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Reduced Crew and Single Pilot Operations implemented on civil aircraft: a legal perspective

By

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Mini-dissertation submitted in partial fulfilment of the requirements for the degree

Master of Laws

LL.M

(Coursework)

in the

FACULTY OF LAW

at the

UNIVERSITY OF PRETORIA

Supervised by

Prof. Dr. Stephan Hobe

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Abstract

The composition of cockpit crews has significantly changed since the inception of international air travel. Advances in technology have led to a gradual reduction in the amount of crew needed in the cockpit to complete a scheduled international service. At present, international air law requires that two pilots are simultaneously present on the flight deck when operating large commercial aircraft. This minimum requirement could change with the introduction of reduced crew operations (RCO) and single pilot operations (SPO). When these concepts are implemented, a lone pilot will be in the cockpit for certain segments (cruise phase) or throughout an entire flight, thus departing from the current two crew minima. This dissertation examines the impact that RCO and SPO will have on the standards and recommended practices set out by the International Civil Aviation Organization and corresponding national aviation legislation.

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Chapter 1: Dissertation outline

1.1 Introduction

The composition of cockpit crews on civil aircraft has significantly changed over the years. At the genesis of commercial flight, it was common to have a cockpit crew consisting of five members: two pilots, a flight engineer, a navigator, and a radio operator.[1] Each member fulfilled a crucial role in a highly complex and high-workload environment. Technological developments improved cockpit systems resulting in the navigator and radio operator roles becoming redundant.[2] A three-member cockpit crew soon became the new norm: two pilots and a flight engineer.[3] The supersonic Concorde and the initial variant of the Boeing 747 are examples of aircraft models that utilized this cockpit crew configuration.[4]

Further advances in technology resulted in the three-crew minimum being reduced to the current custom - the two-pilot cockpit crew.[5] In this configuration, the captain and first officer (FO) share the duties and responsibilities that arise during the completion of a scheduled service. Two-crew cockpits may be at the tail end of their operational life span as the proposed implementation of reduced crew operations (RCO) and single-pilot operations (SPO) on large commercial aircraft has become an active area of research.[6]

The history of the de-crewing process indicates that this step toward a lone pilot occupying the cockpit is the next eventuality. Authors have already detailed RCO and SPO from an operational standpoint,[7] delineated potential frameworks for their

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1 Matthew Johnston, 'Crew Roles in Commercial Aviation' (California Aeronautical University 16 November 2018) www.calaero.edu/crew-roles-in-commercial-aviation/ accessed 17 May 2022. See also Yixiang Lim and more, 'Commercial Airline Single-Pilot Operations: System Design and Pathways to Certification' (2017) IEEE 5.

2 Ibid.

3 Jake Hardiman 'How many pilots did Concorde Need?' (Simple Flying 19 November 2021) <https://simpleflying.com/concorde-pilot-count/> accessed 17 May 2022.

4 Ibid.

5 Yixiang Lim, (n1) 5.

6 Randall Bailey and more, 'An assessment of Reduced Crew and Single Pilot Operations in Commercial Transport Aircraft Operations' (2017) IEEE Xplore 1; 'Reduced Crew Operations' (ICAO Assembly- 40th Session, Technical Commission, A40-WP/426, 2019).

7 Ibid.

implementation,[8] set out the challenges these concepts will face,[9] and have succinctly drafted literature reviews to unify the development of this research area.[10] However, despite the plethora of voices engaging in the development of RCO and SPO, a lacuna exists within this area. Only a handful of scholars have briefly examined these concepts from a legal standpoint, however, none have been substantial, limited to a paragraph or two.[11] Consequently, this dissertation attempts to fill this void by contributing to RCO and SPO research from a legal perspective. Flight Crew Composition, fatigue management, use of psychoactive substances, aircraft certification, and cybersecurity are some of the subject matters addressed in this dissertation.

1.2 Motivations for the study

Preserving the safety standards of the aviation industry is the primary focus of this study. While RCO and SPO are expected to bring about increased savings for airlines, their implementation must not be at the expense of passenger safety and aviation safety in general. Consequently, the motive of this dissertation is to contribute to the development of a legal framework that will aid in the process of the safe implementation of RCO and SPO on civil aircraft in the future.

1.3 Research Questions

- Can RCO and SPO be implemented based on the existing international air law framework?
- What amendments, if any, need to be made to international air law to safely accommodate RCO and SPO?
- Will RCO and SPO maintain or enhance the safety of the aviation industry?

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8 Karl Bilimoria and more, ‘Conceptual Framework for Single Pilot Operations’ (2014) Human Factors NASA 1. See also Stefan Manuel Neis and more, ‘Classification and Review of Conceptual Frameworks for commercial Single Pilot Operations’ (Conference on Digital Avionics Systems, London, September 2018).

9 These challenges are CRM/Human Factors, communication/social concerns, training of first officers, public and pilot acceptance and pilot Incapacitation by Paul Myers III & Arnold Starr Jr, ‘Single Pilot Operations in commercial Cockpits: Background, Challenges, and Options’ (2021) Journal of Intelligence & Robotic Systems 3-7.

10 Daniela Schmid & Neville Stanton, ‘Progressing Towards Airliners’ Reduced-Crew Operations: A Systematic Literature Review’ (2020) 30 The International Journal of Aerospace Psychology 1, 5.

11 Paul Myers and Arnold Starr Jr (n9) 7.

1.4 Methodology

This dissertation applies a desk-based research methodology. In the completion of this dissertation, the author has drawn insight from international treaties, journal articles, books, and case law from various jurisdictions.[12] This is in line with Article 38 of the Statute of the International Court of Justice.[13]

1.5 Limitations

The latest editions of the Annexes discussed below were not used due to their financial cost. Previous versions which are available for free online were used instead. The author acknowledges that this may result in discrepancies. Moreover, Chapter 4 of this dissertation does not follow the trend seen in Chapters 2 and 3 because of financial constraints. The documents needed to complete Chapter 4 in a similar fashion cost a combined total of around $450. Free versions of the Annex required were not available. Therefore, free sources, such as lecture slides published by reputable scholars, IATA-published documents, and other associated materials were used in the alternative to complete the Chapter.

1.6 Chapter Breakdown

Chapter 2: Annex 6, Part I to the Chicago Convention.

Chapter 3: Annex 8, IIIB to the Chicago Convention.

Chapter 4: Annex 17 to the Chicago Convention.

Chapter 5: Provides a conclusion to this dissertation.

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12 Art 38, ICJ Statute.
13 Ibid.

Chapter 2: Annex 6, Part I- Operation of Aircraft

2.1 Introduction

Annex 6 to the Chicago Convention delineates the international SARPs as they pertain to the operation of aircraft and is subdivided into three counterparts.[14] Part I applies to aircraft authorised to conduct international commercial air transport operations,[15] Part II focuses on aircraft operating within international general aviation,[16] and Part III exclusively applies to international operations of helicopters.[17] For purposes of this chapter and the broader research objectives of this study, only Annex 6, Part I is of relevance.[18] Annex 6 covers a wide range of subject matters found within 14 distinct chapters, each one focusing on a specific aspect of the operation of an aeroplane, to ensure the safety of all international air services.

Previously there was a distinction between SIAS and NIATO in the context of the Chicago Convention and its corresponding SARPs. Urgent calls were made to create SARPs for NIATO because SARPs were only provided for SIAS in the Chicago Convention.[19] However, the 5th Edition of Annex 6 did away with the differentiation between the two types of international air services involved in operations for remuneration or hire.[20] It was decided that the SARPs applicable to SIAS would equally apply to NIATO.[21] So while the difference between what constitutes a SIAS and a NIATO remains,[22] the SARPs applicable to both are the same.

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14 Any reference to Annex 6, Part I to the Chicago Convention herein refers to the Eleventh Edition of July 2018.

15 Ch 2, Annex 6, Part I.

16 Ch 2 (Note 1), Annex 6, Part I.

17 Ch 2 (Note 2), Annex 6, Part I.

18 Any reference to Annex 6 hereafter refers to Annex 6, Part I.

19 Applicability, Annex 6.

20 Ibid.

21 Ibid.

22 Reg 1, International Air Services Act, 1993, the Department of Transport (DoT) in South Africa defines 'scheduled international public air transport', synonymous with SIAS, as meaning: an international public air transport service in connection with which flights are undertaken- (a)(i) between the same two or more airports; (ii) or with such a slight variation from the route referred to in subparagraph (i) that each flight can reasonably be regarded as being between the same two or more airports; and (b)(i) according to a published timetable; or (b)(ii) with such a degree of regularity and frequency that they constitute a recognisable systematic series in such a manner that each flight is open to use by members of the public. The DoT of South Africa defines a 'non-scheduled international public air transport service', synonymous with NIATO, as: an international public air transport service other than a scheduled international public air transport service in connection with which a specific flight or a specific series of flights is undertaken.

This chapter is centred on Annex 6, and it begins with an analysis of the flight crew minimum requirement as found in Chapter 9.1.1. It then proceeds to examine fatigue management regulations as set out in Chapter 4.10. This is followed by a discussion on the use of psychoactive substances, as referred to in Chapter 3.4, and how they relate to pilot mental health. It ends with a conclusion.

2.2 Flight crew composition

Flight crew composition controversy has intermittently brought discord to civil aviation since 1947.[23] The central matter in dispute has always been: how many cockpit crew members are required to fly an airliner safely during international passenger service?[24] Pilot associations, labour organisations, regulatory authorities, and manufacturers have historically had differing opinions on the magic number to this question. Manufacturers, airlines, and CAAs have argued that the crew complement should be dictated by design specifications.[25] In contrast, pilot associations have vehemently challenged this point of view by asserting that crew composition should be directed by indicators such as CRM and human factors.[26]

Myers and Starr Jr recall how the ALPA took the matter of a three versus two-person cockpit to Ronald Reagan, the President of the USA at the time, to plead their case.[27] After the eventual permanent removal of the flight engineer from the flight deck, the debate lay dormant for a substantial period as it appeared as though all relevant parties had agreed on the magic number, the two-crew cockpit.

However, growing conversations around further de-crewing measures have catapulted this highly contentious matter back into the spotlight. The proposed implementation of RCO and SPO on civil aircraft has brought about a sense of déjà vu. As in the past, various parties with a vested interest in crew composition requirements have already expressed opposing opinions regarding the withdrawal of a cockpit crew member temporarily or permanently.[28] This study is rooted in the law

23 Nick Komons, *The Third Man: A History of the Airline Crew Complement Controversy, 1947-1981* (Department of Transport, 1987) 1.
24 Ibid.
25 Ibid.
26 Ibid.
27 Paul Myers III and Arnold Starr Jr (n9) 2.
28 The ALPA Int'l states that the risks associated with reduced crew and single pilot operations are well documented. Most prominently, these risks stem from the increased workload for the remaining pilot, the elimination of a critical layer of monitoring and operating redundancy in the

so while it is important to acknowledge these differing opinions it must be noted that this study does not advocate for either perspective. Chapter 9.1.1 of Annex 6 is analysed next to determine who has the authority to set the minimum crew composition on board aircraft engaged in international air services.

2.2.1 Sentence 1 - Chapter 9.1.1 Annex 6, Part I

The first sentence of Chapter 9.1.1 of Annex 6 reads as follows:

> The number and composition of the flight crew shall not be less than that specified in the operational manual.[29]

An operational manual is defined as, a handbook containing procedures, instructions, and guidance for use by operational personnel in the execution of their duties.[30] All operators are mandated to have an operational manual for all aircraft within their fleet to ensure safe and successful operations.[31] This manual may be issued in separate parts, namely sections A, B, C, and D, all of which must be accessible to the various personnel affected by them.[32]

Per the wording of this first sentence, it can be interpreted that operators, who are responsible for drafting the operational manual, have the authority to dictate the minimum number of flight crew needed to operate aircraft within their fleet. If this was the case, RCO or SPO would have been swiftly implemented by airlines without delay.

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cockpit, and the inability of a single pilot to handle many emergency situations, see ALPA, *The Dangers of Single Pilot Operations* (White paper, 2019); Reuters reports that Airbus' Project Connect, aims to certify its A350 jet for single-pilot operations during high-altitude cruise, starting in 2025 on Cathay passenger flights, see Laurence Frost, 'Exclusive Cathay working with Airbus on single-pilot system for long-haul' (Reuters, 17 June 2021) <https://www.reuters.com/business/aerospace-defense/exclusive-cathay-working-with-airbus-single-pilot-system-long-haul-2021-06-16/> accessed 03 January 2023.

