Comparative Analysis of Legislation Governing Maintenance Check Flight of Aircraft

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ABSTRACT

Aviation activity is conducted under the ambit of internationally agreed upon Air Law, which imposes the International Civil Aviation Organisation (ICAO)'s Standards and Recommended Practices upon global aviation stakeholders. The imposition of standardised Air Law is in line with ICAO's founding charter, which declares the principles of regulatory uniformity and safety as fundamental postulates. While ICAO's efforts at the standardisation of Air Law are commendable, certain aviation activities occur in the absence of agreed-upon international standards. The Maintenance Check Flight (MCF) is one such activity.

An MCF supports the aircraft maintenance process by verifying aircraft system operability after the completion of a maintenance task, or as a troubleshooting step before corrective maintenance action. MCFs are considered more risky than regular commercial flights,[1] with several accidents on record which are attributable to the MCF process.[2] Despite the elevated risk associated with MCF, there exist notable inconsistencies in MCF regulation across international aviation legal systems. This inconsistent regulatory stasis appears to be at odds with ICAO's fundamental principles, and prompts a compelling research question: what legislative framework exists to promote safety during MCF activity across different legal systems? This study analyses the practical aspects pertaining to MCFs, as well as South African and European Aviation Safety Agency (EASA) jurisprudence to determine the basis of MCF risk, and whether this risk may be managed by exacting Air Law.

[1] Stephan Poprawa 'Maintenance test flying – an accident waiting to happen?' (2015) Volume 119 *The Aeronautical Journal* 781–90.
[2] Mark Lacagnina 'Check Flight Checkup', *Flight Safety Foundation*, available at: *https://flightsafety.org/asw-article/check-flight-checkup/*, accessed on 9 August 2022.

LIST OF ABBREVIATIONS

AAIB	Air Accidents Investigation Branch
AIC	Aeronautical Information Circular
AMC	Acceptable Means of Compliance
AMP	Aircraft Maintenance Programme
AMM	Aircraft Maintenance Manual
ANAC	Agência Nacional de Aviação Civil
ANRS	Air Navigation Regulations
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
BEA	Bureau d'enquêtes et d'analyses
BFU	Bundesstelle für Flugunfalluntersuchung
CARCom	Civil Aviation Regulations Committee
CARS	Civil Aviation Regulations
CATS	Civil Aviation Technical Standards
CoA	Certificate of Airworthiness
CRD	Comment Response Document
CRS	Certificate of Release to Service
CS	Certification Specifications
EASA	European Aviation Safety Agency
EC	European Commission
ED	Executive Director
ELA	European Light Aircraft
EU	European Union
FAA	Federal Aviation Administration
FCF	Functional Check Flight
FEF	Functional Evaluation Flight
FTSSA	Flight Test Society of South Africa
GM	Guidance Material
GPIAAF	Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários
ICAO	International Civil Aviation Organisation
InFO	Information for Operators

IRs	Implementing Regulations
ISATFM	In-Service Aircraft Technical Flight Manual
JAA	Joint Aviation Authorities
JARS	Joint Aviation Regulations
MCF	Maintenance Check Flight
MEDA	Maintenance Error Decision Aid
MPI	Mandatory Periodic Inspection
NAA	National Aviation Authority
NASA	National Aeronautics and Space Administration
NPA	Notice of Proposed Amendment
NRFO	Non-Routine Flight Operation
NTSB	National Transportation Safety Board
OJ	Official Journal of the European Union
OEM	Original Equipment Manufacturer
PIC	Pilot in Command
PMTF	Post Maintenance Test Flight
RIA	Regulatory Impact Assessment
RMT	Rulemaking Task
SACAA	South African Civil Aviation Authority
SAFO	Safety Alert for Operators
SARPS	Standards and Recommended Practices
SOP	Standard Operating Procedure
SPO	Specialised Operations
STC	Supplemental Type Certificate
TC	Transport Canada
TFASA	Test Flying Academy of South Africa
UAS	Undesired Aircraft State
UKCAA	United Kingdom Civil Aviation Authority

CHAPTER 1: INTRODUCTION

1.1 Introduction

Aircraft maintenance is a fundamental category of Air Law, as defined by the legal treatises of the International Civil Aviation Authority, ICAO. Maintenance stems directly from two stated aims of ICAO in its founding charter: safety and uniformity. The concept of maintenance is not a mere technical practice, as the word suggests. Regular maintenance seeks to ensure that aircraft components and systems remain functional and therefore safe; while the uniformed protocols which govern aircraft maintenance are enshrined in international agreements and are intrinsic to Air Law.

In terms of implementation, aircraft maintenance is conducted periodically in compliance with manufacturer and regulatory requirements to ensure continued airworthiness. An aircraft is deemed airworthy if it conforms to its approved design, is serviceable and is in a condition for safe operation.[3] However, within aircraft maintenance legislation, there exists a more specific categorisation which is the fulcrum of this study: the Maintenance Check Flight (MCF).

A maintenance check is the verification of aircraft or system operability which conventionally occurs after completion of maintenance tasks. In rare instances this operability check may be required prior to the commencement of a maintenance procedure to assist in troubleshooting and fault diagnosis. Such verification could range from a simple system check performed by aircraft maintenance personnel while the aircraft remains safely grounded, to a complex MCF performed by pilots. This dissertation focuses on the latter protocol, the MCF.

An MCF is carried out by a licensed pilot-in-command (PIC) of an aircraft to verify normal aircraft performance, or to establish the correct functioning of systems which cannot be established during ground checks.[4] In certain circumstances an MCF is prescribed by Air Law or mandated by a maintenance procedure, whilst in other circumstances an MCF is performed electively by the aircraft owner or operator for

[3] CAR 1.01.1.
[4] United Kingdom Civil Aviation Authority *Check Flight Handbook CAP 1038* (2017) at 12.

quality assurance purposes. An operator is an entity licensed to conduct air services such as an airline.[5] The objective of an MCF is to verify aircraft system operation relative to an established, safe standard. Although the MCF's objective is the assurance of safety, the flight itself carries an element of risk, as explained by Stephan Poprawa:

> 'Maintenance [check] flights are a necessary component for the [aviation] industry to maintain its exceptional safety standards… But such flights in themselves remain demonstrably one or two orders of magnitude more risky than commercial flights.'[6]

If we consider the safety culture which is rigidly entrenched in all facets of civilian aviation and attributable to ICAO's founding charter, a compelling research question arises: what legislative framework exists across jurisdictions to promote safety during MCF operations?

1.2 Background

The world's first powered, controllable, heavier-than-air aircraft - the Wright Flyer of 1903 - was maintained by a bicycle technician and flown by a self-taught pilot in a world largely devoid of any Air Law.[7] The Wright Flyer and every aircraft hence have required maintenance to ensure their continued serviceability and airworthiness. Pilots have therefore been performing MCFs since the genesis of powered aviation. Precise statistics on the number of MCFs conducted annually are not available, but the quantum is significant. Majority of these flights are performed in complete safety, allowing the aircraft to re-enter service without further ado. It is for this reason that accidents which occur during MCF operations are particularly noteworthy.

On 27 November 2008 an Airbus A320-232 operated by XL Airways Germany[8] was undergoing an MCF prior to its return to the aircraft owner, Air New Zealand. During the flight the aircraft crashed into the Mediterranean Sea at coordinates

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[5] CAR 1.01.1.
[6] Poprawa, op cit n 1 at 781.
[7] Scott Johnson *The Evolution of Aviation Maintenance* (2013) at 3.
[8] XL Airways Germany was a charter airline which operated flights between 2006 and 2013 utilising leased aircraft.

N42°40’34.56” E003°06’31.34”[9] near Perpignan-Rivesaltes airport, France, killing all seven occupants and destroying the aircraft. This accident is colloquially known as *the Perpignan Accident* and became a pivotal case study in MCF safety. An accident is defined in Air Law as ‘an occurrence associated with the operation of an aircraft… in which a person is fatally or seriously injured…, the aircraft suffers damage or structural failure…, or the aircraft is missing or completely inaccessible…’[10]

The Perpignan Accident investigation report published in French by the Bureau d'enquêtes et d'analyses (BEA), France’s air accident investigation authority[11] is the official work of reference, although this research references the English translation thereof. The English translation is intended to provide easier reference for English speakers, but in certain instances may lack the level of accuracy of the original French version.[12] The report cites the absence of a regulatory framework in relation to non-revenue flights as a primary cause of this crash,[13] recommending that aviation regulatory authorities should detail in law different types of non-revenue flights; precisely describing their preparation, programme, operational framework, and crew training requirements.[14] At the time of the crash, Air Law categorised MCF as a non-revenue flight.[15]

1.3 The legal status of investigation reports

After the occurrence of an incident or accident, a state is compelled by ICAO to institute an investigation into the circumstances of the incident or accident.[16] A specialist state authority fulfils this purpose as empowered by an Act or statute, such as France’s Civil Aviation Code (Book VII), which determines the regulatory provisions of the BEA. An investigation is a process whereby information is

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[9] BEA ‘Accident Report: Perpignan Accident During Maintenance Check Flight Final Report (English Translation)’, 2010, at 50 available at: *https://bea.aero/docspa/2008/d-la081127.en/pdf/d-la081127.en.pdf*, accessed on 25 January 2022.
[10] *Annex 13: Aircraft Accident and Incident Investigation* 12 ed (2020) at I–1.
[11] ‘BEA Legal Context’, available at: *https://bea.aero/en/the-bea/legal-context/*, accessed on 26 August 2022.
[12] BEA, op cit n 9 Special foreword to English edition.
[13] Ibid at 98.
[14] Ibid at 99.
[15] EU Regulation EU-OPS 1.175.
[16] Convention on International Civil Aviation 7 December 1944, Article 26.

gathered and analysed by experts to determine the cause of an incident or accident, and as a basis for the proposal of safety recommendations in a final report.[17] According to ICAO, the intention of a safety recommendation is the prevention of further incidents or accidents, and in no case has the purpose of creating a presumption of blame or liability.[18] These investigations are separate to judicial or administrative proceedings which seek to apportion blame or liability.[19] Several jurisdictions enjoy laws to prevent the use of accident investigation reports as evidence in civil and criminal proceedings.[20] The South African Civil Aviation Act states that the findings of accident investigations are not binding on parties and thus may not be used in criminal, civil or disciplinary proceedings.[21] All BEA incident / accident reports state their objective as the prevention of future incidents or accidents, while cautioning that the use of the report for purposes other than safety-enhancement may lead to erroneous interpretations of the contents.[22]

Notwithstanding, the cost and loss of life often associated with aircraft accidents is fertile ground for the pursuit of civil or criminal liability. Some states deviate from ICAO's 'no-blame' policy by allowing litigation to occur as a direct result of an accident investigation, such as New Zealand.[23] The Candidate is not aware of any civil or criminal litigation which arose from the Perpignan Accident, while criminal and civil liabilities arising from air accidents are in fact beyond the scope of this writing.

The significance of the Perpignan Accident report within the context of this research lies in its safety recommendations. A safety recommendation proposes corrective or preventative action which should be taken promptly to enhance aviation safety.[24] The recipient of a safety recommendation must, within ninety days, indicate the corrective or preventative action taken or under consideration, or explain

[17] *Annex 13: Aircraft Accident and Incident Investigation*, supra n 10 at 1–2.
[18] Ibid at 1–3.
[19] Ibid at 5–3.
[20] Ronald IC Bartsch *International Aviation Law: A Practical Guide* 2nd edition (2018) at 169.
[21] Civil Aviation Act of 2009 Chapter 4, Part 1, 11 (5).
[22] BEA, op cit n 9 at 1.
[23] Angela Beazer 'International aircraft accidents: the international legal framework' (2015) *The Legal Lounge*.
[24] *Annex 13: Aircraft Accident and Incident Investigation*, supra n 10 at 6–3.

the reasons why no action will be taken.[25] The BEA's accident report on the Perpignan Accident proposed no less than six safety recommendations to regulatory authorities, of which two relate to MCF.

1.4 Aftermath of the Perpignan Accident

The Perpignan Accident, alongside similar accidents drew the attention of the Flight Safety Foundation (FSF), an international organization chartered to provide expert safety guidance to the aviation industry.[26] In February 2011 the FSF partnered with aircraft manufacturers Boeing, Airbus, Embraer, Bombardier as well as several international airlines and regulatory authorities to host a Functional Check Flight Symposium, wherein MCF safety and regulation were deliberated. A declaration by Jim Burin, Director of Technical Programs at the FSF, during his concluding address was that regulators should establish 'sensible, well-defined regulations… addressing [maintenance] check flights.'[27] This declaration largely echoes the recommendations published in the Perpignan Accident report.

The safety recommendations published in the Perpignan Accident report prompted the European Aviation Safety Agency (EASA), the body which presides over the common rules of civil aviation in the European Union and European Free Trade Association,[28] to review the Air Law governing MCF. EASA determined that MCF operations were 'not sufficiently addressed in law'[29] and that the assumed ratio for accidents or serious incidents associated with MCFs was higher than for regular operations.[30]

On 1 April 2011 EASA commenced a rulemaking process seeking to amend the Air Law governing MCF, with the objective of reducing the probability of future

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[25] Ibid at 6–4.
[26] 'Flight Safety Foundation Website: About the Foundation', available at: *https://flightsafety.org/foundation/*, accessed on 19 September 2022.
[27] Jim Burin 'Functional Check Flight Symposium Concluding Address' (Functional Check Flight Symposium, Canada) available at: *https://flightsafety.org/toolkits-resources/functional-check-flights/functional-check-flight-fcf-symposium-presentations/*.
[28] Regulation 1592/2002 of the European Parliament and Council.
[29] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', 1 April 2011, at 1 available at: *https://www.easa.europa.eu/en/downloads/9494/en*, accessed on 14 October 2022.
[30] 'EASA Notice of Proposed Amendment (NPA) 2012-08', 30 July 2012, available at: *https://www.easa.europa.eu/en/downloads/584/en*, accessed on 14 October 2022.

accidents.[31] This rulemaking process concluded on 24 July 2019 via the adoption and implementation of Regulation (EU) 2019/1384 by the European Commission, containing sui generis Air Law dedicated to the regulation of MCF. This dissertation refers to the Air Law of the EU and European Free Trade Association collectively as *EASA Air Law* because EASA presides over aviation rules in these jurisdictions, of which five states are not EU members: Norway, Iceland, Switzerland, Lichtenstein, and Monaco.[32]

The EASA MCF Air Law addresses several aspects which contribute to the safe conduct of MCFs, including flight crew requirements, additional crew member requirements, personnel training, and the need to develop an MCF manual of procedures.[33] This regulation alongside its associated Guidance Material (GM) and Acceptable Means of Compliance (AMC) is the most exacting MCF Air Law of any aviation legal system at the time of writing.

