	1(1)	1(1)		2(3)
Why Awareness has not increased					
Lagging Behind Other Countries' Regulations and Operational Development	1(1)	1(1)	1(1)		
Non-scheduled operations still a problem		1(1)			
Response to Reports					1(1)
Perceptions Surrounding the Current Flight and Duty Period Regulations					
Perceptions of the Current FDP Regulations					
Rest Periods	2(6)	1(1)		1(1)	1(1)
Scheduling	2(2)	1(2)	1(1)	1(2)	1(1)
Outdated Regulations & Poor Regulatory Support	2(2)	1(1)	2(3)		1(1)
Lack of Stakeholder Engagement	1(3)	1(1)			
Lack of Specificity in Regulations Catering to Different Operational Scenarios	2(4)	2(4)			1(3)
Lack of Current Science		2(2)	1(1)		
Intercountry Operations and the Law					1(2)
Regulations are Performing	1(1)	1(1)			
Recommended Amendments to the Current FDP Regulations					
Scheduling	3(3)	3(3)		1(1)	
Stakeholder Engagement	2(3)	2(6)			
Rest Periods & Rest Facilities	1(1)			1(2)	
Fatigue Risk Management Strategies	1(1)		1(1)		
Crew Health and Safety					1(2)
Maintain Current Regulations		1(1)			

Emerging Risks and Fatigue Management During the COVID-19 Pandemic					
Main Impacts Since the Start of the Pandemic					
Impact on Crew	2(2)	3(7)	1(1)		1(1)
Impact on Regulations	1(1)		1(1)		
Impact on Operations	3(6)	3(7)	2(2)	1(3)	2(3)
Biggest Concerns Since Start of the Pandemic					
Economic Sustainability of the Industry	2(2)	2(2)	2(2)	1(1)	1(4)
Regulations and Regulatory Body	1(2)			1(1)	
COVID-19 Regulations	1(1)	1(1)			
Operation Specific Concerns		1(1)			1(2)
Additional Fatigue Risks Since the Start of the Pandemic					
Increased Crew Stress	2(2)	3(3)		1(1)	
Additional COVID-19 Safety Measures	3(4)	1(1)			
Training & Certification Issues		1(1)	1(1)	1(1)	
Regulations		1(2)			
Changes in Workload	1(1)	1(1)	1(1)	1(1)	
Plans to Manage Risks Going Forward					
Regulation Consideration	2(2)		2(3)	1(1)	1(2)
Scheduling and Operations Considerations	1(1)	1(2)		1(1)	2(2)
Training and Awareness	2(2)	2(2)		1(1)	
Crew Health and Well-being	1(1)			1(1)	
Stakeholder Engagement	1(1)	2(2)			1(1)
Economic Management	1(1)	3(3)			1(1)