29 Ch 9.1.1, Annex 6, Part I.

30 Ch 1, Annex 6, Part I.

31 Olga Zakharova, 'Flight Operations Manuals: How to distribute safety best practices for operations' (Fluix, 15 September 2022) <https://fluix.io/blog/flight-operations-manuals-for-operators#:~:text=Aircraft%20manufacturers%20create%20an%20Aircraft,be%20compatible%20with%20this%20documentation> accessed 01 July 2023.

32 Ibid, most operational manuals are divided into multiple sections…air transport regulations require four primary sections, labelled A, B, C and D, to be include. See also 'What should you know about the operations manual for air operators in EASA regulatory framework?' (EASA Quality Compliance, 18 February 2019) <https://easaqualitycompliance.com/what-should-you-know-about-the-operations-manual-for-air-operators-in-easa-regulatory-framework/> accessed 03 July 2023.

However, airlines are required to get their operational manuals approved by the CAA in their jurisdiction.[33]

An example is made of the USA. According to FAA regulation FAR 14 CFR 121.385, the minimum cockpit crew is two pilots, and the certificate holder shall designate a pilot in command and a second in command. Therefore, all operators registered in the USA are mandated to include in their operational manuals that their aircraft are to be operated by a minimum of two pilots. CAAs across the world have implemented a comparable requirement solidifying the two-cockpit crew minimum as we know it.

Chapter 11.1 of Annex 6 delineates that the flight manual shall be updated by implementing changes made mandatory by the State of Registry.[34] This confirms that operators, in drafting their flight manuals, are bound by the regulatory framework of the CAA in their jurisdiction. Consequently, despite operators having the freedom to draft their own flight manuals, the contents therein must be in line with the regulations set by the CAA.

2.2.2 Sentence 2 - Chapter 9.1.1 Annex 6, Part I

The second sentence of Chapter 9.1.1 is more expansive than the first:

> The flight crew shall include flight crew members in addition to the minimum numbers specified in the flight manual or other documents associated with the certificate of airworthiness, when necessitated by considerations related to the type of aeroplane used, the type of operation involved and the duration of flight between points where flight crews change.

Sentence 2 identifies additional documents where the composition of the flight crew can be identified. These are the flight manual and other documents associated with the certificate of airworthiness. A flight manual is associated with the certificate of airworthiness, containing limitations within which the aircraft is to be considered airworthy, and instructions and information necessary to the flight crew members for the safe operation of the aircraft.[35]

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33 Olga Zakharova (n31).
34 Ibid, State of Registry is defined as the State on whose register the aircraft is entered.
35 Ch 1, Annex 6, Part I.

Zakharova writes that different CAAs, manufacturers, and users may refer to an Aircraft Operating Manual by different names.[36] These names include Aircraft Flight Manual, Airplane Flight Manual, and Aeroplane Flight Manual.[37] In this case, the flight manual referred to in sentence 2 of Chapter 9.1.1 is synonymous with the Aircraft Flight Manual as identified by Zakharova. Additionally, Zakharova submits that OEMs are responsible for creating an Aircraft Flight Manual for each aircraft they make, and air operators subsequently include this document within section B of their operational manuals, as identified above.

The second part of sentence 2 of Chapter 9.1.1 indicates where the minimum flight crew composition can also be found:

> …other documents associated with the certificate of airworthiness.

The phrasing of this extract dictates that if a document is connected to the certificate of airworthiness, it can also be used to determine the minimum flight crew composition of civil aircraft. A certificate of airworthiness is the formal document issued by a CAA to certify that an aircraft is airworthy.[38] In *Airworthiness: an introduction to Aircraft Certification: A Guide to understanding JAA, EASA, and FAA standards*, De Florio specifies that the certificate of airworthiness will be issued to aircraft that conform to a type certificate that has been issued under EASA Part 21 for example.[39]

De Florio highlights the nexus that exists between the certificate of airworthiness and the type certificate. Consequently, the type certificate can be construed as being a document 'associated with the certificate of airworthiness' as defined in sentence 2 of Chapter 9.1.1. A type certificate is issued by a CAA stating the airworthiness standard for the aircraft type, model, aircraft engine, or aircraft propeller.[40] The initial type certificate is likely to be obtained in the country where the aircraft is manufactured.[41]

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36 Olga Zakharova (n31).

37 Ibid.

38 'Certificate of Airworthiness' (Skybrary) <https://www.skybrary.aero/articles/certificate-airworthiness> accessed 04 July 2023.

39 Filippo De Florio, *Airworthiness: an introduction to Aircraft Certification: A Guide to understanding JAA, EASA, and FAA standards* (https://ebookcentral-proquest-com.uplib.idm.oclc.org/lib/pretoria-ebooks/detail.action?docID=270354,Elsevier Science & Technology, 2006).

40 'Type Certificate' (Skybrary) <https://www.skybrary.aero/articles/type-certificate> accessed 04 July 2023; See also Ch 1.1 (Note 1), Annex 8, Part II.

41 Ibid.

The most recently approved type certificates issued to Airbus and Boeing for their A350-900/1000 and B787-8/9/10 respectively will be used below. The type certificate data sheet for the A350 details that the minimum flight crew required to operate the aircraft is two pilots. Similarly, the type certificate data sheet for the B787 outlines that the prescribed minimum flight crew is two pilots. Thus, both OEMs mandate that two pilots are required to safely fly their aircraft during civil operations.

OEMs must set out in their type certificate the minimum number of pilots needed to operate their aircraft. However, because type certificates need to be approved by CAAs, OEMs are bound by the regulations set out by these regulatory authorities. Therefore, despite having the ability to determine the minimum number of pilots needed to operate aircraft built by them, if OEMs seek approval for a type certificate for an aircraft they have manufactured, the minimum crew composition must be in line with CAA regulations.

2.2.3 Remarks

After analysing sentences 1 and 2 of Chapter 9.1.1 of Annex 6 there are multiple concluding remarks. First, the analysis of the first sentence found that the minimum flight crew composition can be found in the operational manual. It was determined that operators are granted the authority to set out the terms to be included in their operational manuals. Mistakenly, it could be assumed then that operators have the power to determine the minimum flight crew composition for aircraft within their fleet. However, it was discovered that operators must draft their operational manuals within the confines of the regulatory framework of the CAA within their jurisdiction. This is the case because all operational manuals must be sent to the relevant CAA for approval.

Second, the analysis of the second sentence found that the minimum flight crew composition could also be found in the flight manual or other associated documents with the airworthiness certificate. Here it was found that OEMs are responsible for drafting the flight manual and the type certificate, the latter deemed to be an ‘associated document’. In this case, it could be inferred that OEMs can set the minimum flight crew composition, however, it was determined that both documents need to be approved by the relevant CAA.

Lastly, it has been established that operators and manufacturers draft their respective documents which include provisions setting out the minimum flight crew composition.

Despite this, OEMs and operators are obliged to draft their respective documents within the bounds of the regulatory framework set by the CAA within their jurisdiction. Therefore, operators and OEMs will only be authorised to incorporate provisions that allow for the temporary or permeant removal of one pilot from the cockpit in their operational manuals, flight manuals, and type certificates, once CAAs amend the regulation that requires a minimum of two pilots.

2.3 Fatigue management

Fatigue is a hazard that predictably degrades various types of human performance and can directly contribute to accidents or incidents. The transport industry was one of the first to regulate and manage fatigue due to the high risk it poses to safety.[42] Several authors confirm that fatigue is a significant issue that continues to plague the aviation sector.[43] Bendak and Rashid submit that aviation faces more fatigue-related complexities in comparison to other modes of transportation because of its unique model of operation.[44]

Fatigue management as it pertains to flight crews is addressed in this part to the exclusion of other sectors of the aviation industry such as cabin crew and air traffic control. The temporary or permanent removal of one pilot from the cockpit is predicted to directly influence pilot fatigue patterns. As such, it must be established if current fatigue management interventions as determined by regulations are satisfactory to support concepts such as RCO and SPO while maintaining or exceeding present safety standards.

ICAO SARPs in its various Annexes support two distinct methods for managing fatigue, the prescriptive and performance-based approaches, which will be discussed first.[45] Thereafter, and due to the extremely complex nature of fatigue management and the vast variances between RCO and SPO, the two concepts and their relation to fatigue management SARPs are addressed separately.

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42 Ibid.

43 Salaheddine Bendak and Hamad Rashid, ‘Fatigue in aviation: A systematic review of the literature’ (2020) 76 International Journal of Industrial Literature; Beth Hartzler, ‘Fatigue on the flight deck: The consequences of sleep loss and the benefits of napping’ (2014) 62 Accident Analysis 309-318; John Caldwell and more, ‘Fatigue and management in the workplace’ (2019) 96 Neuroscience & Biobehavioral Reviews 272-289.

44 Ibid.

45 Ch 4.10.1, Annex 6, Part I.

2.3.1 Chapter 10.4 Annex 6, Part I

This part examines the prescriptive and performance-based approaches as found in Chapter 10.4.1 of Annex 6. ICAO has consolidated all the SARPs that relate to fatigue management into a suite of manuals.[46] One of which is the *Manual for the Oversight of Fatigue Management Approaches Doc 9966* which provides the oversight of fatigue management approaches in general.[47] This manual and Chapter 10.4 of Annex 6 are the primary sources used in the completion of this section.

2.3.1.1 Prescriptive approach

Based on prescriptive limitations, this approach identifies the maximum work periods and minimum non-work periods for pilots and other specific groups of aviation professionals.[48] Importantly, States are responsible for establishing prescriptive limits and operators must draft their SMS within these limitations. The SMS is a systematic approach to managing safety, including the necessary operational structures, accountability, responsibilities, policies, and procedures.[49] Fatigue management is just one out of many other components of an SMS.

The application of this approach requires the State to ensure that the operator is managing their fatigue risks to a level acceptable to the State.[50] However, in this instance, the operator must manage fatigue risks within the constraints of the State's prescribed limits. When setting these limits, State’s identify fatigue hazards within an operational context based on generic information sourced through scientific principles, literature reviews, and best practices.[51] A consequence of this is operators mainly identifying fatigue hazards through reactive measures.

Britton confirms this by mentioning that the prescriptive approach is the strict ‘compliance approach’ to satisfy SMS requirements.[52] Scott is quite critical of the prescriptive approach because of several reasons. Firstly, he believes that this

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46 Manual for the Oversight of Fatigue Management Approaches (MOFMA), Doc 9966, Second Edition- 2016.

47 Ibid.

48 Ibid; Ch 4.10.1, Annex 6, Part I.

49 Ibid.

50 Ibid.

51 Ibid.

52 Tyler Britton, ‘Is Your Aviation SMS Implementation Performing or Prescriptive?’ (SMS Pro, 22 June 2021) < https://aviationsafetyblog.asms-pro.com/blog/your-aviation-sms-program-performing-or-prescriptive-approach> accessed 19 July 2023.

approach is used merely as a ‘checking the boxes exercise’ by operators.[53] Secondly, he finds that most operators who implement this approach do not try and find creative measures to improve fatigue management.[54] Third and most worryingly in his opinion, operators who apply this prescriptive-based approach, do so in a manner that looks to do the least amount of work with the least amount of resources possible to comply with the prescribed limits set by the State.[55]

2.3.1.2 Performance-based approach

The performance-based approach requires an operator to implement a FRMS that is approved by the State.[56] The FRMS is defined by ICAO as:

> A data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles, knowledge, and operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness.[57]

The FAA describes it similarly but expands on ICAO's definition slightly by stating that it is as a system used to continuously monitor and manage fatigue risks associated with fatigue-related errors.[58] In this definition we see the FAA draw attention to the purpose of the FRMS as a mechanism that focuses on the eradication of ‘fatigue-related errors’. Both the ICAO and the FAA’s definition of FRMS detail that the exclusive intension of an FRMS is regulating and mitigating fatigue risks.