The EASA MCF Air Law is a notable outlier when compared to Air Law of other jurisdictions, including South Africa, which does not enjoy such prescriptive MCF legislation. This status-quo exists in contrast to the ICAO stated ideal of 'securing the highest practical degree of uniformity in regulations' across international civil aviation, as published in its founding Convention.[34]

1.5 Context and theoretical framework

All aviation activities function within an internationally agreed-upon framework of conventions, whose genesis is the Convention on International Civil Aviation of 7 December 1944, more commonly referred to as the *Chicago Convention*. The 96 Articles of the Chicago Convention, and numerous Annexes thereto provide the legal basis for all international civilian Air Law,[35] as well as establish the International Civil Aviation Authority, ICAO.[36] ICAO is a specialised agency of the United Nations

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[31] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 29.
[32] 'EASA Website', available at: *https://www.easa.europa.eu/the-agency/the-agency*, accessed on 23 May 2023.
[33] Airbus 'Functional Check Flights' (2015) *Airbus Safety First*.
[34] Convention on International Civil Aviation 7 December 1944, Article 37.
[35] Paul Stephen Dempsey & Ram S Jakhu (eds) *Routledge Handbook of Public Aviation Law* (2017).
[36] Convention on International Civil Aviation 7 December 1944,.

tasked with developing the principles and techniques of international aviation[37] via published Standards and Recommended Practices, or SARPS. The ICAO SARPS do not address MCF, referring only to *test flight* as defined in section 1.6. However, the ICAO principle of safety remains ubiquitous throughout all flight operations.

An analysis of applicable Air Law reveals a largely inconsistent approach to the regulation of MCF across international aviation legal systems. This may be attributable to ICAO's non-reference thereto. At the time of writing there exist no uniformly agreed-upon aviation regulations or standards which specifically address MCF operations across the world's Air Law systems. In the absence thereof, key stakeholders[38] with a vested interest in MCF safety have published non-enforceable recommended practices, such as the Functional Check Flight Compendium by the Flight Safety Foundation[39] which endeavours to reduce the risk of MCFs. Some stakeholders are concerned by the lack of consistency in the regulation of MCF, as evidenced in a remark by David Morgan, head of Air New Zealand Operations Division. During his keynote address at the Functional Check Flight Symposium he declared, 'Our view is that the overall regulatory framework [which governs MCF] is less than optimal across multiple jurisdictions.'[40]

1.6 Terms

There exists ongoing debate amongst scholars in relation to the definition of *Air Law*, which according to Diederiks-Verschoor is broadly 'that body of rules governing the use of airspace, and its benefit for aviation…'[41] Air Law consists of regulations and standards developed and imposed by a state regulatory agency[42] for purposes of

[37] Bartsch, op cit n 20.
[38] Stakeholders are defined by Juran's Quality Planning and Analysis as ultimate users of a product or process, those with a connection to the product or process such as government regulatory bodies.
[39] Flight Safety Foundation *Functional Check Flight Compendium* (2011) available at: *https://skybrary.aero/sites/default/files/bookshelf/2473.pdf*, accessed on 14 January 2022.
[40] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', available at: *https://flightsafety.org/toolkits-resources/functional-check-flights/functional-check-flight-fcf-symposium-presentations/*, accessed on 9 August 2022.
[41] Bartsch, op cit n 20 at 32.
[42] Philippe-Joseph Salazar *Air Law* (2019) at 11.

achieving safety in the air.[43] Therefore, all references to *Air Law* in this writing refer to rules and principles imposed by and presided over by state regulatory authorities.

It is necessary to indicate the semantic difference between the terms *test flight* and *check flight* which are often quoted interchangeably in Air Law, and by aviation practitioners. Test flight is an activity undertaken for purposes of the evaluation of a new design and is rigidly controlled due to the endemic unpredictability of unknown factors.[44] A test flight may be classified according to one of four possible categories as dictated by the objective: experimental, engineering, production, or systems. Experimental test flight intends to define an aircraft's flight envelope, which are the aerodynamic and structural boundaries of aircraft speed, G-loading, and flight conditions within which the aircraft may be safely operated.[45] Engineering test flight incorporates manoeuvres required to certify an aircraft according to a set of governmental regulations, while production test flight is the initial flight undertaken by a certified aircraft in production. A systems test flight is conducted to assess newly installed, modified, or updated aircraft systems.[46] A test flight may occur within or outside of the flight envelope, depending on the objective. A check flight, on the contrary, does not involve evaluation of new designs, but verifies the conformity of a pre-existing design to approved, known data after the completion of maintenance.[47] A check flight is always intended to remain strictly within the flight envelope. Importantly, pilots are ordinarily not trained for flight outside of the normal flight envelope unless having undergone specialist training.

An MCF confirms that an aircraft's flight characteristics and functioning do not differ significantly from the normal characteristics, while also providing an opportunity for aircraft performance to be measured against published data.[48] MCF is also referred to as Functional Check Flight (FCF), Functional Evaluation Flight (FEF) or Post Maintenance Test Flight (PMTF) within certain sources.

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[43] Benjamyn I Scott & Andrea Trimarchi *Fundamentals of International Aviation Law and Policy* (2020) at 5.
[44] EASA Notice of Proposed Amendment (NPA) 2008-20 29 August 2008,23.1 b.
[45] H Walgemoed 'Introduction to Flight Test Engineering' (2005) 14 *NATO Research and Technology Organisation* at 12–1.
[46] Stephen Corda *Introduction to Aerospace Engineering with a Flight Test Perspective* First (2017) at 162.
[47] EASA Notice of Proposed Amendment (NPA) 2008-20 29 August 2008,.
[48] United Kingdom Civil Aviation Authority, op cit n 4.

Throughout this paper the term Maintenance Check Flight (MCF) will be used unless referenced differently by a source. Test flight activity lies beyond the scope of this research and will only be referenced when deemed relevant within the scope of the check flight concept.

MCF is an example of a *non-revenue flight* alongside positioning, training, and demonstration flights. Non-revenue flights are those conducted for purposes other than the ordinary transport of people or material, and do not involve common carriage.[49] These flights do not earn revenue for a commercial air operator but are carried out in general support of the commercial operation.[50]

1.7 Problem statement

Safety is paramount to all aviation activities and is ICAO's most fundamental objective,[51] as outlined in the preamble to the Chicago Convention.[52] Safety is a condition or state within a system or organisation in which the associated risks are reduced and controlled to an acceptable level, if not eliminated entirely.[53] Therefore, the regulatory framework within which aviation activities occur is constantly under scrutiny, development, and revision to ensure safety standards retain relevance with the emergence of new trends and technologies.[54]

Despite the multilateral composition of aviation stakeholders and participants, the global aviation community is unified in its objective of achieving continually improving air safety. One hundred and ninety-three of the world's countries who cooperate through ICAO are currently working toward an agreed upon target of zero fatalities in air accidents by the year 2030.[55] Empirical data indicates a positive trend in commercial air safety to date: in 1959 the jet accident rate was more than 50

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[49] Supplement to Federal Aviation Administration Information for Operators 08032, 16 May 2008 at 1 available at: *https://www.faa.gov/sites/faa.gov/files/InFO08032Sup.pdf*, accessed on 8 January 2023.
[50] Poprawa, op cit n 1 at 782.
[51] Ronald IC Bartsch *International Aviation Law: A Practical Guide* 2nd edition (2018) 56.
[52] Preamble to the Convention on International Civil Aviation 7 December 1944,.
[53] Francesca Pellegrino *The Just Culture Principles in Aviation Law* (2019) Preface.
[54] Bartsch, op cit n 20.
[55] 'ICAO: Safety', available at: *https://www.icao.int/safety/Pages/default.aspx*, accessed on 23 August 2022.

accidents per million departures. By 2019, the jet accident rate had reduced to less than 1 accident per million departures,[56] even though an exponential increase in jet air travel occurred during this period.

In stark contrast to the favourable trend in commercial air safety in recent years, 33 aeroplane accidents and 15 helicopter accidents occurred during flight testing and checking activities in the period 1990-2005.[57] Furthermore, at least one fatal accident and two serious incidents occurred during MCFs between 2008-2018 in Europe. Annex 1 contains a list of additional MCF accidents and incidents. An incident is an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of the operation.[58] If it is considered that an aircraft is subject to flight testing or checking for an insignificant amount of time relative to the time spent in regular service, this statistic illustrates the elevated risk associated with flight testing and checking. EASA acknowledged this elevated risk as a 'safety gap' which it sought to manage via the amendment of applicable Air Law in April 2011.[59]

On the contrary, South African Air Law contains a notable lack of detail on how to manage MCF risk. For instance, no pilot training is required prior to conducting an MCF, and procedures for the safe conduct of an MCF are not specified in law. MCF activity is thus largely un-regulated in South African aviation, and MCF operations are not subject to standardised risk management practices within the greater safety culture.

A safety climate is an expression of how safety is perceived, valued, and prioritised by aviation stakeholders, and should be promoted across all levels. A safety culture is fostered when stakeholders share an awareness of risks associated with an operation and have access to the resources which are required for safe operations.[60] ICAO recommends that a safety culture should be rigidly entrenched

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[56] Boeing Statistical Summary of Commercial Jet Accidents, September 2021 available at: *http://www.boeing.com/resources/boeingdotcom/company/about_bca/pdf/statsum.pdf*, accessed on 23 August 2022.
[57] Lacagnina, op cit n 2.
[58] *Annex 13: Aircraft Accident and Incident Investigation*, supra n 10 at 1–2.
[59] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 29.
[60] ICAO *Document 9859: Safety Management Manual* 4 ed (2018) at 3–1.

in all facets of aviation, so it is surprising that MCF is not the beneficiary of the exacting international safety standards and protocols enjoyed by other flight operations. This dissertation argues that MCF is a statistically high-risk flight activity which poses a danger to stakeholders and the public, and the lack of prescriptive MCF Air Law across jurisdictions represents a missed opportunity to enhance aviation safety standards.

1.8 Aim of research

The aim of this research is to determine what legislative framework exists to promote safety during MCF activity within the EASA and South African Air Law systems, and whether this legislation adequately addresses the burgeoning safety concern associated with MCF.

The attainment of safety is the highest priority in aviation.[61] The 52 signatories of the Chicago Convention agreed on the principles and arrangements to achieve safe and orderly development of international air transport.[62] Two of ICAO's principal functions are the continuous enhancement of safety and the development of internationally agreed-upon aviation standards.[63]

With reference to safety, it has been stated by EASA that MCF poses a higher risk than other flight operations.[64] This research seeks to determine the reasons why this may be so. Our hypothesis is that additional risk is introduced by two sources: human errors committed during maintenance tasks; and the use of unconventional procedures by flight crew during MCF operations.

The Federal Aviation Administration (FAA), the national regulator of civil aviation in the United States,[65] identified the failure of flight crew to respect standard procedures and aircraft limitations as causal factors in non-revenue flight accidents.[66]

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[61] Abeyratne Ruwantissa *Convention on International Civil Aviation, a Commentary* (2014) at 444.
[62] Convention on International Civil Aviation 7 December 1944.
[63] Bartsch, op cit n 20.
[64] 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 30 at 9.
[65] David Lapesa Barrera *Aircraft Maintenance Programs.* (2022).
[66] Federal Aviation Administration FAA Document SAFO 08 24, 12 October 2008.

The training and certification of flight crew is an essential component in the assurance of safe flight operations,[67] and is conducted in pursuance of Article 37 of the Chicago Convention to secure the highest practicable degree of uniformity in relation to aviation personnel for the improvement of air navigation safety.[68] Therefore, specialised crew training for MCF operations is to become a salient point of discussion in this writing.

MCF is not specifically addressed by any ICAO text but is regulated by the South African and EASA aviation legal systems in congruence with stated ICAO principles. The differences and similarities in the regulation of MCF between South African and EASA Air Law will be identified and comparatively analysed to seek an understanding of the fundamental basis of this Air Law, its safety role, and societal relevance.

During the consultative phase of the EASA MCF Air Law amendment process, a common concern was the possibility of prohibitive over regulation of MCF operations for the operators of light aircraft.[69] This concern may be illustrated when an MCF on a technically simple, light aircraft is compared with an MCF on a technically complex aircraft such as an airliner. This research seeks to determine whether a one-size-fits all approach to the regulation of MCF adequately addresses differences in complexity between various types of aircraft.

To answer this question, it is necessary to examine MCF across multiple aviation disciplines to determine whether the provisions of the applicable Air Law are relevant in all contexts. This research intends to garner an appreciation of why MCF should or should not be the beneficiary of exacting Air Law assembled according to the principles of ICAO in the name of safety.

[67] Ruwantissa, op cit n 61 at 243.
[68] Convention on International Civil Aviation 7 December 1944, Article 37.
[69] EASA 'EASA Comment Response Document 2012-08', available at: *https://www.easa.europa.eu/en/downloads/16489/en*, accessed on 14 October 2022.

1.9 Research method and rationale

This research does not involve interviews or attitude surveys and will instead be a review of literature and legislation, underpinned with substantive empirical data. The research is motivated by the candidate's professional experience as an airline pilot conducting MCFs on South African registered aircraft. Experience reveals a lack of certainty surrounding the legal and technical requirements related to MCF, with no standardised approach to pilot training. Therefore, the primary research method to be employed is analytical research of applicable matters of Air Law, underpinned by empirical data concerning MCF incidents and accidents, as well as safety recommendations from within the international aviation community. To supplement South African jurisprudence, it is necessary to examine relevant ICAO principles upon which the Air Law is premised, as well as a foreign jurisdiction. The EASA Air Law has been selected for this purpose, to establish the basis for a comparative study of the relevant elements of law which govern MCF operations.

EASA Air Law governing MCF has been selected for comparative study for two reasons: firstly, this legislation underwent a studious amendment process between April 2011 and July 2019 in accordance with safety recommendations from the Perpignan Accident report and is therefore well justified by lawmakers. Secondly, the resultant Air Law is considered by many subject matter experts to be, at the time of writing, the most exacting MCF law of any aviation legal system. It is not to state these regulations are the 'golden standard' of MCF Air Law, but their prescriptive content is thought-provoking in the comparative study envisioned by this dissertation.

In addition to studying the Air Law and applicable ICAO SARPS, this research will further examine MCF as a specialised flight operation, the risks associated thereto, and risk mitigation practices adopted by practitioners. Safety statistics relating specifically to MCF are not readily available but may be derived utilising accident reports which are in the public domain, annual safety reports provided by the aircraft manufacturers and notably the NASA Aviation Safety Reporting System

(ASRS) online database, the world's largest repository of voluntary, confidential safety information provided by frontline personnel.[70]

The ASRS online database allows the searching of key words to obtain open access to reports of similar natures. A search will be conducted using the following filters: Mission – Test Flight / Demonstration, with key words MCF, maintenance test flight, functional check flight to deduce the viewpoint held by frontline MCF personnel. This statistical data will supplement the analytical research by attempting to determine whether MCF introduces a level of risk or specialisation which may warrant specific regulation or not.

Air law is dynamic, enjoying regular review and amendment. Therefore, this research is according to documents and evidence with a terminus a quo of 1st January 1976, and a terminus ad quem of 31st December 2021. The span of this timeline is anticipated to provide sufficient scope to adequately address the research question.

1.10 Structure of thesis

The overall structure of the study takes the form of seven chapters, including this introductory chapter. Chapter Two is a literature review which analyses the primary and secondary sources pertaining to international Air Law, aircraft maintenance errors, MCF, and accident reports. Chapter Three defines MCF as a legal concept with reference to primary sources, and as a practical concept with reference the secondary sources. This chapter will explain the legal and practical reasons for conducting MCFs, the considerations and requirements when performing an MCF and the risks associated thereto. Chapter Four establishes the foundation of our comparative analysis by examining the EASA MCF Air Law. This chapter studies the MCF Air Law amendment process which occurred between April 2011 and July 2019, to gain insight into the rationale and derivation of present-day (at time of writing) EASA MCF legislation. In addition to the proposed and adopted legislation, Chapter Four also examines the industry responses to, and stakeholder participation

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[70] 'NASA ASRS Database', available at: *https://asrs.arc.nasa.gov/search/database.html,* accessed on 26 September 2022.

within the Air Law amendment process, which seeks to gain a holistic understanding of concerns held by various stakeholders on the subject. Chapter Five examines the South African Air Law which regulates MCF, including proposals submitted for the amendment thereof. This chapter seeks to determine the legal basis for MCFs, and whether the pilots conducting them are required to hold specific qualifications in accordance with the Regulations or not. Chapter Six is a comparative analysis of the similarities and differences between EASA and South African MCF Air Law. This chapter will establish the relevance of the regulations within their respective Air Law systems, as well as examine the safety role played by them. Chapter Seven is the conclusion, wherein the research question 'What legislative framework exists to promote safety during MCF activity across different legal systems?' will be conclusively answered. Furthermore, this concluding chapter will determine whether the safety risk posed by MCF operations warrants exacting regulation or not.

1.11 Limitations

Several sources, including the South African Air Law do not differentiate between the terms test flight and check flight, as explained in the terms sub-chapter. Therefore, a significant number of sources, including statistical accident data combine test flight and check flight information under one umbrella topic. Where possible, MCF sources will be isolated for use in this research, while sources which cannot conclusively be attributed to MCF will be discarded.

This research will refer to the term *test flight* only as stated in regulation or as quoted from a source but is not intended to be a discussion of matters pertaining to developmental or experimental test flying of new designs. Test flying is beyond the scope of this research and will only be discussed when significant within the MCF concept. Despite this assertion, the use of the term *test flight* is necessary for research purposes, as these keywords return sources which are MCF related. The NASA ASRS database is one such example.

It must be acknowledged that the ASRS reports studied for this research are specific to the United States region, and being voluntary, do not constitute every occurrence. It must further be acknowledged that mandatory reporting of irregularities during MCFs is not compulsory across all jurisdictions, nor are these instances traceable. Therefore, the empirical data is intended to substantiate or contradict the research argument via way of example only; and does not represent a complete quantum of statistical data on MCF irregularities.

1.12 Conclusion

Aircraft maintenance is a fundamental category of Air Law which seeks to uphold two salient principles of the Chicago Convention: safety and uniformity. Aircraft maintenance ensures the airworthiness and safety of an aircraft, while uniformed aircraft maintenance protocols are upheld by the world's Air Law systems in compliance with ICAO Standards. The quality of aircraft maintenance is measured by the serviceability of the aircraft and its systems after the fact. An MCF is a compelling means of determining aircraft serviceability and may be required by Air Law, although this is not always the case. MCF is not addressed at ICAO level, meaning there exist no uniformed safety protocols governing MCF operations.

An MCF introduces an element of risk which exceeds that of normal flight operations,[71] with several accidents and incidents attributable to the MCF process, as contained in Annex 1. International stakeholders have deliberated risk mitigation strategies, with some even recommending a review of applicable Air Law.[72] To date, only EASA has actively amended Air Law in the pursuit of MCF safety. The prescriptive EASA MCF Air Law mandates personnel training for pilots as well as a precise operational framework for MCF operations. This exists in contrast to the Air Law of other jurisdictions wherein MCF is regulated to a lesser extent.

The South African MCF Air Law lacks many of the prescriptions contained in the EASA Air Law, which provides the basis for an enlightening comparative analysis. This research will determine the basis of the elevated risk associated with MCF and will question whether this risk may be mitigated by Air Law. This will be achieved

[71] Poprawa, op cit n 1.
[72] Burin, op cit n 27.

by analysing the similarities and differences between the EASA and South African MCF Air Law.

The following chapter presents a review of current literature on the centrality of aviation rulemaking, aircraft maintenance, and MCF operations. This literary position is underpinned by empirical data, which will collectively be used to answer the research question: what legislative framework exists across jurisdictions to promote safety during MCF operations?

CHAPTER 2: REVIEW OF LITERATURE

2.1. Overview

This review of literature seeks to determine what legislative and non-legislative framework exists across jurisdictions to promote safety during Maintenance Check Flight (MCF) operations. It is necessary to examine the MCF concept from two literary angles: the position with respect to Air Law to determine the legal prescriptions, and the position with respect to aircraft maintenance engineering to determine the practical components. This two-angled approach will ascertain when MCFs are required, MCF protocols and procedures, and most importantly the associated risks and how they are mitigated by Air Law and non-Air Law protocols. The research objective is to establish the adequacy of the present structures of governance of MCF operations.

A search of the literature has returned sources which explain the international aviation legal structure, the process of aviation rulemaking, and the roles fulfilled by ICAO and sovereign National Aviation Authorities. Several sources explain the objective of MCFs and offer guidance on how to practically conduct them, while others describe associated safety risks and recommended risk mitigation practices. This study is unique in its attempt to overlay the Air Law, engineering, and safety principles of MCF via reference to multiple primary and secondary sources.

The sources below were identified via a search of keywords pertaining to international air law, International Civil Aviation Organisation (ICAO), Convention on International Civil Aviation of 1944 (Chicago Convention), air law, test flight, check flight, functional check flight and aircraft maintenance in the UCT library using Primo Search. Further sources were obtained via open-access legislation available on the South African Civil Aviation Authority, European Aviation Safety Agency, European Union (Eur-Lex) online platforms, Google Scholar and from within the writer's personal aviation library. South African Government Gazettes were obtained via Sabinet Legal Products using UCT credentials. The Boeing[73] 737-

[73] Boeing is a United States based aerospace company which manufacturers civilian and military aircraft and systems according to the 'Boeing Homepage', available at: at *https://www.boeing.com/company/general-info/*, accessed on 8 January 2022.

800 Aircraft Maintenance Manual (AMM) was issued to the candidate as compulsory literature during employment as technical pilot on the aircraft, while relevant excerpts of the Embraer 145 Aircraft Maintenance Manual were presented by Embraer (Empresa Brasileira de Aeronáutica - a Brazilian aerospace company which produces military and civilian aircraft and components)[74] during the Functional Check Flight Symposium in 2011. The South African Civil Aviation Authority has provided clarification on certain Air Law questions posed by the candidate.

The primary sources cited in this research represent the regulation of MCF by two legal systems, thereby providing the basis for a comparative analysis. The secondary sources are intended to argue that MCF is a specialised high-risk operation, thereby demonstrating the need for regulatory governance and oversight in the interest of maintaining safety.

This literature review is presented in a thematic sequence which initially examines the process of international aviation rulemaking, the regulatory role played by ICAO and state regulators as well as the process through which Standards and Recommended Practices are enacted into Law. Secondly, the South African and EASA Air Law governing MCF is reviewed, followed by an analysis of MCF as a technical practice. Thereafter, the risks associated with MCFs will be investigated before looking at the safety recommendations of relevant MCF accident and incident investigation reports. Finally, Air Law and non-Air Law measures practiced by stakeholders to manage MCF risk shall be reviewed.

2.2. International aviation rulemaking

The genesis of the present-day aviation legal structure is the Convention on International Civil Aviation of 7 December 1944 (henceforth referred to as the Chicago Convention), which mandates to achieve 'the highest practicable degree of uniformity in [air navigation] regulations'[75] throughout the world. According to

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[74] Embraer homepage available at: *https://embraer.com/global/en/about-us*, accessed on 1 August 2022.
[75] Convention on International Civil Aviation 7 December 1944, Article 37.

Dempsey and Jakhu's Routledge Handbook of Aviation Law, the Chicago Convention remains to the present-day 'the fundamental legal instrument governing rights and obligations of States with respect to international civil aviation.'[76] Suffice to say, Air Law as we know it today is premised upon the Articles of the Chicago Convention and the numerous Annexes thereto. Raymond Speciale credits the Chicago Convention as the creator of the foundation of the current system of international transportation by air.[77] In addition to the establishment of the basis of international Air Law, the Chicago Convention establishes the Organisation tasked with the development of the principles of air navigation and international air transport, the International Civil Aviation Organisation or ICAO.[78]

ICAO is a specialised agency of the United Nations which, according to Ron Bartsch, 'acts as the medium by which aviation law develops on an international scale.'[79] Two of ICAO's principle functions are the continuous enhancement of air safety and the development of internationally agreed-upon aviation standards.[80] Francesca Pellegrino defines aviation safety as 'the condition of a system or organisation in which risk associated with aviation activities…if not eliminated, are reduced and controlled at an acceptable level.'[81] Ruwantissa Abeyratne explains that safety is undoubtedly the highest priority in aviation, requiring a regulatory action plan of global dimension to ensure a consistent and compelling legal structure is maintained across jurisdictions.[82] This 'action plan of global dimension' is provided by ICAO in the form of Annexes to the Chicago Convention, which contain the Standards and Recommended Practices (SARPS) of international civil aviation. ICAO develops and amends these SARPS which relate to all aviation aspects within its purview, as provided for in the Chicago Convention.

Pearson and Riley indicate that the SARPS are themselves not laws but rather firm guidelines which should be used to develop and promulgate aviation regulations in

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[76] Dempsey & Jakhu, op cit n 35 at 9.
[77] Raymond Speciale *Fundamentals of Aviation Law* (2006) at 282.
[78] Convention on International Civil Aviation 7 December 1944, Article 43.
[79] Bartsch, op cit n 20 at 55.
[80] Ibid.
[81] Pellegrino, op cit n 53 at Preface vii.
[82] Ruwantissa Abeyratne *Convention on International Civil Aviation: A Commentary* 1st ed. 2014 (2014) at 444.

state legal systems.[83] Abeyratne further elaborates on the role played by ICAO, by indicating that ICAO's privilege is to prescribe legally binding norms in a quasi-legislative sense, while legislative power remains attributable to sovereign states via their own legal systems.[84] Bin Cheng states with respect to ICAO's quasi-legislative authority that ICAO standards are binding upon states in the absence of any notification to ICAO of an inability to comply.[85] Therefore, sovereign states which contract to ICAO (193 at the time of writing[86]) undertake to collaborate in securing uniformity in regulations, standards and procedures[87] within their respective aviation legal systems. State regulators draft and enact air laws in general congruence with ICAO's SARPS, thereby giving legal effect to the state's obligations as an ICAO signatory.[88] Abeyratne, in her publication *Air Navigation Law* summarises ICAO's legislative position by arguing that all SARPS within the ICAO Annexes are formally binding on ICAO member states.[89] Member states are therefore required to notify ICAO of all significant differences between state Air Law and the prescriptions of ICAO's SARPS, in accordance with Article 38 of the Chicago Convention.[90]

ICAO's mandate may be demonstrated by the example of pilot licensing. Article 32 of the Chicago Convention declares that 'the pilot of every aircraft…shall be provided with certificates of competency and licenses issued… by the state in which the aircraft is registered.'[91] Annex 1 to the Chicago Convention contains the SARPS adopted by ICAO as the minimum standards for personnel licensing, which are incorporated within the South African Air Law system as Part 61 of the Civil Aviation Regulations (CARS), 2011. The training methods and syllabi which assure compliance with the relevant CARS are published in the corresponding Civil Aviation Technical Standards (CATS) of Part 61. The CARS and CATS collectively constitute the bulk of South African Air Law.[92]

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[83] Michael Pearson & Daniel Riley *Foundations of Aviation Law* (2015) at 312.
[84] Ruwantissa Abeyratne *Rulemaking in Air Transport: A Deconstructive Analysis* (2016) at 82.
[85] Bin Cheng *The Law of International Air Transport* (1962) at 64–7.
[86] ICAO 'ICAO List of Contracting States', available at: *https://www.icao.int/MemberStates/Member%20States.Multilingual.pdf*, accessed on 6 October 2022.
[87] Convention on International Civil Aviation 7 December 1944, Article 37.
[88] Bartsch, op cit n 20 at 48.
[89] Ruwantissa Abeyratne *Air Navigation Law* (2012) at 124.
[90] Convention on International Civil Aviation 7 December 1944, Article 38.
[91] Ibid Article 32.
[92] Salazar, op cit n 42 at 12.

Notably for purposes of this research, MCF is not specifically addressed by the ICAO SARPS, but is regulated by some state legal systems according to ICAO principles, including those of South Africa and EASA. Therefore, the Air Law systems of both South Africa and the EASA form salient components of this research.

2.3. State regulators: SACAA and EASA

An ICAO member state's legislature will typically pass an Act or statute ratifying the Chicago Convention. A local regulatory body or National Aviation Authority (NAA) is then apportioned responsibility for the drafting of local aviation regulations in congruence with ICAO SARPS. These regulations are enacted via the State's legal system, and henceforth presided over and enforced by the NAA. Scott and Trimarchi's *Fundamentals of International Aviation Law and Policy* defines a National Aviation Authority as a governmental statutory authority of a State with responsibilities for overseeing and regulating aspects of civil aviation.[93] This research refers to the NAA's of South Africa, the United States of America, and the United Kingdom. Additionally, the European regional equivalent of an NAA, EASA, will be referenced.

Philippe-Joseph Salazar's *Air Law* explains that in South Africa the Civil Aviation Act 13 of 2009[94] empowers the South African Civil Aviation Authority (SACAA) to preside over South African aviation legislation as state authority, including the development of regulations.[95] The regulations referred to in the Act are the Civil Aviation Regulations (CARS) which SACAA develops (often in collaboration with interested stakeholders) as proposals for the amendment of regulations. These proposals are henceforth published in the Government Gazette for scrutiny and comment by interested parties, whereafter the agreeable regulations are promulgated by the Minister of Transport as CARS.[96] Once the CARS are in effect, the Director of Civil Aviation is responsible for the development of a subset of legal rules, the Civil Aviation Technical Standards (CATS), which expand on the prescriptions of the

[93] Scott & Trimarchi, op cit n 43 at 14.
[94] Civil Aviation Act 13 of 2009, *Government Gazette* 32266 GN 461 of 27 May 2009 updated by *Government Gazette* 35183 GN 561 of 27 March 2012.
[95] Salazar, op cit n 42 at 11.
[96] South African Civil Aviation Regulations Part 11, Subpart 3 2011,.

CARS.[97] At the time of writing, the CARS 2011[98] and their associated CATS remain in effect. The CARS and CATS which govern MCF differ significantly in content and detail to the EASA Air Law governing MCF.