When implementing this approach, the State requires the operator to manage their fatigue risks to a level equivalent to, or better than, a prescriptive approach.[59] Thus, the responsibility shifts to the operator to identify their limits and manage their fatigue risk within agreed safety objectives and targets.[60] Importantly, these limits are subject to change, for good reason, because they are assessed and amended continuously as new data and research are collected.[61] In this instance, operators are authorised to

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53 Ibid.
54 Ibid.
55 Ibid.
56 Ch 4.10.4, Annex 6, Part I.
57 MOFMA Doc 9966.
58 ‘Fatigue Risk Management Systems for Aviation Safety’ (U.S Department of Transport: FAA, Advisory Circular 120-103A, 05 June 2013) <https://www.faa.gov/documentlibrary/media/advisory_circular/ac_120-103a.pdf> accessed 13 July 2023.
59 Ch 4.10.5, Annex 6, Part I; MOFMA Doc 9966.
60 Ibid.
61 Ibid.

set the prescribed maximum work periods and minimum non-work periods, allowing deviation from the State's prescribed limits.[62]

Additionally, where an operator applies the performance-based approach, the operator shall, as a minimum:

a) Incorporate scientific principles and knowledge within the FRMS;
b) identify fatigue-related safety hazards and the resulting risks on an ongoing basis;
c) ensure that remedial actions, necessary to effectively mitigate the risks associated with the hazards, are implemented promptly;
d) provide for continuous monitoring and regular assessment of the mitigation of fatigue risks achieved by such actions; and
e) provide for continuous improvement to the overall performance of the FRMS.[63]

Fundamentally, the operator must implement reactive, proactive, and predictive processes in the identification of fatigue risks.[64] Britton is in favour of this approach and argues that it results in well-rounded, mature, fatigue standards that are ready to take safety to the next level.[65] Britton acknowledges the downside of this approach in that it requires significantly more effort, documentation, analysis, and thoughtfulness.[66] He does not shy away from mentioning that this approach directly translates into the expenditure of more time and financial resources.[67]

2.3.1.3 A comparative analysis of the two approaches

ICAO's FRMS Task Force, the body responsible for drafting the suite of fatigue management manuals, formulates a comparative analysis of the two approaches.[68] In its analysis, the task force confirms that the FRMS approach allows an operator to deviate from prescribed limits set by the State by implementing more rigorous and evidence-based regulations that go beyond the measures put in place by the prescriptive approach.[69] The task force openly admits that the performance-based

62 Ibid.
63 Ch 4.10.6 (a-e), Annex 6, Part I.
64 Ibid.
65 Tyler Britton (n52).
66 Ibid.
67 Ibid.
68 MOFMA Doc 9966.
69 Ch 4.10.6 (a-e), Annex 6, Part I.

approach goes a step further in mitigating fatigue risks than what would reasonably be expected using the prescriptive approach.[70]

IATA submits that where a FRMS takes operational peculiarities and complexities (circadian rhythm, short v long haul, continuous duty overnights, and CRM) into account, the prescriptive approach does not.[71] Bendak and Rashid concur with IATA by acknowledging that a FRMS is dependent on scientific findings and considers pertinent factors related to fatigue.[72] Moreover, Bendak and Rashid also argue that prescriptive regulations set by authorities are not necessarily based on findings of scientific research, thus failing to consider the complexities listed by IATA.[73]

2.3.1.4 How are the two approaches applied?

In practice, Chapter 4.10.2 (a-c) of Annex 6 grants State's three different options to comply with Chapter 4.10.1 of Annex 6. Firstly, the operator may manage its fatigue risks solely on the prescriptive approach.[74] Secondly, the operator can choose to solely manage its fatigue risks for all its operations based on a FRMS.[75] And lastly, the two approaches can be applied simultaneously.[76]

In *Civil Aviation Rules on Crew Flight Time, Flight Duty, and Rest: Comparison of 10 ICAO Member states*, Missoni and more, submit that despite all the identified States having a common goal towards fatigue management, their prescriptive regulations differ with regards to details and the tools used to mitigate fatigue of flight crew members.[77] Consequently, a highly fragmented fatigue management system is in place. Chapter 4.10.2 of Annex 6 contributes to this fragmentation because it allows for the implementation of three different approaches. This has worryingly resulted in States across the globe implementing fatigue risk management systems that have varying limitations for flight crew members who are engaged in comparable

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70 MOFMA Doc 9966.

71 'Fatigue Risk Management Systems (FRMS)' (IATA, 01 September 2013) <https://www.iata.org/contentassets/5f976bb3ca2446f3a40e88b18dd61fbb/frms-white-paper.pdf> accessed 12 July 2023.

72 Ibid.

73 Salaheddine Bendak and Hamad Rashid (n43) 7.

74 Ch 4.10.2(a), Annex 6, Part I.

75 Ch 4.10.2(b), Annex 6, Part I.

76 Ch 4.10.2(c), Annex 6, Part I.

77 Eduard Missoni and more, 'Civil Aviation Rules on Crew Flight Time, Flight Duty, and Rest: Comparison of 10 ICAO Member states' (2009) 80 Aviation, Space, and Environmental Medicine.

operations. Understanding how this may affect RCO and SPO implementation is addressed next.

2.3.2 RCO and SPO: Fatigue management

Will the highly fragmented fatigue management system that is presently in place do enough to mitigate fatigue risks during RCO and SPO implementation? This is the primary question addressed in this part.

2.3.2.1 RCO and the fatigue risk management system

According to ECA, the temporary removal of one pilot during RCO aims to stretch the maximum FLTs by prolonging in-flight rest for pilots.[78] To achieve this, only one pilot would remain at the controls for extended periods during the cruise phase of the flight.[79] The information below is premised on the fact that RCO implementation will only be carried out if it is proven that it will be done in a manner that maintains or exceeds current safety standards.

Given the inadequacies of the prescriptive approach detailed above, it is argued that ICAO should recommend that States and operators seeking to implement RCO can only do so if they have a FRMS in place. Therefore, disqualifying all States and operators that only apply a prescriptive approach from implementing RCO.

Additionally, States and operators that do qualify, must incorporate thorough research and data in their FRMS that specifically addresses the unique intricacies of pilot fatigue for crew members engaged in RCO. The research and data should include short-term and long-term implications, impact on CRM systems, and all other relevant factors impacted by the temporary removal of one pilot during the cruise phase of flight.

Therefore, Chapter 4.10.2 of Annex 6 as it stands, will not apply to States and operators seeking to implement RCO. The purpose of this is to remove the option to apply a solely prescriptive-based approach due to the fundamental flaws it possesses. Consequently, operators must exclusively apply a FRMS to their RCO implementation but may still opt to apply the prescriptive-based approach in other operational areas.

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78 *The human and the concepts of Extended Minimum Crew Operations (eMCO) and Single Pilot Operations (SiPO)* (ECA, Position Paper, 2021).

79 Ibid.

2.3.2.2 SPO and the fatigue risk management system

SPO is predicted to revolutionise modern-day aviation with the permanent removal of one pilot from the cockpit. A ground-based pilot is most likely going to replace the co-pilot as we know them today. This removal and expected separation of the second pilot from the flight deck is predicted to significantly affect the fatigue levels of the pilot on board and the ground-based pilot.

Firstly, the remaining pilot will be responsible for a large majority of the workload and there is insufficient research detailing how this will impact the fatigue levels of the remaining onboard pilot. And secondly, given that the ground pilot is expected to monitor several aircraft simultaneously, understanding how fatigue affects this ground-based pilot is of utmost importance as well.

The fatigue risks associated with SPO are exponentially greater than those associated with RCO because the former concept permanently removes the second pilot from the flight deck. Consequently, ICAO should mandate that States and operators seeking to implement SPO can only do so if they have a FRMS in place per Chapter 4.10.2(b) of Annex 6. Therefore, prohibiting the reliance on Chapter 4.10.2(a and c) of Annex 6 when SPO is implemented.

However, taking the complexities of SPO into account, there is an argument to be made that the fatigue management system that is in place is wholly insufficient to accommodate this operational model. As a consequence of this, before SPO's inception, ICAO has the unique opportunity to draft a new standardised fatigue management framework to address the current fragmentation issues. This would enhance safety levels across the aviation sector as we continue towards a highly autonomous future.

2.3.3 Remarks

The prescriptive and performance-based approaches to fatigue management were discussed. The prescriptive approach is based on prescribed limits and implementors only use it as a 'checkbox exercise'. In contrast, it was found that the performance-based approach, applied through a FRMS, takes the peculiarities and complexities of fatigue into account. The comparative analysis found that the performance-based approach is preferred over the prescriptive-based approach.

ICAO should require that operators seeking to implement RCO should only be allowed to do so if they have a FRMS that specifically addresses the risks associated with this operational model. As a result, operators may still apply the prescriptive approach to other parts of their operations. In terms of SPO, it was detailed that SPO implementors should be completely prohibited from applying a prescriptive-based approach due to its shortcomings. Additionally, given the radical changes that will be brought about by SPO, it may be a unique opportunity for ICAO to draft a new standardised fatigue management system. The next section examines pilot psychoactive substance use and pilot mental health.

2.4 Psychoactive substances and pilot mental health

Dr. Brock Chisholm, the first Director-General of the World Health Organisation (WHO) famously coined the phrase "without mental health there can be no true physical health".[80] Dr. Chrisolm's profound statement came at a time in history when discourse around mental health was scarce and its impact on the world's population largely unknown. Since then, with each passing decade, there has been greater awareness and research dedicated to mental health.

WHO submits that 1 in 8 people in the world live with a mental disorder which amounts to 970 million people.[81] The two most common mental disorders are depression and anxiety. Durham and Bliss describe these disorders as being "the common cold of psychiatry", emphasising the frequency of their diagnoses.[82] Statistics published by WHO support Durham and Bliss's claims because anxiety and depression account for an estimated 60% of all diagnoses of mental health cases.

It has been reported that the pilot population across the globe is just as susceptible to being diagnosed with some sort of mental disorder, thus, keeping in line with global trends. A study conducted by Wu and more. found that a substantial amount of commercial airline pilots who were questioned met the depression threshold on the

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80 Young-Chul Chung and more, 'Mental health services and research and development in South Korea' (2021) *35 Taiwanese Journal of Psychiatry* 50-58.

81 'Mental disorders' (WHO, 8 June 2022) <https://www.who.int/news-room/fact-sheets/detail/mental-disorders> accessed 20 July 2023.

82 Jake Durham and Timm Bliss, 'Depression and Anxiety in Pilots: A Qualitative Study of SSRI Usage in U.S. Aviation and Evaluation of FAA Standards and Practices Compared to ICAO States' (2019) 37 Collegiate Aviation Review International 78, 84.

PHQ-9 questionnaire.[83] Moreover, a small percentage of pilots disclosed that they had experienced suicidal thoughts. These findings justify the ever-growing concern about the impact mental health is having on the aviation industry, specifically on those in the flight deck.

This section starts by detailing what psychoactive substances are and how they relate to mental health. Thereafter, Chapter 3.4 of Annex 6 is discussed further. This is followed by a comparative analysis of the USA and Australia's contrasting regulatory approaches to SSRI use. The final part highlights the deadly consequences associated with strict regulation of SSRI use.

2.4.1 What are psychoactive substances and how do they relate to mental health?

The NCI defines a psychoactive substance as, a drug or other substance that affects how the brain works and causes changes in mood, awareness, thoughts, feelings, or behaviour.[84] ICAO lists psychoactive substances as being, alcohol, opioids, cannabinoids, sedatives and hypnotics, cocaine, other psychostimulants, hallucinogens, and volatile solvents, whereas coffee and tobacco are excluded.[85] The NCI provides a comparable list of types of psychoactive substances, however, they do include caffeine and nicotine on their list, the key ingredients in coffee and tobacco.[86] In her introduction, Fletcher intentionally alludes to the scale of psychoactive substances from server to inconsequential ones by mentioning that 'they range from heroin to caffeine'.[87]

SSRIs are also considered psychoactive substances. According to the NIH and NHS, SSRIs are drugs that are used to treat depression and some other conditions.[88] These drugs are usually the first choice of medicine for depression because they generally have fewer side effects than most other types of antidepressants. SSRIs are also used

83 Alexander Wu, 'Airplane Pilot mental health and suicidal thoughts: a cross-sectional descriptive study via anonymous web-based survey' (2017) 15 Environmental Health.

84 'Psychoactive substance' (NIH) , <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/psychoactive-substance> accessed 20 July 2023.

85 Ch 1 of Annex 6, Part I.

86 'Psychoactive substance' (N84).

87 Jenna Fletcher, 'What to know about the different types of psychoactive drugs' (Medical News Today, 14 February 2023) <https://www.medicalnewstoday.com/articles/types-of-psychoactive-drugs> accessed 21 July 2023.