The *Routledge Handbook of Public Aviation Law* introduces the first (and now defunct) European NAA, the Joint Aviation Authorities (JAA) which was established in 1970 as a European attempt to standardise regional regulatory matters.[99] Giemulla and Weber's *International and EU Aviation Law* explains the JAA's objective was to achieve standardisation and simplification of flight operations through a regional body of Air Law called the Joint Aviation Regulations (JARS). Giemulla and Weber go on to explain the authoritative limitations faced by the JAA as a result of not possessing sovereign powers, which rendered the JAA largely unable to lay down the 'legal norms or administrative acts'[100] across the region. According to David Barrera's *Aircraft Maintenance Programs,* different state interpretations of the JARS compromised the overall efficiency of the JAA.[101] Therefore a more authoritative and efficient organisation was sought, which resulted in the JAA being succeeded by the European Aviation Safety Agency (EASA).

Florin Coman-Kund explains that Regulation 1592/2002 of the European Parliament and Council established EASA in the year in 2002, an agency tasked with oversight of the common rules of civil aviation in Europe as regional authority.[102] EASA functions as a regional authority of civilian aviation across the 27 European Union member states, as well as across the member states of the European Free Trade Association: Lichtenstein, Norway, Switzerland, Iceland and Monaco.[103] Coman-Kund further explains that EASA provides expert advice to the European Commission (EC) in the regulatory process, while the EC still retains overall regulatory power. Therefore, EASA has no genuine regulatory power of its own. It fulfils an expert advisory and recommendatory role to the EC which retains responsibility for the

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[97] Salazar, op cit n 42 at 12,13,14.
[98] Civil Aviation Regulations 2011, *Government Gazette* 35398 GN 425 of 1 June 2012, and subsequent gazetted amendments.
[99] Dempsey & Jakhu, op cit n 35 at 74.
[100] Elmar Maria Giemulla & Ludwig Weber *International and EU Aviation Law: Selected Issues* (2011) at 319.
[101] Barrera, op cit n 65 at 4.
[102] Regulation 1592/2002 of the European Parliament and of the Council.
[103] 'EASA Website', op cit n 32.

enactment of the Air Law; while EASA implements aviation safety related tasks on behalf of the EC,[104] and fulfils an oversight role.

David Barrera describes the EASA Air Law structure as consisting of a combination of hard law and soft law.[105] Hard law consists of the binding regulations of the EC published as Implementing Regulations (IRs)[106] which regulate civil aviation within the states over which EASA presides. Soft law is non-binding explanatory material which provides guidance on achieving compliance with the hard law, consisting of Acceptable Means of Compliance (AMC), Guidance Material (GM) and Certification Specifications (CS).[107] In summary, EASA advises the EC on legislative matters relating to air safety, which are enacted as IRs by the EC. EASA self-publishes detailed soft law which stakeholders utilise to achieve compliance with the hard law. For ease of reference, EASA consolidates each part of its regulation into an 'Easy Access Rules' format, wherein the IRs are published alongside their related AMC, GM, and CS paragraphs.

South Africa and the states represented by EASA are contracted to ICAO, meaning their respective bodies of Air Law are constructed upon the foundation of ICAO SARPS.

2.4. Applicable ICAO Standards and Recommended Practices

ICAO does not specifically address MCF in any of its Articles or Annexes. However, the South African CARS make provision for a pilot qualification called a Post Maintenance Test Flight (PMTF) rating which qualifies the holder to conduct MCFs.[108] The concept of a rating is imbedded in ICAO Annex 1.

Annex 1: Personnel Licensing defines a rating as 'an authorisation entered on or associated with a license and forming part thereof, stating special conditions,

[104] Florin Coman-Kund *European Union Agencies as Global Actors: A Legal Study of the European Union Safety Agency, Frontex and Europol* (2018) at 127.
[105] Barrera, op cit n 65 at 4.
[106] Dempsey & Jakhu, op cit n 35 at 79.
[107] Barrera, op cit n 65 at 4.
[108] CAR 61.19.4.

privileges or limitations pertaining to such a license.'[109] Annex 1 recommends that contracting states should establish competency and experience requirements for ratings based on a systematic approach to accident prevention.[110] ICAO further states that applicants for ratings shall meet specific requirements in respect of knowledge, flight instruction and skill, and furthermore demonstrate these attributes to the relevant authority.[111]

From this we deduce that an applicant for a rating is required by ICAO to undergo training to achieve competence in the discipline presided over by the rating. Competent means the possession of skills, knowledge, and attitudes to perform a task to the prescribed standard.[112] The training ensures the holder of the rating is competent and therefore safe to exercise the privileges of the rating.

The actual operation of an aircraft during an MCF falls under the ambit of ICAO Annex 6: Operation of Aircraft. Annex 6 contains ICAO's safe operating practices including aircraft operations, maintenance, and responsibilities of flight personnel.[113] Annex 6 mandates that flight crew members are properly rated,[114] which is understood to mean in possession of the requisite ratings as provided for in Annex 1. Annex 6 further mandates that flight crew shall undergo training to ensure competency to perform assigned flight duties.[115] The EASA Air Law mandates specific pilot training for MCF operations as a responsibility of an aircraft operator,[116] whilst not formalising this training as a rating in accordance with Annex 1. In contrast, the CARS require a pilot to possess a Post Maintenance Test Flight rating to conduct MCFs, yet the training requirements are not specified.[117]

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[109] ICAO *Annex 1: Personnel Licensing* 13 ed (2020) at 1–7.
[110] Ibid at 1–13.
[111] Ibid at 2–1.
[112] SACAA Form Number CA 61-14.4 Skills Test or Revalidation Check Report for Instrument Rating, 17 September 2021 at 2 available at: *https://caasanwebsitestorage.blob.core.windows.net/personnellicensingforms/CA%2061-11%204.pdf*, accessed on 24 January 2023.
[113] Dempsey & Jakhu, op cit n 35 at 41.
[114] ICAO *Annex 6: Operation of Aircraft Part II* 10 ed (2018) at 3.9-2.
[115] Ibid at 3.9-1.
[116] Regulation (EU) 2019/1384 of the European Commission.
[117] CAR 61.19.4.

Annex 6 requires the pilot-in-command to ensure the aeroplane is airworthy, with all requisite maintenance having been performed prior to flight.[118] The determination of airworthiness for normal flights is scripted in an aircraft's operating manual as a pre-flight inspection. However, the determination of airworthiness after maintenance activity, and prior to an MCF is less well scripted. Some aircraft manufacturers, such as Boeing publish a detailed pre-flight check sequence to be performed prior to an MCF in a Post Delivery Flight Profile document[119] or equivalent. In other instances, it is left to the pilot to perform a satisfactory airworthiness assessment without published guidance prior to an MCF. The concept of airworthiness is addressed by ICAO Annex 8: Airworthiness of Aircraft.

When an aircraft is designed, built and tested it is required to meet the minimum airworthiness standards contained in ICAO Annex 8.[120] These broad airworthiness standards are applied through the regulatory system of the state of design,[121] wherein they are given the full scope and extent of detail considered necessary for aircraft certification.[122] An example of this is an Airbus A320 aircraft built in the European Union, and certified according to the EASA Certification Specification CS-25, the certification requirements for turbine powered large aircraft.[123] Once compliance with the certification requirements is demonstrated to a regulatory body, a type certificate is issued for the aircraft.[124] *Flight Test Guidelines for Homebuilt / Experimental Aircraft* explains that a type certificate is awarded by a regulatory authority to an aircraft manufacturer after it has been established that the prototype meets legislated requirements for safe flight.[125] All subsequent airframes produced by the manufacturer fall under the ambit of this type certificate provided the design is not unduly altered.

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[118] ICAO, supra n 114 at 2.2-3.
[119] Boeing *Post Delivery 737NG Flight Profile* (2017) at 10–49.
[120] ICAO *Annex 8: Airworthiness of Aircraft* 12 ed (2018) at xviii.
[121] Barrera, op cit n 65 at 11.
[122] ICAO, supra n 120 at xvii.
[123] EASA 'Certification Specification and Acceptable Means of Compliance for Large Aeroplanes (CS-25)', 24 November 2021, available at: *https://www.easa.europa.eu/en/downloads/136622/en*, accessed on 14 October 2022.
[124] Barrera, op cit n 65 at 11.
[125] Desmond Barker & Alan Sutherland *Flight Test Guidelines for Homebuilt / Experimental Aircraft* 1 ed (2014) at 12.

Certain states enjoy bilateral agreements which recognise aircraft certification made by each other's legal systems.[126] In this case the type certificate is de facto accepted by the regulatory authority of another state without the requirement to recertify the type in-state. When a new aircraft is first registered in its state of domicile, the regulatory authority will issue a Certificate of Airworthiness (CoA) affirming the aircraft conforms to its type certificate. ICAO Annex 8 defines airworthy as the status of an aircraft or component which conforms to approved design and is in a condition for safe operation.[127]

The process by which an airworthy aircraft remains safe for operation throughout its operating life is further defined by Annex 8 as continuing airworthiness,[128] which includes the performance of mandatory maintenance. For purposes of continuing airworthiness, Annex 8 requires information to be provided by the Original Equipment Manufacturer (OEM) for the accomplishment of maintenance tasks and fault diagnosis, as well as the time intervals at which maintenance should occur. The OEM maintenance procedures, often published in the format of an Aircraft Maintenance Manual or AMM may require an MCF to be performed as a mandatory step in a maintenance procedure.

The ICAO Airworthiness Manual, Document 9760, acknowledges that an MCF may be required as specified in the aircraft manufacturer's maintenance manual.[129] This is the only reference to an MCF within any ICAO text, and is not elaborated upon further. The South African and EASA Air Law make provision for MCFs to occur at the behest of an aircraft's maintenance manual or following major repairs. However, the specific details pertaining to MCFs in these two bodies of Air Law differ significantly.

2.5. South African Air Law

South African Air Law does not differentiate between the terms *check flight* and *test flight* as explained in the Introduction Chapter, referencing only the term test flight

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[126] Barrera, op cit n 65 at 26.
[127] ICAO, supra n 120 at I–1.
[128] Ibid.
[129] ICAO *Document 9760: Airworthiness Manual* 3 ed (2014) at III-4–11.

to describe both activities. Present day regulation (at time of writing) mandates a test flight in the following instances: prior to the initial issuing of a Certificate of Airworthiness as well as for the validation thereof; after maintenance, adjustments or repair which are likely to affect flying characteristics and as stipulated in the AMM; and when prescribed by the Director of Civil Aviation.[130]

The first reference in Air Law to test flight was a privilege of the test pilot rating in Government Notice 1747, published in Government Gazette 16807 of 10 November 1995 amending the Air Navigation Regulations (ANRS) 1976.[131] Regulation 2.34 was amended to include two classes of test pilot rating which qualify the holder to act as pilot-in-command of an experimental prototype aircraft with different mass quanta,[132] without reference to MCF privileges. Regulation 3.16D specifies that an applicant for a Class 1 Test Pilot rating shall have completed a recognised test pilot's course, while the applicant for a Class 2 Test Pilot rating need only satisfy the Commissioner [of Civil Aviation] that he has adequate knowledge of test flying techniques,[133] with no further elaboration. Aeronautical Information Circular (AIC) 30.6[134] explained that a written recommendation from a Class 1 Test Pilot would satisfy the Commissioner of the adequacy of an applicant's knowledge of test flight techniques.

Although these ANRs were superseded by Civil Aviation Regulations (CARS) 1997[135] and subsequently by CARS 2011,[136] the requirements for Class 1 and 2 Test pilot ratings remain unamended in present-day law, other than a title change to Post Maintenance Test Flight (PMTF) rating.[137] Furthermore, AIC 30.6 has been withdrawn meaning there is no guidance on how an applicant for a Class 2 PMTF

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[130] CAR 61.19.2 at 2.
[131] Air Navigation Regulations, 1976 Government Gazette 2273 GN 141 and Subsequent Gazetted Amendments (Repealed) 30 January 1976,.
[132] Government Gazette 16807 10 November 1995,.
[133] Air Navigation Regulations, 1976 Government Gazette 2273 GN 141 and Subsequent Gazetted Amendments (Repealed) 30 January 1976,.
[134] Aeronautical Information Circular 30.6 (Withdrawn) of the Candidate's Personal Library 15 September 2002.
[135] Civil Aviation Regulations 1997, Government Gazette 18286 GN 1219 of 26 September 1997, and Subsequent Gazetted Amendments.
[136] South African Civil Aviation Regulations, 2011 Government Gazette GN 35398 GN 425 of 1 June 2012 and Subsequent Gazetted Amendments.
[137] South African Civil Aviation Regulations 2011 Part 61: Pilot Licensing Subpart 19: Post-Maintenance Test Flight Rating 2011, at 61.

rating may satisfy SACAA of the adequacy of 'knowledge of test flying techniques'. A request for clarification on this requirement was submitted by the Candidate to the SACAA's Personnel Licensing Department in December 2021 via electronic mail. The response explained 'In cases like this [application for Post-Maintenance Test Flight Rating, Class 2], the information will be presented to a review board. The board, on behalf of the Director [of Civil Aviation] will decide on the outcome,'[138] without elaboration on the criteria upon which the review board base their decision.

A Class 2 PMTF rating qualifies the holder to conduct experimental test flying on aircraft with a mass not exceeding 2700kg.[139] Experimental test flying is beyond the scope of this research. However, the veracity of a Class 2 PMTF rating is questioned by Desmond Barker and Alan Sutherland when they point out that no formal training is required for the issuance of the rating.[140] Barker and Sutherland explain that a test pilot is a specialist aviator who requires rigorous training to fulfil the role safely and effectively.[141] Test pilots are specifically trained to recover from situations outside of the normal flight envelope, while non-test pilots are not. This begs the question, is it safe to allow Class 2 PMTF holders to conduct experimental test flights without training? Interestingly, EASA Air Law does not require pilots conducting experimental test flights on aircraft weighing less than 2000kg to hold a test pilot rating, meaning they too have undergone no training for the task.[142]

2.6. EASA Air Law

MCFs are specified as a task of continuing airworthiness in EASA Part M,[143] which contains the Air Law governing continuing airworthiness. Part M identifies four instances when an MCF may be required: as required by the aircraft maintenance procedure for the completion of a maintenance task; for reliability or quality assurance based on experience despite not being required by a maintenance

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[138] SACAA Personnel Licensing Department Reply to Candidate Email Requesting Clarity on CAR 61.19.1, 10 December 2021.
[139] CAR 61.19.4.
[140] Barker & Sutherland, op cit n 125 at 40.
[141] Ibid.
[142] EASA FCL.820 (b) (2) (ii).
[143] EASA Annex 1 (Part M) to Regulation (EU) No 1321/2014 (''Annex 1 (Part M) to Regulation (EU) No 1321/2014'').

procedure; as confirmation that ground-based troubleshooting has restored normal operation; or when a known issue may only be satisfactorily diagnosed in flight conditions.[144] An aircraft lease or sales agreement may require an MCF to demonstrate airworthiness during aircraft handover from one operator to another. This is referred to as a change of operator demonstration flight and follows an almost identical format to an MCF despite not being required by Air Law.

The Perpignan Accident occurred during a change of operator demonstration flight on 27 November 2008. The investigating authority Bureau d'enquêtes et d'analyses (BEA) in its accident report[145] issued a recommendation that EASA should detail in law types of non-revenue flights (including MCFs), with stipulations concerning their preparation, programme, operational framework, and crew training.[146] In response to this recommendation EASA commenced rulemaking task RMT.0393 to establish MCF legislation, which was not 'sufficiently addressed' by regulations at the time.[147] A proposal of dedicated MCF Air Law was published by EASA in 2012 via Notice of Proposed Amendment NPA 2012-08[148] which invited stakeholder input. Three hundred and sixty-two comments were received from affected stakeholders including airlines, regulatory authorities and individual aircraft owners, and were published in EASA Comment Response Document (CRD) to NPA 2012-08.[149] A number of these comments disagreed with EASA's view of the need to mitigate MCF risk via regulation, including the United States Federal Aviation Administration (FAA) who cited MCF as a risk which should be mitigated at organisational and not regulatory level.[150] Diamond Aircraft questioned the need to embark on an Air Law amendment process on the basis on a single accident (the Perpignan Accident),[151] while a recurring objection by small aircraft operators was that the proposed MCF Air Law would be too onerous, costly and impracticable for implementation.[152]

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[144] EASA GM M.A.301(i) Contunuing Airworthiness Tasks.
[145] BEA, op cit n 9.
[146] Ibid.
[147] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 29.
[148] 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 30.
[149] 'EASA Comment Response Document 2012-08', op cit n 69.
[150] Ibid at 51.
[151] Ibid at 33.
[152] Ibid at 92.

Nevertheless, EASA proceeded with the regulatory amendment process and Opinion 01/2017[153] contained the proposed regulation and rationale which was implemented in 2019 via Commission Regulation (EU) 2019/1384 as the so-called 'hard law'. EASA Explanatory Notice 2019/019/R[154] provided the 'soft law' consisting of acceptable means of compliance and guidance material to Regulation 1384.

This EASA MCF Air Law, published in the *Easy Access Rules for Air Operations* differentiates between Level A and Level B MCFs premised upon the complexity of the flight and associated magnitude of risk.[155] Level A MCFs are more complex than Level B MCFs, and therefore require a flight programme, MCF manual and flight crew training syllabus to be fulfilled by an operator intending to conduct an MCF.[156] Via the promulgation of this Air Law, EASA has satisfied the ICAO Annex 1 requirement of mandating a training syllabus 'based on a systematic approach to accident prevention.'[157] To understand EASA's justification, we must examine the MCF concept more closely to seek out its associated risks.

2.7. MCF concept

The *Journal of Applied Engineering Science*'s original scientific paper titled 'Post-Maintenance Flight Test as a Mechanism of Motion in MIRCE Mechanics' defines MCF as 'accepted nomenclature for an assessment of the functionality of a functionable system at the end of the maintenance tasks.'[158] The United Kingdom Civil Aviation Authority (UKCAA)'s *Check Flight Handbook* explains that MCFs provide assurance of the correct functioning of an aircraft or system which cannot be fully established during ground checks.[159] This sentiment of only flight checking aspects which cannot be checked on the ground is in agreement with the article 'Be

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[153] EASA Document Library available at: *https://www.easa.europa.eu/downloads/22142/en*, accessed on 21 January 2022.
[154] EASA Document Library available at: *https://www.easa.europa.eu/downloads/103444/en*, accessed on 21 January 2022.
[155] Regulation (EU) 2019/1387.
[156] Ibid.
[157] ICAO, supra n 109 at 1–13.
[158] Knežević Jezdimir 'Post-Maintenance Flight Test as a Mechanism of MIRCE Mechanics' (2018) 16 *Journal of Applied Engineering Science* 185–91.
[159] United Kingdom Civil Aviation Authority, op cit n 4 at 12.

Prepared – Check Flights and Aircraft Upsets' by Harry Nelson,[160] published in the *Functional Check Flight Compendium*, a useful compendium of information compiled by the Flight Safety Foundation to reduce the risk of MCFs.[161]

MCFs are not required after every maintenance episode. EASA Air Law prescribes MCFs in only four instances cited in the previous sub-chapter.[162] The CARS require an MCF when stipulated by an Aircraft Maintenance Manual (AMM), following any major modification or repair to an aircraft,[163] or when maintenance may have affected the flight characteristics of the aircraft.[164] These flights are categorised as prescribed MCFs[165] because they are mandated by a procedure or an element of law. When not prescribed, some operators elect to perform an MCF in line with best engineering practice[166] for the assurance of the quality and reliability of the aircraft. These are referred to as elective MCFs.

2.8. Quality assurance role of MCF

On 8 and 9 February 2011 the Flight Safety Foundation, an international aviation body which champions aviation safety,[167] convened the Functional Check Flight Symposium to address MCF practices and seek stakeholder consensus on risk management.[168] Two United States based airlines, American Airlines and United Airlines explained during their respective presentations that MCFs fulfil a quality assurance role within their organisations.[169] These flights allow the functional evaluation of aircraft systems after maintenance, thereby providing an opportunity for the exposure of defects before the aircraft returns to service. Delegates from

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[160] Nelson (Airbus) Harry 'Be Prepared - Check Flights and Aircraft Upsets' (2011) *Functional Check Flight Compendium* 4–18.
[161] Flight Safety Foundation, op cit n 39.
[162] EASA GM M.A.301(i) Continuing Airworthiness Tasks.
[163] CAR 43.02.16 2011,.
[164] CAR 61.19.1.
[165] United Kingdom Civil Aviation Authority, op cit n 4 at 24.
[166] Ibid.
[167] 'Flight Safety Foundation Website: About the Foundation', op cit n 26.
[168] Jim Burin 'Functional Check Flight Symposium Introduction Address' (Functional Check Flight Symposium, Canada) available at: *https://flightsafety.org/toolkits-resources/functional-check-flights/functional-check-flight-fcf-symposium-presentations/*.
[169] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40.

Cathay Pacific Airways, an intercontinental airline based in Hong Kong stated that their organisation also finds qualitative benefit in these check flights.[170]

Juran's Quality Planning and Analysis explains the reason an object requires testing, checking or evaluation is to determine its conformity relative to a specified requirement, or its fitness for use.[171] Juran defines this process as a quality function,[172] in which MCF seeks to determine whether the aircraft or its systems might pose a risk to human safety or not. Juran further attributes the quality function as a contributor to cost reduction within an organisation. An in-service breakdown of an aircraft is costly to operators, particularly if the aircraft becomes grounded away from its maintenance base. The timely detection of post-maintenance defects via an MCF is a strategy employed by operators to mitigate in-service breakdowns after in-depth maintenance activity. Stephan Poprawa credits MCF a necessary component in maintaining the aviation industry's exceptional safety records[173] by allowing the exposure of defects to trained personnel before they can present a hazard during regular operations. These defects may arise from the installation of defective components or are attributable to errors committed during the maintenance tasks. Dylan's Schmorrow's master's thesis analysing human error in naval aircraft maintenance related mishaps reveals one in four incidents and accidents are at least partially attributable to maintenance error.[174]

The *Aircraft Maintenance Incident Handbook*, a topical publication concerning maintenance anomalies, states that 'maintenance error continues to be one of the most obvious safety threats [to aviation]'.[175] This publication identifies human factors training of maintenance personnel as an essential element in the management of maintenance error. Boeing's Maintenance Error Decision Aid (MEDA) points out that human maintenance errors are seldom performed on purpose, and ironically

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[170] Ibid.
[171] Frank Gryna, Richard Chua & Joseph DeFeo *Juran's Quality Planning and Analysis for Enterprise Quality* 5 ed (2007) at 467.
[172] Ibid at 15.
[173] Poprawa, op cit n 1 at 788.
[174] Dylan Schmorrow *A Human Error Analysis and Model of Naval Aviation Maintenance Related Mishaps* (Thesis, Naval Postgraduate School, 1998) at v.
[175] United Kingdom Civil Aviation Authority *Aircraft Maintenance Incident Analysis CAP 1367* (2015) at 6.

occur whilst a technician is attempting to perform a task correctly.[176] Alan Hobbs acknowledges that despite the essential role played by maintenance in continued system reliability, human error is a notable cause of system failure.[177] Hobbs discusses human errors according to their causal factors, including organisational factors such as personnel training, technical misunderstandings, procedural violations and even slip-ups caused by fatigue. Human errors in aircraft maintenance may be categorised as omissions and commissions. Omissions are errors in which there is a failure to perform a necessary action, such as leaving an oil cap open; while a commission is an error in which an action is performed which should not have been, such as connecting a flight control cable in reverse.[178] According to Boeing, the most common errors are omissions.[179]

A notable paper titled 'Contemporary Analysis of Aircraft Maintenance-Related Accidents and Serious Incidents' echoes the causal factors identified by Hobbs, citing inadequate maintenance procedures, ineffective inspections and incorrect installations as causal in maintenance incidents and accidents.[180] It must, however, be born in mind that aircraft maintenance is an on-going process, consisting of both line maintenance and scheduled maintenance, as explained in the *Journal of Air Transport Management's* recent article 'Aircraft line maintenance scheduling and optimisation.'[181] Scheduled maintenance checks are performed according to periodicity and consist of numerous tasks which occur over a long maintenance duration, not dissimilar to the annual service on a motorcar. A scheduled maintenance task on a large aircraft may take weeks or months to complete and could involve extensive disassembly and reassembly of aircraft components. In-depth scheduled maintenance is also called heavy maintenance.[182] As an example, the *Springer Handbook of Mechanical Engineering* describes the heavy maintenance or D-Check on a Boeing 737 as occurring every 22000 flight hours or 108 months,

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[176] William Rankin 'MEDA Investigation Process' (2007) Quarter 2 *Boeing Aero Magazine* at 17.
[177] Alan Hobbs *An Overview of Human Factors in Aviation Maintenance* (2008) at 1.
[178] Ibid at 10. Ibid.
[179] W Rankin & L Sogg Update on Maintenance Error Decision Aid (MEDA) Process., MEDA Workshop and Seminar, 21 May 2003, Paper Presented at the MEDA Workshop. Ibid.
[180] Jennifer Insley & Cengiz Turkoglu 'A Contemporary Analysis of Aircraft Maintenance-Related Accidents and Serious Incidents' (2020) 7 *MDPI Aerospace Journal*.
[181] Syed Shaukat et al 'Aircraft Line Maintenance Scheduling and Optimisation' (2020) 89 *Journal of Air Transport Management*.
[182] Barrera, op cit n 65 at 188.

requiring 50000 man-hours to complete over a duration of approximately 6 weeks.[183] While scheduled maintenance is pre-planned and pre-emptive, line maintenance is the execution of simple maintenance tasks of short duration before a flight, to ensure the daily airworthiness of an aircraft - such as rectifying a single defect or replacing a worn-out tyre.[184] This maintenance is reactive rather than pre-emptive.

The duration between scheduled maintenance episodes is a continuum of line maintenance tasks which seldom require an MCF unless for troubleshooting. MCFs are more often associated with heavy maintenance, as the complexity of heavy maintenance tasks is more likely to influence aircraft system operability and flight characteristics. AMM tasks which prescribe MCFs are generally heavy maintenance tasks.

An example of a heavy maintenance task requiring an MCF is the Elevator Power Off Flight Test published in the Boeing 737 AMM, which the candidate has performed on several occasions. According to the AMM, the check flight is necessary because the maintenance action may affect the flight characteristics of the aeroplane.[185]

The United Kingdom Civil Aviation Authority's Air Accidents Investigation Branch (AAIB)[186] has on record five loss-of-control events which occurred during an Elevator Power Off Flight Test on Boeing 737 aircraft during MCFs.[187] The most recent occurrence on 12 January 2009 was classified by the AAIB as a Serious Incident in investigation report EW/C2009/01/02. This MCF saw the Boeing 737-73V roll to ninety-one degrees while pitching to thirty degrees below the horizon and losing nine thousand feet of altitude before control was regained. The loss of aircraft control was attributable to a component which was misaligned during the preceding

[183] Karl-Heinrich Grote & Hamid Hefazi *Springer Handbook of Mechanical Engineering* 2 ed (2021) at 1136.
[184] Shaukat et al, op cit n 181.
[185] *Boeing 737-600/700/800/900 Aircraft Maintenance Manual* (2018).
[186] The AAIB investigates civil aircraft accidents and serious incidents within the UK, its overseas territories and crown dependencies according to the AAIB Homepage available at: *https://www.gov.uk/government/organisations/air-accidents-investigation-branch*, accessed on 25 October 2022.
[187] Air Accidents Investigation Branch AAIB Bulletin 9/2010, available at: *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/384837/Bulletin_9-2010.pdf*, accessed on 25 October 2022.

maintenance activity, and the subsequent mishandling of the event by the captain during the Elevator Power Off Flight Test manoeuvre.[188]

This event, which constituted a reportable breech of safety, is the sum of two different causal factors, namely improper maintenance work done by maintenance personnel and improper application of inflight procedures by the pilots during the MCF. Both factors contribute to the elevated risk associated with MCF.

2.9. MCF risk

ICAO's Safety Management Manual identifies safety risk as a relationship between the predicted probability and consequential severity of a particular hazard.[189] ICAO recommends these two variables should be examined using a matrix to plot the probability and severity of a particular hazard to determine whether the risk is acceptable, tolerable, or intolerable. For instance, an improbable hazard with negligible consequences is acceptable while a frequently occurring risk with catastrophic consequences is intolerable in the aviation sector.[190] The following paragraphs explain the safety risk associated with MCF operations.

Boeing's 'Statistical Summary of Commercial Jet Airplane Accidents between 1959 and 2020' records one hundred and twenty-four accidents as having occurred during MCF, ferry, positioning, and demonstration flights, which are collectively called non-revenue flights.[191] The significance of this statistic is contextualised when one considers that during an aircraft's life it will likely fly thousands of flights in regular service yet will undergo very few non-revenue flights. The *AeroSafety World* magazine of May 2011 reveals that one quarter of turbine engine aircraft accidents in the previous decade occurred during non-revenue flights, thereby prompting the FAA to publish a Safety Alert for Operators (SAFO) in an attempt to improve safety during non-revenue flight operations, including MCFs.[192]

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[188] AAIB Field Investigation Report EW/C2009/01/02, January 2009.
[189] ICAO, supra n 60 at Glossary viii.
[190] Ibid at 2–17.
[191] Boeing Statistical Summary of Commercial Jet Airplane Accidents: 1959-2020, September 2021.
[192] Flight Safety Foundation 'AeroSafety World: Improving Non-revenue Flight Safety' (2011).