88 'SSRI' (NIH) <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/ssri> accessed 21 July 2023; see also 'Overview- Selective serotonin reuptake inhibitors (SSRIs)' (NHS, 8 December 2021) <https://www.nhs.uk/mental-health/talking-therapies-medicine-treatments/medicines-and-psychiatry/ssri-antidepressants/overview/> accessed 21 July 2023.

to treat other mental health conditions such as general anxiety disorder, obsessive-compulsive disorder, panic disorder, PTSD, social anxiety disorder, and other known disorders.[89] The NHS lists the 8 SSRIs currently prescribed in the UK and similarly across other jurisdictions as citalopram, dapoxetine, escitalopram, fluoxetine, fluvoxamine, paroxetine, sertraline, and vortioxetine.[90]

Fletcher makes the distinction between legal and illegal psychoactive substances.[91] Legal ones are caffeine, alcohol, nicotine, and prescription medicines (used appropriately).[92] Illegal substances are heroin, cocaine, methamphetamine, and certain opioids.[93] She argues that illegal psychoactive substance use usually poses a higher risk than legal ones because they may not undergo professional manufacturing processes in a laboratory, thus a person cannot be sure what ingredients an illegal drug may contain. Broadly speaking this may be true, however, there is merit in mentioning that the endemic abuse of alcohol and its detrimental consequences have been well documented.

The relationship between psychoactive substances and mental health is highly complicated and a contentious subject matter. On one side, illegal drug and alcohol abuse are major contributing factors to negative mental health conditions.[94] On the other side, SSRI use has been found to be effective in treating mental health conditions.[95] The aviation industry itself continues to grapple with psychoactive substance use and abuse, especially amongst its pilot population, because of these complexities. The next section details how pilot psychoactive substance use is regulated in the aviation sector.

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89 Andrew Chu and Roopma Wadhwa, 'Selective Serotonin Reuptake Inhibitors' (NIH: National Library of Medicine, 1 May 2023) <https://www.ncbi.nlm.nih.gov/books/NBK554406/> accessed 21 July 2023.

90 'Overview- Selective serotonin reuptake inhibitors (SSRIs)' (n88).

91 Jenna Fletcher (n87).

92 Ibid.

93 Ibid.

94 Hyungjin Kim and more, 'Validation of Key behaviourally based mental health diagnoses in administrative date: suicide attempt, alcohol abuse, illicit drug abuse and tobacco use' (2012) *12 BMC Health services reserves* 1,4.

95 Marc Lener, 'Antidepressants 101: Pros and Cons' (Healthline, 30 November 2021) <https://www.healthline.com/health/depression/antidepressants-pros-and-cons> accessed 21 July 2023.

2.4.2 Chapter 3.4 Annex 6, Part I

Chapter 3.4 of Annex 6 does not directly address the use of psychoactive substances. The provision indirectly addresses this subject matter by stating that the provisions concerning the use of psychoactive substances are respectively found in Chapter 1.2.7 of Annex 1 and Chapter 2.5 of Annex 2.[96] These two chapters are discussed further.

According to Chapter 1.2.7.1 of Annex 1:

> Holders of licences provided for in this Annex shall not exercise the privileges of their licenses and related ratings while under the influence of any psychoactive substance which might render them unable to safely and properly exercise these privileges.[97]

The licenses referred to in this provision include commercial pilot licenses and airline pilot licenses.[98] Pilots engaged in international air services all have these licenses. Interestingly, remote pilot licences also fall within the ambit of the licenses referred to in this provision.[99] Pilots issued with these licences will play an important role in SPO implementation because there will be a ground pilot that can control the aircraft remotely.

The provision above does not put a blanket ban on the use of psychoactive substances. Rather, it mentions that pilots shall not fly while 'under the influence of psychoactive substances which might render them unable to safely and properly exercise these privileges'.[100] The phrase 'which might' allows for a broad interpretation because it does not definitively define the quantity, frequency, etc of psychoactive substance usage that renders a pilot 'unable to safely and properly exercise' their duties. Understanding how this ambiguity translates into different regulatory approaches is discussed in the next part.

Chapter 1.2.7.2 of Annex 1 must be read in conjunction with Chapter 2.5 of Annex 2. The first provision holds that pilots shall not engage in any problematic use of substances.[101] The second provision expressly states that:

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96 Ch 3.4, Annex 6, Part I.
97 Ch 1.2.7.1, Annex 1.
98 Ch 2.4, 2.6, and 2.13, Annex 1.
99 Ch 2.13, Annex 1.
100 Ch 1.2.7.1, Annex 1.
101 Ch 1.2.7.2, Annex 1.

> No person whose function is critical to the safety of aviation (safety-sensitive personnel) shall undertake that function while under the influence of any psychoactive substance, by reason of which human performance is impaired. No such person shall engage in any kind of problematic use of substances.[102]

Earlier in this study it was held that the role of a pilot is considered critical to the safety of aviation, thus, the second provision applies to pilots as well. Both provisions find that pilots 'shall not engage in any problematic use of substances'.[103] What constitutes 'problematic use' is discussed in the section to follow. Chapter 1.2.7.3 recommends that:

> Contracting States should ensure, as far as practicable, that all licence holders who engage in any kind of problematic use of substances are identified and removed from their safety critical functions. Return to the safety critical functions may be considered after successful treatment or, in cases where no treatment is necessary, after cessation of the problematic use of substances and upon determination that the person's continued performance of the function is unlikely to jeopardize safety.[104]

The next section details how the USA and Australia apply this recommendation and the other provisions identified above in their respective jurisdictions.

2.4.3 The USA and Australia compared: polar opposites in regulating pilot use of SSRIs

The USA is considered to have the strictest regulations on pilot use of SSRIs. In contrast, Australia is believed to be the most progressive State in terms of how it chooses to regulate the use of SSRIs by its pilot population. These two States have purposefully been selected because of the vast differences in their approach to SSRI use.

2.4.3.1 How does the USA regulate pilot use of SSRIs?

Before 2010, if a pilot was diagnosed with anxiety, depression or was taking an SSRI it was immediate grounds for revocation of their medical certificate.[105] During that

102 Ch 2.5, Annex 2.
103 Ibid and Ch 1.2.7.2, Annex 1.
104 Ch 1.2.7.3, Annex 1.
105 Jake Durham, 'Depression and Anxiety in Pilots: A Qualitative Study of SSRI Usage in U.S Aviation and Evaluation of FAA Standards and Practices Compared to ICAO States' (DEd thesis, Oklahoma State University 2018).

period a pilot using an SSRI had to demonstrate successful discontinued use for 90 days before reconsideration was granted.[106] The FAA only recently declared that pilots requesting medical certificates while being treated with one of several specific antidepressant medications may have their application considered.[107]

The FAA allows the use of these specific antidepressants Fluoxetine, Sertraline, Citalopram, Escitalpram, and Bulpropion.[108] Any SSRI that is not found on this list is not acceptable for use.[109] It is expressly noted that the authorisation process is conducted on a case-by-case basis, with the final authority being the AMCD as AMEs are not allowed to issue the medical certificate in this instance.

US pilots have two avenues to potentially obtain their medical certificates while using SSRIs. It must be noted that there is no guarantee that a medical waiver will be granted in these instances.[110] The first option requires the pilot to discontinue the use of the SSRI for 60 days and have a favourable report from the treating physician indicating a stable mood and no adverse side effects.[111] The second option allows pilots to be considered for an FAA Authorization of a SI or SC of a medical certificate only if certain requirements are met.[112]

The applicant must demonstrate for a minimum continuous period of 6 months, recently reduced from 12 months, that they are clinically stable as well as on a stable dose of medication without any aeromedical significant side effects or an increase in symptoms.[113] An applicant may not apply for reconsideration before the 6-month continuous threshold is met. Additionally, the applicant can only use one of the listed SSRIs at a time and must not have symptoms or a history of certain listed conditions. These conditions are psychosis, suicidal ideation, electroconvulsive therapy, treatment with multiple SSRIs concurrently, and multi-agent drug protocol use.[114] Once these requirements are met the applicant will still have to be further evaluated by a

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106 Jake Durham and Timm Bliss (n82) 80.

107 'Guide for Aviation Medical Examiners' (United States Department of Transport: FAA, 28 June 2023) <https://www.faa.gov/ame_guide/app_process/exam_tech/item47/amd/antidepressants> accessed 24 July 2023.

108 Ibid.

109 Ibid.

110 Jake Durham and Timm Bliss (n82) 80.

111 'Guide for Aviation Medical Examiners' (n107).

112 Ibid.

113 Ibid.

114 Ibid.

HIMS AME.[115] Thereafter, the FAA can still deny a pilot who successfully meets all these requirements if they believe that the applicant's past psychiatric history raises safety concerns.[116]

We see that the USA has interpreted Chapter 1.2.7.1 of Annex 1 in a manner that allows for SSRI use in two instances. Furthermore, any use of SSRIs outside of the set requirements detailed in these two avenues will constitute 'problematic use' as described in Chapter 1.2.7.2 of Annex 1 and Chapter 2.5 of Annex 2. The FAA's inclusion of the minimum 60 days cession of SSRI use and the 6 continuous month rule demonstrates that they are strictly applying the recommendation found in Chapter 1.2.7.3 of Annex 1.

In *Depression and Anxiety in Pilots: A Qualitative Study of SSRI Usage in U.S. Aviation and Evaluation of FAA Standards and Practices Compared to ICAO States*, Durham and Bliss extensively cover the shortcomings of the USA's approach to SSRI use.[117] They found that approximately 59% of pilots in the USA do, or would, refuse the use of SSRI medication if they were prescribed one.[118] Furthermore, these authors detailed that around 60% of pilots who were diagnosed with depression would continue flying without taking the prescribed medication.[119] Roughly 15% said they would take the recommended medicine without notifying the FAA.[120] And only 25% submitted that they would take the prescribed medication and cease flying.[121]

2.4.3.2 How does Australia regulate pilot use of SSRIs?

Australia has allowed the supervised use of antidepressants by its pilots since 1987.[122] This has afforded pilots on SSRIs the opportunity to obtain their medical certificates and continue flying. In contrast, other ICAO States, like the USA, during these earlier years insisted that SSRI medications were not compatible with aviation safety.[123]

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115 Ibid.
116 Jake Durham and Timm Bliss (n82) 90.
117 Ibid 78-109.
118 Ibid 83.
119 Ibid.
120 Ibid.
121 Ibid.
122 Linda Werfelman, 'Antidepressants in Aviation' (2008) Aviation Medicine 24, 24.
123 Jake Durham (n105).

Australia has allowed the use of Fluoxetine, Sertraline, Citalopram, Escitalopram, Venlafaxine (low dose only), and Desvenlafaxine.[124] Similar to the USA, Australia acknowledges that each case of depression or mental health disorder is different. Consequently, medical certificates are issued on a case-by-case basis as well.[125] The CASA considers the applicant's unique circumstances when issuing a waiver and requires them to use one SSRI at a time. These are the only similarities between the USA's and Australia's approach.

Australia regulates SSRIs from the standpoint that well-managed depression is compatible with medical certification.[126] As a result, the CASA does not prescribe a rigid application process for flight crew members using SSRIs. The CASA does require that a psychiatric report must confirm that the applicant only has unipolar depression.[127] Any change in administered medication requires the pilot to report it to the DAME. The pilot will then be grounded for a period of 2 to 4 weeks.

The above demonstrates that Australia applies a lenient interpretation of Chapter 1.2.1.7 of Annex 1. This is no surprise because it is well documented that Australia believes that SSRIs have no adverse effects on the safety of aviation. In terms of 'problematic use' as described in Chapter 1.2.7.2 of Annex 1 and Chapter 2.5 of Annex 2, the CASA sets a much lower threshold as compared to the FAA. The major difference between the two CAAs lies in the application of Chapter 1.2.7.3 of Annex 1. Where the FAA applies a grounding period of 90 days for cession and 6 months of continuous use, the CASA only applies a grounding period of 2 to 4 weeks. This is crucial when considering the negative financial implications associated with grounding a pilot.

Surprisingly, the CASA's tolerant approach to SSRI use by pilots has not resulted in adverse safety statistics. Paradoxically, it has produced better safety outcomes. As far back as 2008 in *Antidepressants in Aviation*, Werfelman disclosed that Australian

124 'Depression and anxiety safety fact sheet' (CASA, 8 March 2023) <https://www.casa.gov.au/resources-and-education/publications-and-resources/aviation-medicine-fact-sheets-and-case-studies/depression-and-anxiety-safety-fact-sheet#Effectsofflyingondepression> accessed 26 July 2023.
125 Ibid.
126 Ibid.
127 'Depression' (CASA, 20 October 2021) <https://www.casa.gov.au/licences-and-certificates/medical-professionals/dames-clinical-practice-guidelines/depression#Pilot/controllerinformation> accessed 25 July 2023.

researchers found that pilots who took prescribed antidepressants were no more likely than others to be involved in accidents and incidents.[128] This statement came after a study was conducted that involved 962 pilots. Half of whom were on SSRIs and the other half were not. The study conclusively showed:

> that no evidence of adverse safety outcomes arising from permitting individuals to operate as commercial or private aircrew or air traffic controller while using antidepressants, provided specific criteria are met and maintained.[129]

Australia's approach is preferred for several reasons. Firstly, pilots are more willing to disclose their depression in Australia because they will most likely only be grounded for a period of 2 to 4 weeks and not a minimum of 90 days or 6 months. Another crucial point is how Australia has proactively destigmatised mental health. Durham confirms that it is often social stigmas that prevent pilots from seeking professional help. Research has found that pilots in the USA are less likely to pursue the FAA certification process because of industry stigma towards mental health.[130]

Mulder and de Rooy have long sounded the alarm on flight crew mental health issues, warning that it is a "serious threat to aviation safety".[131] In recent years this threat has regrettably materialised as mental health has been ruled as one of the main contributing factors in several fatal accidents. These accidents are examined below to demonstrate the consequences of implementing strict SSRI regulations and the importance of destigmatising mental health among pilots.