SAFO 08024 cites two common factors as contributory towards non-revenue flight accidents: the flight crew's failure to adhere to Standard Operating Procedures (SOPs) and the flight crew's failure to operate the aeroplane within its performance limitations.[193] The FAA recommends that operators should monitor post flight data from non-revenue flights to detect instances of procedural non-compliance, and to take appropriate action upon crew members including education.[194] This approach seems retrospective, without acknowledging the fact that it may not be possible to conduct non-revenue flights and in particular MCFs according to SOPs owing to the unique demands of these flights.

Stephan Poprawa's qualitative insights in *The Aeronautical Journal*, 'Maintenance test flying – an accident waiting to happen?' reveal that MCFs by their very nature will expose the pilots to activities outside of their normal procedures and operational envelope.[195] Poprawa further states that the predominant cause of fatal accidents during MCFs is complex loss of aircraft control,[196] such as the loss-of-control events cited by the AAIB above. According to the empirical data cited by Poprawa, MCF is one to two orders of magnitude more risky than regular commercial flights, and he therefore recommends standardisation of regulations as well as specific crew training. Such courses are presently offered by some aircraft Original Equipment Manufacturers (OEMs) such as Airbus.[197]

Airbus, a European manufacturer of commercial aircraft, helicopters, defence, and space equipment[198] acknowledges the 'peculiarities and risk' of MCF in its insightful *Safety-First* publication dedicated to 'Functional Check Flights.'[199] The publication outlines the proposed EASA MCF regulatory framework (which was still under development at the time this publication was written)[200] and introduces the Technical

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[193] Federal Aviation Administration Safety Alert for Operators, 12 October 2008, 08024 available at: *https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/airline_safety/SAFO08024.pdf*, accessed on 31 October 2022.
[194] Ibid.
[195] Poprawa, op cit n 1 at 781.
[196] Ibid.
[197] Ibid at 789.
[198] 'Airbus Homepage', available at: *https://www.airbus.com/en/who-we-are*, accessed on 16 February 2022.
[199] Airbus, op cit n 33 at 001.
[200] Ibid at 007.

Familiarisation Flight Course. This course was developed by Airbus for non-test pilots, and is designed to improve the safety, quality and efficiency of MCFs by conveying the foundational elements to attendees.[201] The *Safety First* publication identifies the *Airbus In-Service Aircraft Technical Flight Manual* (ISATFM) as the appropriate reference document for use by trained crew during the conduct of MCFs, in order to verify that an aeroplane's 'operational characteristics have not been adversely affected following maintenance actions.'[202] Importantly, Airbus insists users of this manual sign a legal waiver confirming the ISATFM's use as a guideline for the development of the user's own MCF document, as well as the removal all references to the original Airbus document.

Boeing's equivalent document to the ISATFM is the *Post Delivery Flight Profile* which provides information concerning 'assessment of aeroplane operation following heavy maintenance to crews already trained in proper flight testing procedures and techniques.'[203] In the Purpose and Scope chapter, this manual cautions that 'only highly experienced, properly trained crews should be at the controls while performing the manoeuvres outlined in this document,'[204] highlighting the specialist nature of MCF operations.

At the FCF Symposium David Morgan explained that OEMs will not formally supply MCF procedure manuals to operators unless a new aircraft is purchased, which may cause out-of-date manuals to circulate.[205] Morgan also revealed his experience of a general reluctance by OEMs to provide MCF checklist information to operators.[206] The perceived unavailability of updated MCF information from OEMs may exacerbate the MCF risk by forcing operators to conduct MCFs without the necessary resources, which could compromise safety.

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[201] Ibid at 015.
[202] Ibid at 017.
[203] Boeing, op cit n 119.
[204] Ibid.
[205] David Morgan 'Functional Check Flight Symposium Keynote Address' at 9 available at: *https://flightsafety.org/toolkits-resources/functional-check-flights/functional-check-flight-fcf-symposium-presentations/,* accessed on 14 January 2022.
[206] Ibid.

Francesca Pellegrino explains that safety infringements are often attributable to errors or failures committed by humans and may be categorised as active or latent in nature. Active failures are violations committed by an individual with immediate negative consequences, while latent failures are less apparent organisational deficiencies caused by circumstances such as inadequate resources or a lack of training.[207] The lack of rigid manufacturer guidance on the safe conduct of MCFs represents a latent failure, while the incorrect application of a procedure by a poorly trained pilot performing an MCF is an active failure.

The principle of training and experience of pilots for MCF is a common theme in several confidential reports published in the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) archives. Raymond Speciale describes ASRS as a platform permitting the anonymous reporting of unsafe or potentially unsafe acts or conditions for purposes of identifying safety deficiencies without fear of retaliation or punishment.[208] The ASRS online database allows the searching of key words to obtain open access to reports of a similar nature. A search of the ASRS database returned sixty-two anonymous MCF safety reports.

It must be acknowledged that the ASRS reports studied during this research are specific to the United States region and being voluntary, they do not constitute every occurrence. Nevertheless, numerous reports cite control difficulties during MCFs caused by the failure of a component which was worked on in the preceding maintenance action. In some instances, the pilots experienced a significantly heightened workload because of simultaneous system failures, while others felt inadequately trained for the MCF assigned to them. In two reports the pilots simply refused to fly an MCF as they had not undergone any training. Some reporters experienced operational pressure to conduct an MCF in marginal weather conditions.[209]

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[207] Pellegrino, op cit n 53 at 3.
[208] Speciale, op cit n 77 at 135.
[209] 'NASA ASRS Database', op cit n 70.

This sub-chapter has identified the risk associated with MCFs as originating from two separate sources: incorrect application of procedures by pilots (which may be the result of inadequate training); and aircraft component or system failure caused by human errors during the preceding maintenance episode. Regardless of the source of the risk, constraining the number of personnel aboard an aircraft undergoing an MCF restricts the exposure of risk to a minimum number of personnel.

2.10. The carriage of essential personnel only

The carriage of persons onboard an aircraft undergoing an MCF is restricted by South African and EASA Air Law to essential personnel only, consisting of pilots and trained task specialists.[210] A task specialist's role is to assist the pilots by reading checklists and monitoring aircraft parameters.[211] Several presenters at the Functional Check Flight Symposium including the National Aviation Authorities of Brazil and Canada, as well as Embraer, Boeing, and Airbus emphasised that no passengers should be carried on an MCF.[212]

Airbus recommends an MCF be crewed by three persons on the flight deck, including two pilots and a task specialist. Engineering personnel may be situated in the passenger compartment during an MCF, for example cabin specialists tasked with assessing the functionality of cabin systems and lavatories. Airbus cautions the pilots to retain clear communications throughout the MCF to ensure cabin personnel do not become isolated or incapacitated during a check of the oxygen system, which requires the depressurising of the cabin.[213]

By assuming non-piloting duties, the task specialists reduce the MCF pilots' workload while improving the thoroughness of the check. Although not stated, a further implication of constraining the number of personnel aboard the aircraft is a minimisation of casualties in the event of an accident.

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[210] CAR 43.02.16 (2).
[211] EASA GM1 SPO.SPEC.MCF.125 Crew Composition and Persons on Board (d).
[212] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40.
[213] Airbus, op cit n 33 at 026.

2.11. Accident investigation report recommendations

Aircraft accidents and incidents often reveal latent safety deficiencies within an organisational system. Lebow's thought-provoking *Safety in the Skies: Personnel and Parties in NTSB Aviation Accident Investigations* explains that an investigation seeks to determine the cause of an accident or incident as grounds for the amendment of procedures, laws or protocols to guard against future reoccurrence.[214] Francesca Pellegrino's *The Just Culture Principles in Aviation Law* quantifies the significance of lessons learnt during these investigations in preventing future accidents and incidents by promoting improvements in operational procedures and training.[215] The recommendations published in investigation reports are not intended to be used in pursuing civil or criminal liability, but rather in the pursuance of safety, as explained in ICAO Annex 13.[216]

Two notable incidents are on record as having occurred in airliners[217] during the first flight after maintenance, in which an MCF was neither required nor carried out. These incidents occurred on regular flights, conducted by line crew members not specifically prepared or trained for any post-maintenance unpredictability. The first incident involved an Airbus A320-200 from Lufthansa Airlines, registered D-AIPW, which came perilously close to crashing after take-off from Frankfurt-Main airport on 20 March 2001 because the captain's controls were operating in reverse. The control reversal was caused by an undetected maintenance error. An English translation of the incident report published in German by the Bundesstelle für Flugunfalluntersuchung (BFU), Germany's Federal Bureau of Aircraft Accident Investigation[218] recommends that operators should implement rigid procedures to ensure the airworthiness of an aeroplane after maintenance activity,[219] consisting of thorough functional checking of aircraft systems including flight controls.

[214] Cynthia Lebow et al *Safety in the Skies: Personnel and Parties in NTSB Aviation Accident Investigations* Master (2000) at 13.
[215] Pellegrino, op cit n 53 at 12.
[216] *Annex 13: Aircraft Accident and Incident Investigation*, supra n 10 at 1–3 and 5–3.
[217] An airliner is a transport category aeroplane as defined by the FAA, which includes jet aeroplanes with more than 10 seats or with a mass exceeding 12500lbs.
[218] 'Bundesstelle Für Flugunfalluntersuchung (BFU) Homepage', available at: *https://www.bfu-web.de/EN/The%20BFU/theBFU_node.html*, accessed on 4 November 2022.
[219] JAR OPS 1.890: Maintenance Responsibility (Repealed) Succeeded by Part 145 in Regulation (EU) 1321/2014.

The second incident, on 11 November 2018, involved an Embraer E190-100LR registered P4-KCJ of Air Astana, an airline based in Kazakhstan, wherein the incorrect installation of the aircraft's flight control cables during heavy maintenance resulted in control reversal and consequent loss of control during flight.[220] Although this aircraft landed safely, it was deemed to be beyond economical repair and was written off. The recommendation of the Portuguese investigating authority, the GPIAAF – Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários, is for the aircraft manufacturer Embraer to establish proper guidance to support operators returning aircraft to service after heavy maintenance,[221] while the aircraft operator Air Astana electively implemented procedures to better prepare pilots for flight after heavy maintenance checks.

Both instances occurred in the absence of an MCF, as one was not required by Air Law. It should be recalled that the objective of an MCF is to establish the correct functioning of aircraft systems.[222] Therefore, one cannot help but question whether an MCF by trained crew could have prevented both incidents entirely.

EASA acknowledges in its Notice for Proposed Amendment 2012-08 document 'the assumed ratio for accidents or serious incidents associated with these [MCFs] is higher than for regular operations.' The historic occurrence of accidents and incidents during MCFs precipitated EASA Rulemaking Task.0393 which sought to amend legislation governing MCFs.[223] The Perpignan Accident is a notable case cited by EASA RMT.0393. The BEA's Perpignan accident report recommends that Air Law should detail all non-revenue flights an operator may perform, while mandating a precise description of non-revenue flight practices in an operator's operations manual including flight preparation, operational framework and crew training and qualifications.[224] These BEA recommendations do not specifically refer

[220] Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes & Ferroviários Accident Safety Investigation Final Report 08/ACCID/2018 (English Translation), 18 June 2020, 08/ACCID/2018 available at: *https://reports.aviation-safety.net/2018/20181111-0_E190_P4-KCJ.pdf*, accessed on 25 January 2022.
[221] Ibid.
[222] Air Accidents Investigation Branch, op cit n 187 at 5.
[223] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 29.
[224] BEA, op cit n 9 at 99.

to MCFs by name as these flights are understood to occur under the ambit of all non-revenue flights.

The AAIB adopts a more specific approach in Bulletin 09/2010, published after the loss of control of Boeing 737-73V G-EZJK, wherein it recommends that Air Law should require detailed and controlled procedures for conducting and recording findings during MCFs. The AAIB further recommends the provision of regulatory guidance on minimum flight crew training, proficiency, and crew composition requirements for the conduct of MCFs.[225] Outside of Air Law requirements, certain stakeholders have implemented risk mitigation procedures of their own accord, to enhance MCF safety.

2.12. Risk mitigation procedures by industry

The Functional Check Flight (FCF) Symposium in February 2011 was an industry centric initiative addressing various aspects pertaining to MCF safety, including proactive risk mitigation.[226] The keynote speaker at the symposium, David Morgan of Air New Zealand declared in his opening address, 'Our view is that the overall regulatory framework is less than optimal across multiple jurisdictions.'[227] Morgan explained that a lack of regulatory guidance on MCF pilot training and procedures opens gaps in safety systems, which some operators address using in-house protocols. The FCF Symposium provided a platform for seven airlines including Air New Zealand, Cathay Pacific, American Airlines, United Airlines, Easy Jet and Spanair (which ceased operations on 27 January 2012) to explain internal policies for the control and conduct of MCFs. These participants outlined their MCF operating procedures, crew selection, training, and maintenance of competency[228] for the learning benefit of all attendees.

Representatives from aircraft manufacturers Airbus, Boeing, Bombardier, and Embraer who attended the symposium acknowledged the elevated risk associated with MCF operations. The manufacturers emphasised the need for these flights to be

[225] Air Accidents Investigation Branch, op cit n 187 at 30–1.
[226] Burin, op cit n 168.
[227] Morgan, op cit n 205.
[228] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40.

crewed by experienced crew trained for the task, as well as the importance of rigorous adherence to an accurate pre-determined check flight plan.[229] Air New Zealand revealed their experience of a general reluctance by aircraft manufacturers to provide detailed MCF schedules, which has led to operators developing their own procedures as an evolutionary process – learning from past experiences and mistakes. This remark is particularly poignant considering Air New Zealand was the owner of the aircraft destroyed in the Perpignan Accident, in which four Air New Zealand personnel lost their lives along with an employee of the New Zealand CAA and two German pilots.[230]

Airbus explained their reluctance to avail detailed MCF material to operators is premised upon their inability to control the execution of these unconventional procedures by a client airline. As a result, they are willing to issue MCF guidance under a legal waiver on condition that an operator will develop their own MCF schedules based on local conditions.[231]

Also, in attendance at the FCF Symposium were delegates from the National Aviation Authorities of Brazil, Canada, and the European Union. Transport Canada (TC) acknowledged that detailed procedures including training, crew suitability and planning are not always available which may create a moderate level of risk. TC proposed an MCF awareness campaign via the distribution of guidance material to the industry, while not suggesting that regulatory amendments may yield an increase in safety.[232] The National Civil Aviation Authority of Brazil, Agência Nacional de Aviação Civil or ANAC suggested future regulations should specify procedures for the safe conduct of MCFs, without elaborating on any intrinsic details.[233] EASA utilised the platform to express extreme concern about the 'MCF [safety] issue' and

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[229] Ibid.

[230] The names of the victims are: Air New Zealand pilot Brian Horrell acting as observer on the flight deck, aircraft engineers Murray White, Michael Gyles and Noel Marsh providing technical assistance, New Zealand CAA representative Jeremy Cook providing assistance from the regulator, Captain Norbert Kappel was in command assisted by first officer Theodore Ketzer.

[231] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40 Airbus Presentation at 9.

[232] Ibid Transport Canada.