2.4.4 The deadly consequences of the restrictive use and regulation of certain psychoactive substances (SSRIs)

In 2015, the mental health of commercial pilots was swiftly placed under the microscope following the crash of Germanwings Flight 9525. The French Bureau d'Enquêtes et d'Analyses (BEA) wrote in its accident report:

> In the cruise phase of the accident flight, the co-pilot Andreas Lubitz, waited until he was alone in the cockpit (and locked the captain out). He then intentionally modified the

128 Linda Werfelman (n122) 24.

129 Ibid.

130 Jake Durham (n105).

131 Sanne Mulder and Diederik de Rooy, 'Pilot Mental Health, Negative Life Events, and Improving Sfety with Peer Support and a Just Culture' (2018) 89 Aerospace Medicine and Human Performance 41, 41.

autopilot settings to order the aeroplane to descend…before the aircraft impacted the terrain in the French Alps.[132]

An investigation into the crash uncovered evidence that the co-pilot experienced a psychotic depressive episode that started in 2014 and lasted until the day of the accident.[133] Lubitz failed to disclose his mental health condition and took unapproved prescription medication.[134] According to the accident report, contributing factors that might have led to his failure to self-declare were related to the financial consequences of losing his licence, as a result of strict regulations, which would have destroyed his professional ambitions.[135] Moreover, the report conclusively found that the crash was caused by the "deliberate and planned action of the co-pilot who decided to commit suicide while alone in the cockpit".[136]

Two years prior, in 2013, LAM Mozambique Airlines Flight 470 crashed en route to its destination. The captain locked the co-pilot out of the cockpit during the cruise phase of the flight.[137] Once alone, the captain proceeded to intentionally adjust the altitude of the aircraft to reflect a value below ground level.[138] The plane eventually impacted the ground in Namibia killing all on board.[139] The captain's mental state at the time of the crash was not known. However, he was experiencing high stressors in his personal life.[140] His son had recently died from suicide and did not attend the funeral and his daughter had recently undergone heart surgery.[141] Mulder and de Rooy articulate that negative life events have played a substantial role in most aircraft accidents because of unidentified mental health problems.[142]

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132 Bureau d'Enquêtes et d'Analyses, 'Final Report: Accident on 24 March 2015 at Prads-Haute Bléone (Alpes-de-Haute-Provence, France) to the Airbus A320-211 registered D-AIPX operated by Germanwings' (Hereafter 'Germanwings Accident) (BEA, March 2016) 86.

133 Terouz Pasha and Paul Stoke, 'Reflecting on the Germanwings Disaster: A Systematic Review of Depression and Suicide in Commercial Airline Pilots (2018) 9 Frontiers in Psychiatry 1, 2.

134 Jake Durham and Timm Bliss (n82) 81.

135 BEA 'Germanwings accident' (n132) 89.

136 Ibid 96.

137 Tanja Laukkala and more, 'Copycats in Pilot Aircraft-Assisted Suicide after the Germanwings Incident' (2018) International Journal of Environmental Research and Public Health 1, 2.

138 Ibid.

139 Ibid.

140 Victoria Moores, 'Human tragedy of the LAM Mozambique air crash' (TimesAerospace, 12 September 2016) <https://www.timesaerospace.aero/news/atm-and-regulatory/human-tragedy-of-the-lam-mozambique-air-crash> accessed 04 January 2023.

141 Ibid.

142 Sanne Mulder and Diederik de Rooy (n131) 42.

The University of North Dakota (UND) highly respected in the aviation industry for its John D. Odegard School of Aerospace Sciences was hit with tragedy in 2021.[143] John Hauser, a flight student pursuing his commercial pilot license died when his plane crashed during a routine evening flight.[144] The proceeding investigation determined that John suffered from depression and that suicide may have caused the accident.[145]

Christopher Lee Daniel, an airline captain at a reputable US carrier, died from suicide in 2022.[146] A few years before his death, a doctor had suggested to captain Daniels that his low mood and trouble sleeping might be symptoms of mild depression.[147] The late pilot's family wrote that he "did not want to get help for his depression because he knew what that meant for his career."[148] Captain Daniels chose not to seek medical treatment for his condition due to fears that the FAA might revoke his flying status per the strict provisions detailed in the previous section of this study.[149] Captain Daniels was not involved in an aircraft-assisted suicide, however, the underlying factors that led to him not disclosing his battles with his mental health are of interest.

The accidents discussed here show that untreated mental health of flight crew members has fatal consequences. Almost 20 years ago Dr. Anthony Evans, former chief of Aviation Medicine at ICAO, acknowledged that jurisdictions were taking an antidepressant was disqualifying (or discouraged), led to pilots flying when depressed and untreated, or failing to declare their depression/treatment to an AME. [150] The Germanwings accident occurred around 10 years after Dr. Evans's statement and despite this Lubitz still failed to disclose his mental health condition and took unapproved prescription medication. The accident report in this instance is almost written verbatim to Dr. Evans's observations.

143 'Aviation' (University of North Dakota) <https://aero.und.edu/aviation/> accessed 03 January 2023.

144 Jeremy Kariuki and Michael Wildes, 'What's Changed at the University of North Dakota Since Its 2021 Tragedy?' (Flying, 2022) <https://www.flyingmag.com/whats-changed-at-the-university-of-north-dakota-since-its-2021-tragedy/> accessed 03 January 2023.

145 Ibid.

146 William Hoffman, 'We Need to Change the System That Keeps Pilots from Seeking Mental health Care' (Scientific American, 22 November 2022) < https://www.scientificamerican.com/article/we-need-to-change-the-system-that-keeps-pilots-from-seeking-mental-health-care/#> accessed 02 January 2023.

147 Ibid.

148 'Tessa, Lennon and Lincoln' (Gofundme, 17 June 2022) <https://www.gofundme.com/f/tessa-lennon-and-lincoln> accessed 29 December 2022.

149 Ibid.

150 Linda Werfelman (n122) 27

Statistics released by Pasha and Stoke also found that,

> pilots involved in aviation accidents that had SSRI detected within their bodies, 88% had not disclosed their psychiatric conditions and 95% had never reported the use of antidepressants in the first place.[151]

Dr. Evans's arguments, the Germanwings accident, and the statistics published by Pasha and Stoke suggest that stricter aeromedical regulations tasked with the management of pilot mental health are insufficient and ineffective. Durham and Bliss confirm that additional work is needed to unify and improve standards within the international aviation community concerning pilot mental health.[152] It is argued here that Australia's approach to SSRI should be the blueprint for this standardisation.

This study focuses on pilot mental health because there is serious concern that the implementation of RCO or SPO will exacerbate the issues raised here. The inefficiencies of the current regulation of SSRI use among pilots should be remedied, especially before RCO and SPO become a reality. A lone pilot occupying the cockpit during RCO and SPO poses a significant risk to the safety of civil aviation when considered in the context of the Germanwings 9525 and LAM Mozambique accidents.

2.4.5 Remarks

What constitutes a psychoactive substance and its relation to mental health is discussed in this part. It was found that SSRIs which are used in the treatment of mental health conditions are also considered psychoactive substances. ICAO regulates the use of psychoactive substances in Chapter 2.3 of Annex 6, Chapter 1.2.7 of Annex 1, and Chapter 2.5 of Annex 2. All of which were discussed from a flight crew perspective. Thereafter, a comparative analysis was carried out on the USA and Australia's regulation of pilot SSRI use to illuminate the disparities between a strict and lenient approach. In closing, several deadly accidents in which pilot mental health was a contributing factor were examined further. The purpose of this, is to highlight the deadly consequences of the restrictive use and regulation of certain SSRIs.

Most notably, it was found that Australia's accommodating approach and intentional destigmatisation of pilot mental health is favoured and should be used as a blueprint.

151 Terouz Pasha and Paul Stoke (n133) 7.
152 Jake Durham and Timm Bliss (n82) 90.

It is advised that this blueprint be implemented by ICAO States prior to the introduction of RCO and SPO. Given the operational model of both concepts, the temporary or permanent isolation of one pilot on the flight deck, it is argued that strict regulation of pilot mental health and SSRI use will lead to an increase in safety risk.

2.5 Conclusion

This chapter examines Annex 6, Part I to the Chicago Convention in the context of RCO and SPO implementation. Specific chapters from this Annex regulating the minimum crew composition, fatigue management, and the use of psychoactive substances were addressed in sperate sections. The latter is discussed in tandem with pilot mental health. Conclusions to each section can be found under the remarks heading. The next chapter addresses Annex 8 to the Chicago Convention in a similar fashion.

Chapter 3: Annex 8, Part IIIB- Airworthiness of Aircraft

3.1 Introduction

Annex 8 to the Chicago Convention includes broad standards that define the minimum requirements for the recognition of Certificates of Airworthiness by ICAO States.[153] Annex 8 is divided into four separate parts. Part I - Definitions, Part II - Procedures for certification and continuing airworthiness of aircraft, Part III and IV respectively incorporate the technical requirements for the certification of large aeroplane designs and helicopters.[154]

Annex 8 is an extension of Article 33 of the Chicago Convention:

> Certificates of airworthiness and certificates of competency licenses issued or rendered valid by the contracting State in which the aircraft is registered, shall be recognised as valid by the other contracting States, provided that the requirements under which such certificates or licenses were issued or rendered valid are equal to or above the minimum standards which may be established from time to time pursuant to this Convention.[155]

The caveat given in Article 33 refers to the standards found in Annex 8. In *Airworthiness: An introduction to Aircraft Certification and Operations*, De Florio confirms that CAAs' airworthiness standards are composed in line with ICAO's Annexes.[156] He further submits that certification processes are based on the airworthiness standards set out by CAA's rather than directly on ICAO standards themselves.[157] Therefore, manufactures and associated parties are indirectly bound to the standards set by ICAO.

This chapter has two sections that delve into selected standards from Annex 8 as they relate to RCO and SPO. The first section analyzes the systems and equipment standards. The first section is further divided into four subsections. Subsection 1 expands on Chapter 6.1 of Annex 8. Subsection 2 explores the contents of the *Safety*

153 Any reference to Annex 8 to the Chicago Convention herein refers to Part IIIB of the Third Edition. 'Annexes 1 to 18' (ICAO) <https://www.icao.int/safety/airnavigation/nationalitymarks/annexes_booklet_en.pdf> accessed 03 August 2023.

154 Ibid.

155 Art 33, Chicago Convention.

156 Filippo De Florio (n40).

157 Ibid, "States are free to create their own standards, but level of airworthiness that must be maintained by national code is indicated by the broad standards of Annex 8".

Oversight Manual 9734 and assesses how this manual relates to the standards found in Chapter 6.1 of Annex 8. The third subsection contextualises the identified standards in relation to RCO and SPO. The final subsection uses the MCAS as a case study to demonstrate the fatal consequences that directly resulted from these standards not being adhered to. The second section of this chapter studies the operating environment and human factors standards found in Annex 8. Section 2 has two parts. Subsection 1 examines Chapter 9.1.2 and subsection 2 discusses Chapter 9.1.3 of Annex 8. It ends with a conclusion.

3.2 Systems and Equipment

Technology has been an integral part of aviation safety since the beginning of commercial flight. Auto-pilot, auto-throttle, ground proximity warning systems, TCAS, and on-board weather radar are just some of the systems that have been introduced.[158] Modern cockpits have seen a significant increase in automation because of new sophisticated hardware and software systems.

RCO and SPO realisation is expected to be implemented on the back of a significant roll out of novel systems and hardware intentionally created for cockpits and ground stations a like. The ability to monitor pilot fatigue levels, detect pilot incapacitation, autonomous landing, and taxi assistance are some of the capabilities these new systems are expected to possess. The central aim of this section is to identify the legal considerations that must be accounted for before introducing new systems and equipment on board civil aircraft for RCO and SPO.

3.2.1 Chapter 6.1 Annex 8, Part IIIB

Chapter 6.1 is separated into three parts:

> 6.1.1: The aeroplane shall be provided with approved instruments, equipment and systems, including guidance and flight management systems necessary for the safe operation of the aeroplane in the anticipated operating conditions. These shall include the instruments and equipment necessary to enable the crew to operate the aeroplane within its operating limitations. Instruments and equipment design shall observe human factors principles.

[158] Mark Miller and Sam Holley, 'Deficits in Cognitive Resilience of Commercial Pilots: The Case for Adding a Computer Information and Automation Tenet in Digital Flight Operations (2023) 98 Human-Centered Aerospace Systems and Sustainability Applications 74, 75.

6.1.2: The design of the instruments, equipment, and systems required by 6.1.1 and their installation shall be such that:

a) an inverse relationship exists between the probability of a failure condition and the severity of its effect on the aircraft and its occupants, as determined by a system safety assessment process:
b) they perform their intended function under all anticipated operating conditions: and
c) electromagnetic interference between them is minimised.

6.1.3: Means shall be provided to warn the crew of unsafe system operating conditions and to enable them to take corrective action.

Chapter 6.1.1 confirms that all instruments, equipment, and systems placed on an aircraft must be approved first. This approval is generally granted by CAAs in the certificate of airworthiness as described in Chapter 2 above. The last sentence of Chapter 6.1.1 places emphasis on the fact that 'instruments and equipment design shall consider human factor principles'. The *Human Factors Training Manual Doc 9683* thoroughly explains the significance of HF principles in aviation.

The Human Factors and Ergonomics Society defines HF as the study of how people use technology.[159] It involves the interaction of human abilities, expectations, and limitations, with work environments and system design.[160] Importantly, the society notes that HFE refers to the application of human factors principles to the design of devices and systems.[161] HFE will be discussed further in the next section of this chapter.

Chapter 6.1.2 contains three fundamental guidelines for CAAs and OEMs to follow when installing new instruments, equipment, or systems. If either one of these guidelines are overlooked during the design and installation process it could lead to catastrophic consequences. Even if all three guidelines are adequately carried out there is still a margin of error. Mark and Miller submit that incidents involving computer information and automation errors have increased by as much as 72%.[162]

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159 'What is Human Factors and Ergonomics' (Human Factors and Ergonomics Society) <https://www.hfes.org/About-HFES/What-is-Human-Factors-and-Ergonomics#:~:text=Human%20factors%20(HF)%20is%20the,design%20of%20devices%20and%20systems> accessed 12 August 2023.

160 Ibid.

161 Ibid.

162 Mark Miller and Sam Holley (n158) 74.

Chapter 6.1.3 ensures that measures are put in place to timeously warn the crew about any system failure that may occur. According to Miller and Holley, a sudden system failure is likely to provoke a startled response.[163] This causes confusion and a delayed and sometimes insufficient or inappropriate response before adequate recovery action is taken.[164] The miracle-on-the-Hudson perfectly demonstrates the importance of these warnings.[165] ICAO's *Safety Oversight Manual 9734* is discussed next because of its considerable role in safeguarding adherence to the provisions identified here.

3.2.2 Safety Oversight Manual 9734

The *Safety Oversight Manual 9734* is divided into Part A and B. Part A's objective is to emphasis the obligations and responsibilities for safety oversight of an ICAO contracting State.[166] Part B's objective is to provide guidance for States wishing to establish or participate in an RSOO.[167] According to Chapter 2.1.8 of Part B:

> Under the Chicago Convection, only the State has responsibility for safety oversight, and this responsibility may not be transferred to a regional body. Thus, although the State may delegate specific safety oversight tasks and functions to an RSOO, such as inspections for the certification of an operator, the State must still retain the minimum capability required to carry out its responsibilities under the Chicago Convention. States must always be able to properly and effectively monitor the safety oversight functions delegated to the RSOO.[168]

The above extract confirms that ICAO States who are party to a RSOO, EASA for example, are still bound to the contents of Part A. The State may defer certain responsibilities to the RSOO, however, it remains the individual State's responsibility to properly and effectively monitor the tasks delegated to the RSOO.

Chapter 2.1.1 of Part A is clear:

> Safety oversight is defined as a function by means of which States ensure effective implementation of the SARPs and associated procedures contained in the Annexes to the Chicago Convention on International Civil Aviation and related ICAO documents. Safety oversight also ensures that the national aviation industry provides a safety level

163 Ibid 78.
164 Ibid.
165 Jean Paries, 'Lessons from the Hudson' (2011) Resilience Engineering in Practice.
166 Ch 1.1, *Safety Oversight Manual,* Part A.
167 Ch 1.1, *Safety Oversight Manual*, Part B.
168 Ch 2.1.8, Ibid.

> adequate to, or better than, that defined by the SARPs. As such, an individual State's responsibility for safety oversight is the foundation upon which safe global aircraft operations are built. Lack of appropriate safety oversight in one Contracting State therefore threatens the health of international civil aircraft operations.[169]

The above extract includes a couple of fundamental points. Firstly, ICAO States' safety oversight obligations are not limited to Annex 8 only. The manual applies to all the other Annexes to the Chicago Convention as well. Therefore, the contents of the previous chapter and the chapter to follow in this dissertation must also be read in the context of the *Safety Oversight Manual*. However, emphasis is placed on Chapter 6.1 of Annex 8 because of the extreme risks associated with the fast-paced adoption of novel systems and equipment on board commercial aircraft.

Secondly, the extract highlights in simple terms that if one ICAO State fails in its duties and responsibilities, then all ICAO States fail. The closing sentences of the extract drives this point home. The manual reaffirms that an ICAO State's responsibility cannot be understated in this regard on the basis that safety oversight is a major obligation, and its implementation ensures the continued safety and regularity of all international air transport.[170] It maintains the health of aircraft operations across borders and throughout the world.[171]

Assembly Resolution A32-11 facilitated the creation of a Universal Safety Oversight Audit Program (USOAP), constituted to carry out regular, mandatory, systematic, and harmonised safety audits.[172] Assembly resolution A35-6 expanded the USOAP to cover all safety-related Annexes and enable the transition to a comprehensive systems approach for the conduct of safety oversight audits.[173] Assembly Resolution A35-6 further directed the Secretary-General to ensure that this new approach maintained, as core elements, the safety provisions contained in Annex 6, and Annex 8.[174] Listing these Annexes by name highlights their importance and stresses the obligation placed on ICAO States to ensure that they are either achieving or exceeding the standards found within the identified Annexes.

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169 Ch 2.1.1, *Safety Oversight Manual,* Part A.
170 Ch 2.1.3, Ibid.
171 Ch 2.3.1.1, Ibid.
172 Ch 2.1.4, Ibid.
173 Ch 2.1.6, Ibid.
174 Annex 1, 11, 13 and 14 are also included in the list.

3.2.3 RCO and SPO: Systems and Equipment

Airbus currently leads the way in the development and testing of new systems and equipment expected to facilitate RCO and SPO. Through its subsidiary, Airbus UpNext, the aircraft manufacturer has launched the DragonFly project.[175] An A350-1000 is currently the test bed aircraft for this new pilot assistance technology and is operated out of Toulouse-Blagnac Airport.

Automated emergency diversion during the cruise phase of flight is one of the systems currently being tested.[176] It is predicted to play a crucial role in RCO realisation. The system will have the ability to autonomously reroute the aircraft to the nearest airport while taking flight zones, terrain, and weather conditions into account.[177] This is significant because, in the event of pilot incapacitation, the system would be able to take control of the aircraft. The system that makes this possible is inspired by biomimicry. It consists of three cameras attached to the nose area of the aircraft which aid the system in identifying features in landmarks making it possible to safely manoeuvre autonomously within its surroundings.[178]

Fascinatingly, the system can communicate with and take instructions from ATC and the Airline Operations Control Centre.[179] In the current two-crew cockpit system the PM is usually responsible for ATC communications, while the PF focuses on flying the aircraft. Therefore, the temporary or permanent removal of the PM might not increase the PF workload, in terms of ATC communication, because the system would be able to attend to and complete this task.

Supporters of SPO are sure to mention that the Dragonfly project has successfully completed autonomous taxi in real-time conditions at Toulouse-Blagnac Airport.[180] This autonomous technology may keep the workload of the remaining pilot at an acceptable level during taxi which is a high workload phase. Operationally, the

175 'Airbus tests new technologies to enhance pilot assistance' (Airbus, 12 January 2023) <https://www.airbus.com/en/newsroom/press-releases/2023-01-airbus-tests-new-technologies-to-enhance-pilot-assistance> accessed 12 August 2023.

176 'Airbus tests new technologies to enhance pilot assistance' (n175).

177 Ibid.

178 Ibid.

179 'Will Airbus "Project Dragonfly" spell the END for Pilots?!' (Youtube, Mentour Now!, 6 August 2023) <https://www.youtube.com/watch?v=2YF8jQ9-DH4> accessed 10 August 2023.

180 'Airbus tests new technologies to enhance pilot assistance' (n175).

autonomous system would steer the aircraft from stand to runway, thus, allowing the single pilot (PF) to focus their attention on preparing the aircraft for departure.

It is becoming increasingly clear that new technologies supported by systems and equipment will soon have the capabilities to complete tasks currently carried out by human pilots. Project Dragonfly is just one of many initiatives expected to be launched in the coming years. However, all these concepts can only be rolled out commercially once it is proven that all the systems and equipment necessary for their implementation are deemed to be in line with the standards contained in Chapter 6.1 of Annex 8 and any other relevant standards set out by CAAs and ICAO. The next part details what can go wrong if these novel systems and equipment are not certified according to the SARPs.

3.2.4 MCAS: The lessons learnt from two fatal accidents

In 2011 Boeing confirmed that it would start manufacturing the MAX variant of its 737.[181] Initially, Jim Albaugh, president of Boeing at the time, publicly stated that the OEM was opposed to the idea of reusing the existing 737 airframe with next-generation engines.[182] He envisioned that Boeing would create a new narrow-body airframe from scratch. However, Boeing hastily scrapped Mr. Albaugh's plan in direct response to the success of the A320neo variant launched by its fierce competitor Airbus.[183]

Boeing quickly encountered serious difficulties in trying to fit the new engines onto the wing because the CFM LEAP-1B, used for the MAX, was significantly wider than its predecessors.[184] The low ground clearance of the 737 airframe led Boeing to increase the height of the landing gear. In addition to this, Boeing positioned the engines higher on the wings and slightly forward of the old position.[185]

181 David Slotnick, 'The first Boeing 737 MAX crash was 2 years ago today. Here's the complete history of the plane that's been grounded since 2 crashes killed 346 people 5 months apart' (Business Insider, 29 October 2020) <https://www.businessinsider.com/boeing-737-max-timeline-history-full-details-2019-9?IR=T> accessed 3 July 2021.

182 Ibid.

183 Reece Lenting, 'Where will the buck land: An analysis of the Maneuvering Characteristics Augmentation System (MCAS) and who can be held liable for its faults according to international law' (LLB dissertation, University of Pretoria 2021).

184 Phillip Johnston and Rozi Harris, 'The Boeing 737 MAX Saga: Lessons for Software Organizations' (2019) 21 SQP 4.

185 Ibid.

The relocation of the engines changed the aircraft's CG and increased the chances of an unintended vertical vector change in the positive direction, nose up, during take-off. To prevent the aircraft from entering a stall, Boeing deployed its MCAS, a technology it had exclusively used on its military aircraft.[186] It is important to note that the system had never been deployed on commercial aircraft before. A significant fact because military aircraft are not subject to the SARPs found in the Chicago Convention and its corresponding Annexes.[187]

Tragically, in 2018 and 2019, 346 people died in two separate accidents. In both cases, the aircraft involved was a Boeing 737-MAX. Flight JT610 crashed on 29 October 2018 while Flight ET302 failed to reach its destination on 10 March 2019. Subsequent investigations into the crashes conclusively found that MCAS was a main contributing factor in both incidents.[188] Tough questions were directed towards Boeing and the FAA surrounding the civil certification of MCAS. Did the FAA fail to meet its obligations and carry out its safety oversight responsibilities as prescribed in Annex 8 and the Safety Oversight Manuals?