[233] Ibid ANAC.

to outline the Rulemaking Task.0393 for the proposed amendment of MCF legislation.[234]

Sharing this safety concern, the Flight Safety Foundation established an MCF steering team of subject matter experts who compiled the comprehensive *Functional Check Flight Compendium*, a document containing detailed MCF safety information.[235] The United Kingdom Civil Aviation Authority's *Check Flight Handbook*, CAP 1038 serves a similar purpose to the *Functional Check Flight Compendium*, most notably containing check flight techniques and safety precautions to be used during check flights by pilots who have previously received adequate familiarisation with check flight procedures.[236] Both documents are available as freeware online, and are in wide circulation within the aviation community.

In South Africa there has previously also been concern over test flight regulation and safety. In 2016 the Flight Test Society of South Africa (FTSSA),[237] a non-profit group of subject matter experts comprising internationally trained test pilots represented by Petri Van Zyl, chief flight instructor at the Test Flying Academy of South Africa accompanied by James O Connell, Charl Coetzee and Jannie Scott submitted a proposal for the amendment of test flight legislation to the South African Civil Aviation Regulations Committee (CARCom).[238] The proposer found the South African Regulatory framework governing test flight to be inadequate, specifically lacking any differentiation between various types of test flights, and the pilot training requirements to safely conduct them. The proposal included the removal of test pilot ratings from CARS Part 61 (Pilot Licensing), and the insertion of an entirely new Part 70: Test Pilot Ratings containing inter alia personnel qualification requirements and training syllabi for three test pilot ratings: Category 1, Category 2 and Post Production Test Pilot Rating.[239] The proposal states that an MCF is not test flight,

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[234] Ibid.
[235] Flight Safety Foundation, op cit n 39.
[236] United Kingdom Civil Aviation Authority, op cit n 4 at 10.
[237] FTSSA: Flight Test Society of South Africa, available at: *https://ftssa.org*, accessed on 27 March 2022.
[238] SA CAR 11.03.1.
[239] Flight Test Society of South Africa Proposed Addition of Part 70 to the Civil Aviation Regulations 2011 (''Proposed Addition of Part 70 to the Civil Aviation Regulations 2011'') sourced from the Flight Test Society of South Africa.

and therefore makes no provision for an MCF rating despite identifying MCFs as a privilege of all three categories of proposed Test Pilot Ratings. The doctrine of a maintenance check or test pilot qualification is therefore unclear in this proposal, which thoroughly addresses matters of test flight but largely omits MCF.

The proposed Part 70 regulations were rejected by stakeholders within the South African aviation community when made available for comment by CARCom. The comments by stakeholders remain confidential according to the CARCom secretariat, meaning the reasons for rejection are unknown. However, Mary Stephens, a senior manager at SACAA indicated a lack of consensus amongst stakeholders (including flight schools, airlines and aircraft owners) on which types of aircraft would be subject to Part 70, as well as concern over the availability of training resources and cost contributed to the rejection.[240] These factors led to the dismissal of the proposal by CARCom, thus the regulations of Subpart 19 to Part 61 of the Civil Aviation Regulations 2011 remain in effect at the time of writing.

2.13. Summary

The foundation of all Air Law is the Chicago Convention, through which 52 signatories ratified the founding principles of international civilian Air Law and established the international governing body ICAO. The ideals contained in the 96 articles of the Chicago Convention are given substance and practicality by the Standards and Recommended Practices (SARPS) published in the ICAO Annexes and Documents, which seek to achieve uniformity amongst ICAO member states.

The ICAO SARPS are themselves not laws but are given legal effect when an ICAO Member State's legislature enacts them as local regulations. These regulations along with their supporting technical publications constitute Air Law. The Air Law of each member state is presided over and enforced by a local or regional regulatory body such as SACAA or EASA.

[240] SACAA Senior Manager: Consistency and Standardisation Aviation Safety Operations reply to Candidate email requesting 2016 CARCom meeting minutes, 27 October 2022.

South Africa and the countries represented by EASA are all ICAO contracting states, and therefore enjoy Air Law in general congruence with the ICAO SARPS. MCF is not addressed in name by the ICAO SARPS but is regulated by the SACAA and EASA in accordance with ICAO Annex 1: Personnel Licensing, Annex 6: Operation of Aircraft (Part II) and Annex 8: Airworthiness of Aircraft.

The CARS governing MCF in South Africa are almost identical to the repealed ANR's of 1976 and provide no training syllabus for the qualification of flight crew, despite the qualification being termed a *Post-Maintenance Flight Test rating,* as allowed for in ICAO Annex 1. In contrast, EASA does not mandate an Annex 1 based qualification for pilots conducting MCF yet requires rigid flight crew training and operational control as provided for in Annex 6.

MCF is a component of the Annex 8 derived legislation governing continuing airworthiness of aircraft. Airworthiness is confirmed by verifying the operability of systems or components after maintenance action which cannot be determined on the ground, or for troubleshooting purposes prior to maintenance. Some airlines find that MCFs provide an assurance of the quality of their aircraft serviceability, by enabling the detection of defects prior to re-entry into service.

Statistically MCF introduces an element of risk above that encountered during a normal flight. The literature identifies two risk causal factors, namely the commission of error by maintenance personnel during the execution of a maintenance task; and the non-standard procedures followed by flight crew for purposes of assessing aircraft system operability in flight. The incidents and accidents referenced in this research are attributable to both causal factors (see Annex 1 for a list of MCF incidents and accidents).

Cited accident investigation reports recommend amendment of legislation in relevant jurisdictions as a step to improve MCF safety. The EASA MCF legislation amendment process concluded in 2019 with the adoption by the European Commission of the world's only comprehensive MCF Air Law. This Air Law governs MCF operations in a comparatively small percentage of global operations, and elsewhere in the world air operators have implemented their own risk mitigation strategies to control MCF risk in the absence of exacting regulations.

The dangers of MCF were topical at the FCF Symposium in February 2011. In his concluding address Jim Burin, Director of Technical Programs at the Flight Safety Foundation, summarised the suggestions for risk mitigation in three salient areas: aircraft manufacturers should provide more information to operators on the conduct of MCFs without liability concerns, operators should adopt the best practices discussed at the symposium within their MCF regimes while regulators should draft sensible, well-defined regulations in collaboration with stakeholders.[241] The EASA MCF legislation is to-date the only regulatory material which actively seeks to manage and mitigate the risk of MCF operations in agreement with the theme of the Functional Check Flight Symposium.

This literature has evidenced that MCF presents unique risks which are manageable via the use of appropriate risk mitigation strategies, procedures, and personnel training. Except for the EASA Air Law, regulatory structures remain largely absent in this regard and operators therefore manage MCF risk at organisational level via the use of internationally recognised best practices and their own past experiences.

[241] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40.

CHAPTER 3: AIRCRAFT MAINTENANCE AND MAINTENANCE CHECK FLIGHT

3.1. Introduction

Despite significant improvements in the quality and reliability of aeronautical components since the first powered flight in 1903, aviation equipment still requires maintenance attention from time to time.[242] Aircraft maintenance is a fundamental category of Air Law as defined in the ICAO Annexes, enacted within every contracting state's legal system, and carried out by trained personnel at the behest of aircraft owners and operators. The principal objective of aircraft maintenance is to ensure the aircraft remains airworthy in accordance with the Chicago Convention.[243] An aircraft is deemed airworthy if it conforms to its approved design and is in a condition for safe operation.[244]

3.2. Initial airworthiness approval of aircraft design

Aircraft manufacturers (referred to as Original Equipment Manufacturers or OEMs) design aircraft according to basic criteria derived from ICAO Annex 8, which are enacted through the regulatory system of the state of design as certification standards.[245] Certification standards are regulations which a newly designed aircraft must comply with to demonstrate to the regulatory authority that it is safe to operate.[246] An example of a certification standard employed by EASA is Certification Specification CS-25,[247] which contains the design and certification requirements for turbine powered large aircraft.[248] An OEM demonstrates compliance with the relevant certification standards via the process of experimental and engineering test flights.[249] A test flight is a precisely planned and meticulously executed means of obtaining qualitative and quantitative data on the characteristics and performance of a new aircraft.[250] After the completion of the requisite number of

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[242] Harry Kinnison *Aviation Maintenance Management* 1st ed (2004) at 13.
[243] Convention on International Civil Aviation 7 December 1944, Article 31.
[244] ICAO, supra n 120 at I–1.
[245] Barrera, op cit n 65 at 11.
[246] Mario Asselin *Operational Aircraft Performance and Flight Test Practices* (2021) at xx.
[247] EASA, op cit n 123 at 25.
[248] EASA CS-Definitions defines large aircraft as an aircraft with a maximum certified take-off weight of more than 5700kg.
[249] Corda, op cit n 46 at 162.
[250] Ibid at 171.

test flights (in the order of hundreds for large aircraft), the data is presented to the regulatory authority as evidence of compliance with the relevant certification standard. Once an OEM has demonstrated their aircraft's compliance with the certification standard, the regulatory authority issues a type certificate for the aircraft.[251] Colloquially an aircraft with a type certificate is said to be type certified. Air Law also accommodates non-type certified aircraft, a concept which is beyond the purview of this writing. EASA maintains an official record of types certified according to EASA Certification Standards in its certification database. For example, the type certificate data sheet for the Airbus A320, the type of aircraft involved in the Perpignan Accident, is issued by EASA to Airbus S.A.S of Blagnac France as confirmation that the A320 meets the certification specifications of CS-25.[252] Flight testing a newly designed prototype for eventual type certification is a process with notable risks which are mitigated by strict test criteria and adherence to meticulously pre-planned flight schedules.[253] Following type certification, the OEM may legally commence production of the aircraft for sale to local and international customers.

When a new type-certified aircraft is first registered in its state of domicile, a Certificate of Airworthiness (CoA) is issued by the local regulatory authority to confirm compliance with the type certificate.[254] For example, if an Airbus A320 is acquired by a South African operator, the SACAA must be satisfied that the aircraft complies with CS-25, and will thereafter issue a CoA for that particular aircraft.

A CoA remains valid subject to the laws of the state of registry, provided the aircraft's airworthiness is reconfirmed by periodic inspection during maintenance.[255] An SACAA CoA is valid for twelve months, but will be rendered invalid if the aircraft does not undergo mandatory maintenance as specified in Part 43 of the Air Law.[256] These requirements constitute continuing airworthiness.

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[251] Barrera, op cit n 65 at 11.
[252] 'EASA Type Certificate Data Sheet: Airbus A318, A319, A320, A321', 12 May 2023, available at: *https://www.easa.europa.eu/en/downloads/16507/en,* accessed on 17 October 2022.
[253] Corda, op cit n 46 at 161.
[254] ICAO, supra n 120 at II-3–1.
[255] Ibid.
[256] CAR 21.08.12.

3.3. Continuing airworthiness

Continuing airworthiness is a demonstration of the sustained airworthy condition of an aircraft to a regulatory authority.[257] Continuing airworthiness tasks include regular maintenance, fault reporting, modifications and repairs which are deemed necessary by the regulatory authority for the safe operation of an aircraft. ICAO Annex 8 requires the state of manufacture (the state where the type certificate was issued) to supply information describing the continued airworthiness tasks for an aircraft type.[258]

EASA's continuing airworthiness requirements originate in Regulation (EU) 1321/2014 and are published as Air Law in the Easy Access Rules for Continuing Airworthiness, while the CARS Part 43 refer. Both bodies of Air Law mandate aircraft maintenance as a compulsory aspect in continuing airworthiness, in concordance with ICAO Annex 8 and Document 9760, the Airworthiness Manual.

3.4. Aircraft maintenance - general

ICAO Annex 8 defines maintenance as 'the performance of tasks required to ensure the continuing airworthiness of an aircraft.'[259] Maintenance is the process of ensuring that a system continually performs its intended function, at its designed level of reliability and safety.[260] Reliability is necessary to meet flight schedules and fulfil commercial obligations, while safety is ICAO's foremost objective.

To achieve the goals of reliability and safety an ICAO contracting state is compelled to adopt requirements in law to ensure all aircraft are maintained in an airworthy condition.[261] The CoA is the legal declaration of the aircraft's airworthiness by the state regulatory authority. However, it remains the

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[257] ICAO, supra n 129 at III-9–1.
[258] ICAO, supra n 120 at II-4–1.
[259] Ibid at 1–3.
[260] Kinnison, op cit n 242 at 35.
[261] ICAO, supra n 120 at II-4–3.

responsibility of an aircraft owner or operator to maintain an aircraft in an airworthy condition.[262] Failure to do so will render a CoA invalid.

Aircraft maintenance has thus evolved into a highly sophisticated practice governed by Air Law. The CARS Part 91, which apply to all aircraft operated within the Republic as well as all South African registered aircraft[263] require all aircraft to undergo maintenance in accordance with an Aircraft Maintenance Program (AMP) approved by the SACAA.[264] An AMP is compiled by an owner or operator describing the procedures for sustained airworthiness.[265]

An AMP is based on OEM data, and must specify the maintenance tasks and intervals, considering the anticipated utilisation of the aircraft.[266] The AMP specifies a schedule of inspections and overhauls required for continuing airworthiness.[267] These tasks may be scheduled according to calendar intervals, hours flown, or individual flight cycles as approved by the regulatory authority.[268] This is called scheduled maintenance.[269]

3.5. Scheduled maintenance

Scheduled maintenance intervals vary considerably with aircraft type and will be specified in the AMP. Scheduled maintenance tasks are classified according to their scope, complexity, and man-hour requirements and are colloquially referred to as line, base, and heavy maintenance.[270] Line maintenance is performed prior to each flight while the aircraft remains in service - such as a pre-flight inspection; base maintenance requires the aircraft to be removed from service for a short duration of hours or days and generally occurs in a hangar – such as a weekly inspection; while heavy maintenance is in-depth base maintenance which occurs over weeks or months

[262] ICAO, supra n 114 at 2.6-1.
[263] CAR 91.01.1 at 01.
[264] CAR 91.09.1 at 09.
[265] CATS 43.02.8 Section D.
[266] CATS 43.02.3 at 2.
[267] CATS 43.02.8 Section A.
[268] Regulation (EU) 2020/1159.
[269] Kinnison, op cit n 242 at 6.
[270] Barrera, op cit n 65 at 187.

during which the aircraft is partially disassembled, inspected, repaired and reassembled.[271]

An example of scheduled maintenance work is the Mandatory Periodic Inspection (MPI), which is required by South African Air Law to occur at one-hundred flight hour intervals, or within a period of twelve months, whichever occurs first.[272] Air Law offers two alternatives to the MPI, namely progressive inspection and block inspection programs. Both alternatives negate the one-hundred flight hour and twelve-month requirement, subject to their being based on OEM data and approved by the SACAA.[273] An example is a Boeing 737 aircraft which is required to undergo a range of base checks called A, B, C and D checks. An A-check may occur every 350 flight hours and is completable overnight, whereas a D-check may occur every 22000 flight hours and take more than 6 weeks.[274] The D-check is an example of heavy maintenance.