As per De Florio, CAA's implemented ICAO SARP's according to their national frameworks.[189] Consequently, Boeing was able to circumvent national standards and regulations because of the delegation process introduced by the FAA.[190] The regulatory deficiencies of the delegation process, extensively detailed by Lenting,[191] allowed Boeing to unilaterally implement MCAS without sufficient testing and without disclosing what the system entailed.[192] Concerningly, Boeing did this despite the FHA confirming that failure of the sole AOA sensor, responsible for sending data to MCAS, fell within the catastrophic classification.

186 Phillip Johnston and Rozi Harris (185) 4.

187 Ch 3(a): This Convention shall be applicable only to civil aircraft and shall not be applicable to state aircraft and (b): Aircraft used in military, customs, and police services shall be deemed to be state aircraft, Chicago Convention.

188 Komite Nasional Keselamatan Transportasi *Final Report KNKT.18.10.35.04* 27; Ethiopian Aircraft Accident Investigation Bureau *Interim Investigation Report AI-01/19* 11.

189 Filippo De Florio (n40).

190 Reece Lenting (n184).

191 Ibid, 'The ODA unit blurs the line between manufacturer and national regulator… The author argues that there is no clear distinction between regulator and manufacturer through the implementation of delegation. The continued enforcement and operation of ODA without sufficient supervision could potentially lead to further aviation disasters.'

192 Ibid.

3.2.4 Remarks

The above case study shows that it is of paramount importance for CAAs to ensure that their standards and regulations as derived from Annex 8 are adhered to. The *Safety Oversight Manual* set further demands that CAAs be diligent and thorough in attaining these set standards and regulations specifically concerning those found in Annex 6 and 8. In light of the accidents caused by MCAS, ICAO must look into various ways of ensuring that CAA's are adequately overseeing the certification processes of new systems and equipment, like those found in the DragonFly project and similar initiatives, particularly those that are introduced to facilitate RCO and SPO.

3.3 Operating environment and human factors

The Boeing 787 and Airbus 350 were the last large commercial aircraft designed from a blank canvas. A significant amount of research and resources went into designing their cockpits, especially with human factors in mind, because the 'human/machine interface is usually the weak link in an operating environment'.[193] Stanton, Harris, & Starr assert that HF, specifically, the integration of the human with technology, and not the technology itself, is the limiting factor.[194] Chapter 9 of Annex 8 is discussed below to elaborate on the unique relationship between humans and machines in the context of RCO and SPO.

3.3.1 Chapter 9.2 of Annex 8

Chapter 9.2.1 of Annex 8 reads:

> The aeroplane shall be designed in such a way as to allow safe and efficient control by the flight crew. The design shall allow for variations in flight crew skill and physiology commensurate with flight crew licensing limits. Account shall be taken of the different expected operating conditions of the aeroplane in its environment, including operations degraded by failures.

The above extract sufficiently regulates the expected operating model of RCO. As previously stated, the current design of the two-crew cockpit can accommodate a sole pilot during cruise without diminishing that pilot's ability to safely operate the aircraft. However, the final sentence expressly states that 'operations degraded by failures'

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193 Ch 9.1 (Note 1), Annex 8.

194 N Stanton, D Harris and A Starr, 'The future flight deck: Modelling dual, single and distributed crewing options' (2016) 53 Applied Ergonomics 331.

must be accounted for as well. This raises a fundamental question. If a failure occurs or an emergency arises on the flight deck, during RCO, is the design of the two-crew cockpit conducive for the sole pilot to recover without assistance from an additional crew member? Currently, there is insufficient research and data to conclusively answer in the affirmative.

In terms of SPO, the above provision is insufficient and must be expanded given the operational model of this concept. The provision must be amended to include ground stations where the remote pilot will be based and operate. The ground pilot is expected to play a critical role during ordinary operations of international air services. Consequently, ICAO may require that these amendments be promulgated before CAA's or RCOO allow for the international implementation of SPO.

According to 9.2.2 of Annex 8:

> The workload imposed on the flight crew by the design of the aeroplane shall be reasonable at all stages of flight. Particular consideration shall be given to critical stages of flight and critical events which may reasonably be expected to occur during the service life of the aeroplane, such as a contained engine failure or windshear encounter.

Advanced automation has made it increasingly possible for RCO to be implemented because it has helped reduce much of the activity in the cockpit during the cruise phase of flight.[195] During cruise, pilots mainly monitor systems, check fuel usage at regular intervals, and conduct flight path assessments for weather and turbulence. However, a lone pilot working environment can lead to reduced stimulation, a drop in vigilance, and increased boredom.[196] Therefore, RCO implementation cannot only be measured on workload comparability or reduction because the consequence of that reduction or similarity on the remaining pilot must be thoroughly investigated. The purpose of this investigation is to determine the impact it will have on other human factors, such as fatigue and mental health as discussed in Chapter 2 above.

Things become a little more complicated with SPO because of the relocation of the second pilot to the ground. The provision may need amending to include several changes. The design of the ground station must be written into the provision for two

195 Salaheddine Bendak and Hamad Rashid (n43) 8.
196 Ibid.

reasons. Firstly, the design of the ground station must be done in a way that maintains the remote pilot's workload at reasonable levels throughout ordinary operations during all phases of flight. Secondly, in the event of pilot incapacitation of the on-board pilot, the design of the remote station must be such that the workload of the remote pilot also remains at or exceeds regulatory acceptable standards.

The continued safety of commercial flight during SPO also depends on research outcomes proving that any failure of the data link between the ground station and the aircraft, ceasing the ground pilot's ability to communicate and assist the remaining pilot, can occur without significantly increasing the remaining pilot's workload beyond acceptable levels, especially during critical phases of flight. Lim argues that to achieve certification, SPO needs to show that the pilot workload remains at an acceptable level during normal and emergency operations.[197]

3.3.2 Chapter 9.3 of Annex 8

Chapter 9.3 of Annex 8 prescribes that:

> During design of the aeroplane, account shall be taken of ergonomic factors including:
>
> a) ease of use and prevention of inadvertent misuse;
> b) accessibility;
> c) flight crew working environment;
> d) cockpit standardization; and
> e) maintainability.

The Merriam-Webster dictionary defines ergonomics in general as an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely.[198] The *Manual on Human Factors (HP) for Regulators 10151* defines ergonomics from an aviation perspective as a subset of HF that focuses specifically on designing technical systems, product, and equipment to meet the physical needs of the user.[199] These considerations are important to factor in as to avoid ergonomic issues that often come about because the effort required to

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197 Yixiang Lim (n1) 8.

198 'Ergonomics' (Merriam Webster Dictionary) <https://www.merriam-webster.com/dictionary/ergonomics> accessed 22 August 2023.

199 *Manual on Human Factors (HP) for Regulators 10151, First Edition (Advanced unedited), 2021.*

complete a task overloads the sustaining and supportive process of the body.[200] Thus, leading to unwanted fatigue, injury, or errors.[201]

Stanton submits that ergonomics and human factors in aviation are essential for the safety and efficiency of commercial airlines.[202] According to him, ergonomics methodologies have moved from focusing on individual tasks to entire systems.[203] Interestingly, Harris and Stanton have previously described aviation as being a system of systems.[204] Pilot-in the-loop or pilot-in-the-mesh are the terms used to describe the relationship between flight crew members and this system.[205] The essential purpose of ergonomics is understanding how pilots function and operator as a crucial actor in this system with the hope of maintaining or improving the safety of commercial flight.

Miller and Holley argue that the biggest driving force shaping the future designs of cockpits are ergonomic considerations.[206] They further note that Airbus is promoting their new A350 model, the DragonFly project discussed above, as a starting point for RCO and SPO which will be supported by a computer-centred ergonomic design philosophy.[207] Miller and Holley submit that the design of future cockpits, or the redesign of current cockpits, for RCO and SPO realisation will require better knowledge of ergonomics given the introduction of new actors into the system.[208] Specific to SPO, ground stations must be included in this discussion and scrutinised more because of their intended purpose. The need for further research and data collection into ground pilot-in-the-loop/mesh cannot be overlooked in the development of SPO.

3.3.3 Remarks

As we continue to head towards a future dictated by automation, the safety of commercial aviation depends on us fully understanding how the human, in this case

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200 Robert Bridger, *Introduction to Ergonomics* (2nd Edition, Routledge, 2008) 7.
201 Ibid.
202 Miquel Angel Piera and more, 'A socio-Technical Simulation Model for the Design of the Future Single Pilot Cockpit: An Opportunity to Improve Pilot Performance' (2022) 10 IEEE Access 22330.
203 Ibid.
204 D Harris and N Stanton, 'Aviation as a System of Systems: Preface to the Special Issue of Human Factors in Aviation' (2010) 53 Ergonomics 145-148.
205 Miquel Angel Piera and more (n203) 22330.
206 Mark Miller and Sam Holley (n158) 74.
207 Ibid.
208 Ibid.

the flight crew, engages with their highly autonomous work environment. Continued research into pilot-in-the-loop or mesh will aid in the mission to strengthen the relationship between humans and machines as RCO and SPO become a reality. Ergonomic methodologies, in addition to other HFs, must play a central role in the design of future cockpits and ground stations to maintain current safety standards or in the best-case scenario, enhance them.

3.4 Conclusion

This Chapter identified and discussed select provisions from Annex 8 as they pertain to the implementation of RCO and SPO. Annex 8 to the Chicago Convention only contains standards and no recommended practices. The exclusive inclusion of standards demonstrates the critical nature of the contents therein for the continued safety of the aviation industry at large. There is an obligation on ICAO States, whether individually or party to a RCOO, to implement their standards and regulations per Annex 8 and the *Safety Oversight Manual 9734.* Especially regarding the implementation of novel technologies earmarked for RCO and SPO through initiatives like Airbus' Dragonfly project. The MCAS was used as a case study to illustrate the detrimental consequences that may arise if any ICAO State fails to carry out its duties. Moreover, cockpit environments specially designed for RCO and SPO must be completed in such a way that takes workload and ergonomic considerations into account. It was found that these considerations must be extended to ground stations as well where the remote pilot is expected to operate from during ordinary SPO. Lastly. cockpit and ground station designs must also take other HFs into account, such as those explored in Chapter 2 of the dissertation.

Chapter 4: Annex 17- Security

4.1 Introduction

Malicious actors with varying motivations have used aviation as their weapon of choice. 9/11 will forever remain engrained in the memory of society and the aviation industry at large as a tragic example of how aviation has been used as a weapon of mass destruction. The aviation sector has constantly had to stay abreast with malevolent actors and their ingenious techniques to safeguard the safety of commercial aviation.

ICAO drafted and published Annex 17 as its defence to prevent and counteract unlawful interference in civil aviation.[209] Since then, ICAO through its Council, has facilitated the publication of 10 editions of Annex 17. Each edition has been introduced with the sole purpose of trying as best as reasonably possible to stay one step ahead of the bad guys. RCO and SPO are expected to see new vulnerabilities introduced into the aviation system. An examination into cybersecurity measures, as implemented by signatory States, is conducted to determine if they adequately address the vulnerabilities expected to come about with RCO and SPO realisation.

4.2 Cybersecurity

Throughout its existence, aviation has faced a variety of challenges and threats from a security standpoint. Miller and Holley have raised some concern by referencing statistics taken from an adjacent transport sector, maritime.[210] The authors found that the number of cyber-attacks targeted at shipping navigation systems has increased exponentially in recent times.[211] According to their figures, 2020 saw a 400% increase in similar attacks.[212] Albeit, this was substantially lower than the 900% increase witnessed between the years 2017 to 2019.[213] Despite these statistics seemingly showing a decrease in attacks, the percentage remains worryingly high. The aviation industry should pay careful attention to these cases because it is only a matter of time before similar statistics are seen in air transport. Consequently, the aviation sector must learn from maritime and utilise cutting-edge technologies to prevent similar

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209 Annex 17, Chicago Convention (1974, First Edition).
210 Mark Miller and Sam Holley (n158) 80.
211 Ibid.
212 Ibid.
213 Ibid.

attacks from spilling over into civil aviation. This section identifies the main cybersecurity vulnerability that may arise when implementing RCO and SPO.

4.2.1 The data link

A critical function of SPO is the data link that will enable the ground pilot to take remote control of the aircraft. For instance, during pilot incapacitation of the onboard pilot, the ground pilot would act similarly to how an RPAS operator functions. The use of a data link between ground stations and the aircraft presents an opportunity for unscrupulous actors to hijack these networks and unlawfully take over the aircraft or send incorrect data to the aircraft that could put it and its occupants in danger. The UK Department of Transport rightfully submits that:

> It is almost certain that the aviation industry, especially airlines, will continue to be a target for malicious cyber actors. Their methods are likely to evolve as innovation and new technologies are deployed.[214]

ICAO and its member States must remain ahead of the curve to prevent the illicit use of these communication links. One method to do this is to introduce laws that protect the cybersecurity of these communication channels. The recent release of the Cybersecurity Policy Guidance in 2022 by ICAO shows its commitment to this cause. IATA writes that the objective of the Cybersecurity document is to serve as a guide to help States and the industry focus resources and actions to achieve a systematic approach to cybersecurity in civil aviation, including current and legacy systems.[215] Furthermore, the central deliverable for ICAO States and associated stakeholders is to be able to develop a system-of-systems approach that enables civil aviation to be protected against cybersecurity threats, to respond to and recover from cybersecurity incidents in a timely way, and to withstand new threats without significant interruption.[216] Any corruption of the data link regardless of intent is just one of the many new threats that the industry will encounter.

One of IATA's main outcomes is to ensure civil aviation is cyber-resilient. In *Cyber Safety and Security for Reduced Crew Operations (RCO)*, Driscoll, Roy, and Ponchak

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214 Rachel Showerby, 'Cyber Security in Aviation' (UK Department of Transport).

215 'Cyber Security Guidance' (IATA, January 2022).

216 Ibid.

make two valid points.[217] Firstly, it is not always possible to design a system, the data link in this instance, that has a 'failsafe' state and no type of dual-redundant architecture that would be safe for such systems.[218] ICAO is highly unlikely to allow for SPO operations if this were to be the case for these crucial data channels.[219] Secondly, the authors argue that a simple dual redundancy can only give you availability and integrity, but not both.[220] If both characteristics are necessary, the system needs to be at least triplex.[221] The criticalness of the data link for SPO demands that both are present and Driscoll, Roy, and Ponchak thoroughly explain why this is the case.

According to Driscoll, Roy, and Ponchak:

> While safety, security, and certification issues for the hardware and software that make up the nonhuman parts of an RCO or SPO system have not been totally neglected in previous studies, these issues certainly have taken a backseat to studying the human parts of these systems.[222]

IATA has put measures in place in an attempt to balance the scales. The association has requested that ICAO States designate an appropriate authority for aviation cybersecurity specifically created to oversee aviation cybersecurity and resilience. A leader in implementing this is the UK CAA. It believes that 'the changing threat landscape encourages a proactive approach to cybersecurity and in response means aviation organisations need dynamic protection.[223] The UK CAA is extremely aware of the fact that cybersecurity strategies and policies must be reviewed regularly to keep pace with these ever-changing cybersecurity trends and threats. The UK CAA understands that the issues raised by Roy and his colleagues cannot be overlooked for much longer. If SPO is to become a reality, there must be a drive towards producing more research into the underrepresented subject matters within cybersecurity. It must be noted though, that there has been a steady increase in publications addressing these neglected areas. It remains to be seen if enough is being done.

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217 Kevin Driscoll, Aloke Roy, and Denis Ponchak, 'Cyber Safety and Security for Reduced Crew Operations (RCO)' (2017) IEEE Aerospace Conference, Big Sky, MT, USA, 2017.
218 Ibid.
219 Ibid.
220 Ibid.
221 Ibid.
222 Ibid.
223 'Cyber Security Crtitical Systems Scoping Guidnace' (UK CAA, CAP1849, August 2020).

The UK CAA sets a perfect example as they understand that it is important to clearly identify and document critical network and information systems to aid in applying comprehensive, appropriate, and proportionate cybersecurity measures. There is no doubt that the UK CAA will characterise the data link as a critical network and information system. As a result, the organisation will conduct an investigation to determine if the loss of confidentiality, integrity, or availability would result in loss of life (flight safety) or inability to deliver the essential service or essential function.[224]

IATA understands that for critical infrastructure to be protected, including these data links, a multilateral collaboration approach within civil aviation that also extends to external authorities such as military, cybersecurity, and national security is required.[225] Once again it is seen here that if one ICAO State fails in its duty to protect these data links once operational, then all ICAO States will fail. Thus, resulting in the health of international civil aircraft operations being threatened. Therefore, ICAO States should engage in data-sharing practices to facilitate the standardisation and protection of these safety-critical systems. One area where ICAO States can collaborate already is in the facilitation of data encryption.

4.2.2 Encryption legislation

In his position as Regional Officer, Aviation Security, and Facilitation, Jose Pecharroman found that lack of encryption or authentication of critical systems is a concerning scenario. Driscoll, Roy, and Ponchak expand on Pecharroman's concern and argue that several hurdles must be overcome before encryption can be used to sufficiently protect communication links during SPO.[226] Despite these hurdles, the authors also acknowledge that the only viable option to secure these links is through encryption.[227]

Driscoll, Roy, and Ponchak extensively discuss how there are laws in almost every country that place some form of restriction on the export, import, and domestic use of encryption technologies.[228] These laws are tasked with regulating the paradox of

224 Ibid.
225 'Cyber Security Guidance' (IATA, January 2022).
226 Kevin Driscoll, Aloke Roy, and Denis Ponchak (n218) 8.
227 Ibid 8.
228 Ibid 9.

encryption because it is perceived in two conflicting ways.[229] On one hand, it is a tool used to protect privacy and security. However, on the other hand, it can also be used to facilitate criminal activity.[230]

Koomen's examination of the EU and how it is tackling this contentious debate demonstrates what an arduous task it is to try and find the right solution.[231] The first issue is that efforts to weaken or break encryption in an attempt to combat crime ultimately undermine EU privacy and security policies.[232] As we spearhead into the digital age, the European Commission has prioritised creating an EU fit for the digital age where concepts such as SPO can be materialised. Therefore, the EU must strike a balance between allowing encryption to protect privacy, critical information, and networks, such as the data link needed in SPO, while also ensuring that it is not used for unlawful means. Moreover, the European Commission has the additional task of getting all its Member States to come to a consensus on the way forward for encryption legislation. A difficult undertaking given the polarising opinions on the subject.

In *Decrypting Australia's 'Anti-Encryption' legislation: The meaning and effects of the 'systemic weakness' limitations*, Davis delves into the same debate as it develops in Australia.[233] According to him, Australia's telecommunications legislation is also quite polarising because, from one perspective, he argues that it is a draconian 'anti-encryption' law that allows the Australian Government to compel companies to 'build surveillance backdoors into their encrypted products or services'.[234] In contrast, it can also be said that the legislation is a measured response to 'going dark'.[235] This is the same debate that is on the table at the European Commission.

Providing for these backdoors in national legislation becomes equally contentious from an aviation standpoint. Returning to Driscoll, Roy, and Ponchak, they raise important

229 Maria Koomen, 'The Encryption Debate in the European Union: 2021 Update' (2021) International Encryption Brief 1.
230 Ibid.
231 Ibid.
232 Ibid.
233 Peter Davis, 'Decrypting Australia's 'Anti-Encryption' legislation: The meaning and effects of the 'systemic weakness' limitations' (2022) 44 Computer Law & Security Review 1-17.
234 Ibid 1.
235 Ibid "The phenomenon of 'going dark' or 'going spotty' describes the challenges faced by law enforcement and intelligence agencies around the world with deciphering encrypted information at rest and in transit". CF

questions about trust, backdoors, and encryption keys.[236] They use an illustration to bring their point across:

> As a complex example to illustrate the point, let's say that an aircraft manufacturer includes some cryptographic equipment manufactured by some avionics supplier; the aircraft manufacturer sells the aircraft to a leasing company; the leasing company leases the aircraft to a scheduled airline; the airline rents the aircraft to a charter company at times when the airline isn't using that aircraft; and, the charter company hires a crew that normally works for some other rival airline. Whose keys should be used for the encryption? Should the cryptographic equipment have software with a dedicated link to some key management infrastructure owned by the avionics company? the aircraft manufacturer? the leasing company? the airline? Or, should the crew load keys as part of preflight? If so, what keys should be used? the charter airline's keys? the crew's personal keys? the keys they use as employees of the rival airline? Should there be one set of keys for all systems on the aircraft that want to communicate with the ground? Or, should some systems have keys (or use a key infrastructure) that is different from other systems?[237]

The lengthy extract above demonstrates why it is so important that ICAO States promulgate encryption legislation that is well-balanced because the safety of civil aviation depends on it as we head into the digital age. National legislation must therefore address authorised backdoor access and key management policies in light of the data links expected to be used during SPO.

4.3 Conclusion

Cybersecurity is becoming a greater concern for IATA, ICAO, and its signatory States as we head further into the digital age. Cybersecurity is a dynamic threat that constantly evolves as new technologies are introduced. Therefore, it is imperative for these parties to constantly evaluate their cybersecurity strategies and policies to establish if they are still relevant and operative. This section examined the cybersecurity risks associated with RCO and SPO, however with a focus on the latter. The data link used to send signals from the ground pilot to the aircraft is the central feature of this section. Thereafter, encryption was discussed, and it was said that it may be the only viable option to protect the data links that are needed during SPO.

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236 Kevin Driscoll, Aloke Roy, and Denis Ponchak (n218) 9.
237 Ibid 10.

Despite being the only viable option, the polarising opinions on encryption coming from the intelligence community, law enforcement, policymakers, tech companies, industry, and civil society have resulted in vigorous debate. In light of this ICAO States have the responsibility of finding the balance in their national legalisation between going completely dark, authorizing the use of back doors, and the management of keys before SPO is introduced.

Chapter 5: Dissertation conclusion

The number of publications focused on RCO and SPO has steadily increased as more and more stakeholders investigate the potential cost savings that could come from implementing these concepts. Scholars have published a plethora of publications that address RCO and SPO from various standpoints. Despite all these voices adding to the development of these novel concepts, the author found that only a few of them have briefly examined these de-crewing measures from a legal perspective. Consequently, this dissertation aims to contribute to RCO and SPO discourse from a legal perspective because it is underrepresented. The primary sources used in the completion of this dissertation are the Chicago Convention and its corresponding Annexes. The author acknowledged that many provisions in these documents may very well relate to RCO and SPO in some way, however, due to space constraints only a handful were selected.

Chapter 2 identified and expanded on three headings taken from Annex 6, Part I, flight crew composition, fatigue management, and the use of psychoactive substances. The latter was discussed with pilot mental health at the forefront. It was held that OEMs and operators can only reduce the minimum flight crew composition once CAAs authorise them to. Secondly, the removal of one pilot temporarily or permanently is expected to affect the remaining pilot's fatigue patterns. The current fragmented approach to fatigue management may be insufficient to safely accommodate RCO and SPO. Therefore, it is strongly suggested that fatigue management is standardised before the realisation of these concepts. Lastly, the discussion on the use of psychoactive substances and pilot mental health found that Australia's measured approach should be used as a blueprint by other ICAO States.

Chapter 3 addressed two crucial topics found in Annex 8, Part IIIB. Systems and equipment were explored first, and this was followed by an investigation into the operating environment and human factors as they relate to aircraft certification. Two accidents caused by the MCAS were used as a case study to demonstrate what could go wrong if ICAO States fail to meet their obligations. Failure to adequately oversee the certification process of new systems and equipment used in RCO and SPO, like those used in the Dragonfly project, could result in similar catastrophic consequences. Secondly, it was found that ergonomic considerations must be prioritised when designing cockpits for RCO and SPO use. Further research into pilot-in-the-loop/mesh is needed to better understand the relationship between pilot and machine.

Chapter 4 was tasked with attending to cybersecurity as found in Annex 17. Due to the limitations set out in Chapter 1, the author deviated from the structure used in the preceding chapters. Aviation has long been the target of malicious actors for several varying reasons. The sector has had to protect civil aviation from bombs placed in checked luggage and onboard hijackings as seen during the 9/11 attacks. SPO will see the introduction of a data link that will allow the ground pilot to remote control the aircraft which brings about new cyber vulnerabilities. It was held that encryption may be the only viable solution to protect these networks. However, encryption is a polarising subject and has given rise to fierce debate around the correct use of the technology. It was held that ICAO States must find a middle ground on encryption use before SPO is introduced.

According to this dissertation, it is possible to implement RCO and SPO on condition that certain amendments and improvements are made to the exiting aviation law framework. These changes range from small alterations to national legislation and regulations to other instances where standardisation is necessitated on a globe scale through the adoption of international aviation law instruments. This dissertation does not conclusively find that these alterations will maintain or enhance the safety of the aviation sector. Consequently, the minimum flight crew requirement on board large commercial aircraft will remain in place until such a time that a simple determination can be made, that having one pilot in the cockpit is just as safe as having two pilots.

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