MCFs are often required after heavy maintenance to verify the aircraft's operational characteristics have not been adversely affected.[275] Airbus's *In-Service Aircraft Technical Flight Manual* (ISATFM) and Boeing's *Post Delivery Flight Profile* manual describe procedures and manoeuvres to be used during an MCF,[276] but the availability of these manuals is restricted as explained in the previous chapter. Not all OEMs publish MCF information, forcing operators to design their own MCF profiles. This practice may elevate risk, as it occurs in the absence of OEM guidance.

Scheduled maintenance is preventative and pre-planned, thereby allowing aircraft owners or operators to make provision for the requisite downtime in their scheduling. Components and systems which fail outside of the maintenance schedule require unscheduled maintenance to restore aircraft serviceability.

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[271] Ibid at 188.
[272] CATS 43.02.8 Section A.
[273] Ibid Section A.
[274] Grote & Hefazi, op cit n 183 at 1136.
[275] Airbus, op cit n 33 at 017.
[276] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40 Boeing Presentation.

3.6. Unscheduled maintenance

Unscheduled maintenance is required when components or systems develop unforeseen defects, meaning it occurs outside the intervals specified in the AMP. Unlike the preventative nature of scheduled maintenance, unscheduled maintenance is corrective. Air Law identifies hard landings, lightning strikes, and bird strikes as events requiring unscheduled maintenance.[277]

Regardless of whether maintenance activity is scheduled or unscheduled, it is carried out by personnel who are required by Air Law to be trained and certified for the accomplishment of this task. These personnel are referred to as mechanics, technicians, repairers, maintainers, or engineers[278] and are subject to an array of external factors which influence their workmanship. These are called human factors.[279]

3.7. Human factors in aircraft maintenance

Despite significant technological advancements involving the use of robotics in industrial processes over the last half century, aircraft maintenance remains largely a hands-on process. Aircraft maintenance personnel are confronted by unique working conditions such as working at height, in confined spaces, in sweltering heat or numbing cold, during all hours of the day and night.[280] Air Law acknowledges the factors affecting maintenance personnel and seeks a safe interface between the human and other system components by proper consideration of human performance.[281] The job of an aircraft maintenance engineer involves a complex interaction of individuals, their tools and their work environment.[282] Aviation regulators recognise that these human factors have the potential to precipitate errors which could impact safety, and therefore establish countermeasures in Air Law to

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[277] CATS 43.02.8 Section A.
[278] Kinnison, op cit n 242 at 5.
[279] Justin Samuel Garr *Reduction of Human Factors-Related Accidents During the Flight Test of Homebuilt Aircraft Through the Application of Professional Flight Test Practices* (University of Tennessee, 2007) at 28.
[280] Hobbs, op cit n 177 at 3.
[281] Regulation (EU) No 2020/270.
[282] Douglas Wiegmann & Scott Shappell *A Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System* (2003) at 26.

minimise this risk.[283] Aircraft maintenance personnel training includes human factor modules such as error mitigation and human capability limitations, in addition to technical competencies.[284]

EASA Air Law identifies certain maintenance tasks as critical due to their potentially significant impact on safety, including tasks that may affect the control of an aircraft.[285] Air Law recommends that such tasks be performed by a qualified technician, and thereafter inspected by an independent qualified person to identify any potential deficiencies or errors.[286]

Despite the existence of Air Law which intends to mitigate the risk posed by human error, the evidence and causes of human errors are generally qualitative and elusive.[287] Consequently maintenance error remains possible throughout the aircraft maintenance process, as evidenced by statistical data. The 2021 International Air Transport Association Safety Report cites aircraft maintenance error as a latent contributory factor in 14% of air accidents in the period 2017-2021.[288] Latent factors may lie dormant or undetected within a system for prolonged periods before being triggered by an external factor, and thereafter affecting flight safety.[289]

An error is defined as the mental or physical activity of an individual which fails to achieve its desired goal.[290] Humans by their very nature make errors, and it is these unsafe acts which precipitate many air accidents.[291] Errors are categorised as omissions, commissions, timing errors or errors of precision.[292] Omissions are failures by maintenance personnel to perform necessary actions when required, while commissions are actions performed which should not be. Timing errors are those

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283 Barrera, op cit n 65 at 197.
284 Regulation (EU) No 2020/270.
285 ED Decision 2016/011/R.
286 Ibid AMC2 M.A.402(h).
287 Wiegmann & Shappell, op cit n 282 at 15.
288 International Air Transport Association IATA 2021 Safety Report, April 2022, Edition 58 available at: *https://www.iata.org/contentassets/bd3288d6f2394d9ca3b8fa23548cb8bf/iata_safety_report_2021.pdf*, accessed on 30 December 2022.
289 Wiegmann & Shappell, op cit n 282 at 48.
290 Khadijah Habib & Cengiz Turkoglu ‘Analysis of Aircraft Maintenance Related Accidents and Serious Incidents in Nigeria’ (2020) *Aerospace*.
291 Wiegmann & Shappell, op cit n 282 at 51.
292 Hobbs, op cit n 177 at 10.

performed at the incorrect point in a maintenance schedule, while errors of precision are those in which inadequate levels of accuracy were maintained throughout the maintenance process.[293] The most common errors in the Boeing database are omissions.[294]

Recent years have witnessed a proliferation of human error taxonomies by aviation maintenance stakeholders seeking to quantify the risk posed by human error. One of the most useful and easily comprehensible tools is James Reason's Swiss Cheese Model. It shows, in laymen's terms, how the fundamental elements of an organisation work together to defend against unsafe acts.[295] Each elementary defence layer is visualised as a slice of Swiss cheese, in which the holes represent an intrinsic deficiency of the organisational layer. Several slices are overlaid such that in an ideal world the holes never line up, thereby disallowing unsafe acts to penetrate. However, accidents occur when the holes in different defence layers align, degrading the integrity of the system and making it susceptible to catastrophic failures.[296] Using James Reason's Swiss Cheese Model, the Perpignan Accident is analysed according to an accumulation of failures across multiple safety layers:

The first safety defence layer was breached when maintenance personnel employed an inappropriate aircraft washing procedure in which high pressure water penetrated the angle of attack sensors.[297] This water did not affect the sensors while in liquid form but immobilised them when it froze during the MCF.

The second safety defence layer was breeched when air traffic control (ATC) approval was not obtained for the performance of an MCF. Consequently, ATC refused the flight crew's request to perform mandatory MCF manoeuvres at a safe altitude.[298] The crew thus attempted their low airspeed check during final approach to runway 33 at Perpignan-Rivesaltes Airport, at an altitude providing an insufficient safety margin in the event of a malfunction.

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[293] Ibid.
[294] Ibid.
[295] Wiegmann & Shappell, op cit n 282 at 45.
[296] Ibid at 47.
[297] BEA, op cit n 9 at 89.
[298] Ibid at 54.

The low airspeed protection system was designed to enhance flight safety by preventing an A320 from reaching a dangerously low airspeed and suffering a stall.[299] This safety mechanism did not operate because the frozen angle of attack sensors failed to detect the impending aerodynamic stall. Consequently, the A320 entered an unintended stall, resulting in a catastrophic loss of altitude while close to the sea. An aerodynamic stall is an out-of-control condition characterised by a loss of lift when the critical angle of attack between the wing and the oncoming airflow is exceeded.

The flight crew did not expect the aircraft to suffer a stall, believing the low airspeed protection system would prevent a stall. The inadvertent progression into a stall was very startling to the pilots, who did not apply all necessary steps to recover control of the aircraft, including manual input of the stabiliser pitch trim to assist in lowering the nose.[300] This inaction of the crew resulted in loss of control of the A320, which impacted the sea at 15h46 on 27 November 2008.

An accumulation of failures across multiple defence layers allowed the continuation of unsafe acts which caused this accident, as visualised using James Reason's Model. Reason's may be utilised to describe the progression of unsafe acts in any safety-based organisation and is not unique to aviation maintenance. Another example of a human error taxonomy, the Maintenance Error Decision Aid (MEDA) aims to identify and correct weaknesses in safety defences at maintenance level.

Boeing's MEDA identifies contributory factors which lead to maintenance errors such as fatigue and inadequate knowledge of systems or procedures,[301] thereby allowing organisations to learn from past mistakes. The central philosophy of MEDA is that human errors in aircraft maintenance are seldom made on purpose, thereby promoting the concept of a just culture wherein blame is not apportioned to individuals for errors, whilst accountability is shared across the organisation.[302]

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[299] Ibid at 29.
[300] Ibid at 101.
[301] Hobbs, op cit n 177 at 31.
[302] Rankin, op cit n 176 at 18.

Just culture principles originate in ICAO Annex 19, Safety Management, which provides legal safeguards to ensure the appropriate use and protection of safety information,[303] thereby encouraging the reporting and admission of errors by aviation personnel. ICAO's stance on a just culture is expanded in its Document 9859, the Safety Management Manual which intends to support contracting states in implementing effective safety programmes.[304] ICAO recommends that investigations into safety breeches should focus hazards, risks, and opportunities for improvement rather than apportioning blame or punishment.[305]

Notwithstanding well-defined Air Law structures seeking to manage human error in a just culture, maintenance error continues to be one of the most obvious safety threats to aircraft.[306] Therefore post maintenance operability checks play an important role in the verification of defect-free operation prior to releasing an aircraft to service after maintenance. However, not all operability checks successfully detect defects. This was evidenced by the near accidents of Lufthansa Airlines A320-200 D-AIPW on 20 March 2001[307] and Air Astana Embraer E190-100LR P4-KCJ on 11 November 2018,[308] both explained in the previous chapter.

Investigation reports published by the German BFU and Portuguese GPIAAF recommended amendments to the quality assurance processes for releasing an aircraft to service after maintenance, and the issuance of further guidance on post maintenance operability checks.[309] It should be recalled from Chapter 1.3 that incident and accident investigations seek to determine the cause of an occurrence to guard against the future reoccurrence[310] while not apportioning blame.[311] These investigations therefore also function within a 'just culture.'

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303 Pellegrino, op cit n 53 at 53.
304 ICAO, supra n 60 at Foreword iii.
305 Ibid at 9–17.
306 United Kingdom Civil Aviation Authority, op cit n 175 at 6.
307 Bundesstelle für Flugunfalluntersuchung (BFU) Investigation Report 5x004-0/01 (English translation), May 2003 available at: *https://www.bfu-web.de/EN/Publications/FinalReports/2001/Report_01_5X004-0_Frankfurt_A320.pdf?__blob=publicationFile&v=1*, accessed on 8 January 2023.
308 Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes & Ferroviários, op cit n 220.
309 Ibid.
310 Lebow et al, op cit n 214 at 13.
311 Bartsch, op cit n 20 at 156.

3.8. Post maintenance operability check

After the completion of certain aircraft maintenance tasks, it is necessary to determine whether the component or system is operating to within specified tolerances or limits via the performance of a functional check.[312] A functional check is defined as a 'quantitative check to determine if one or more functions of an item performs within the limits specified in the appropriate maintenance data.'[313] Functional checks are generally more effective at error detection and risk mitigation than visual inspections.[314]

The requirement for a functional check is published in an AMP and will originate in the aircraft maintenance manual. Maintenance personnel are required by law to be theoretically and practically trained in the facilitation of functional checks.[315] An example of a functional check is the ground-running of an engine after the completion of a maintenance task on the engine.

Many functional checks are successfully performed by aircraft maintenance personnel while the aircraft remains on the ground. However, the operability of certain systems or components can only be determined by exposing the aircraft to flight conditions. In these instances, an MCF is required.

3.9. MCF

MCF is defined in Air Law as the flight of an aircraft with a valid CoA, carried out for troubleshooting purposes or to check the functioning of systems or components after maintenance, if functionality cannot be assured during ground checks.[316] EASA Air Law lists four specific instances where MCFs are required, namely: when stipulated in an Aircraft Maintenance Manual (AMM); after maintenance as required by the operator; as requested by the maintenance organisation for confirmation of

[312] Corda, op cit n 46 at 162.
[313] EASA Easy Access Rules for Continuing Airworthiness (Regulation (EU) 1321/2014) GM1 ML.A.302(d)(2).
[314] Hobbs, op cit n 177 at 26.
[315] EASA Easy Access Rules for Continuing Airworthiness (Regulation (EU) 1321/2014) Appendix II to Part 66.
[316] Regulation (EU) 2019/1387 Annex 1 Definitions.

successful rectification of a known defect; or to assist the isolation of a fault (troubleshooting).[317] These MCFs are prescribed components of an AMP,[318] meaning their necessity is well documented within the program. MCFs may also be conducted when not prescribed by a maintenance program or element of Air Law. These elective MCFs are simple confidence checks performed in accordance with engineering best practices,[319] and may lack the structure of prescribed MCFs because their requirement does not originate in doctrine. Regardless of the differences in origin, prescribed and elective MCFs share a general common objective: the verification of normal operation of an aircraft and its systems.

An MCF differs considerably to a normal flight because the attention of the crew is directed exclusively towards technical aspects of the aircraft, and not towards transportation of passengers from origin to destination. MCFs do not generate revenue for an operator whose core business is air-transportation and are thus considered non-revenue flights.[320]

Some MCFs require the flight crew to simply verify normal operation of aircraft systems after maintenance and are colloquially referred to as ‘shakedowns’ or ‘systems acceptance flights.’ These MCFs are elective in nature and will likely be flown using normal operating procedures, without a specific check flight program. Other MCFs require the use of unconventional procedures to verify the operation of backup systems; or for the aircraft to be flown to its certification limits to confirm normal behaviour throughout the flight envelope.[321] Such flights are quantitative, requiring the crew to measure and record aircraft system performance against data published in the AMM.

An AMM is a tome of thousands of pages of detailed information about the maintenance of aircraft systems and components.[322] Where applicable, an AMM

[317] Ibid.
[318] United Kingdom Civil Aviation Authority, op cit n 4 at 24.
[319] Ibid.
[320] Airbus, op cit n 33 at 006.
[321] A flight envelope refers to the operational limitations of an aircraft. Containing an aircraft within these limitations is said to be operating within the envelope.
[322] Kinnison, op cit n 242 at 58.

describes the functional checks required during an MCF. Surprisingly few AMM maintenance procedures require an MCF.

A sample Airbus AMM indicates that MCFs are not compulsory unless a system cannot be properly ground tested, however MCFs are good practice following actions or repairs which could affect the aircraft's aerodynamic characteristics.[323] In the case of Embraer, only one maintenance task on the ERJ145 model requires an MCF – specifically following work on the elevator.[324] The Boeing 737NG AMM requires an Elevator Power Off Flight Test following maintenance on the elevator control system because maintenance action can affect flight characteristics, the magnitude of which cannot be determined on the ground.[325] This MCF is a mandatory step for the completion of the elevator maintenance procedure – without the MCF the maintenance task is considered incomplete.

The candidate has performed several Elevator Power Off Flight Tests on Boeing 737 aircraft with vastly unpredictable outcomes. In some instances, the aircraft pitched down, in others it pitched up with varying levels of aggression, while in other instances no pitch moment was evident at all. The quantitative data from this check is required by maintenance personnel to perform further adjustments, if necessary, after the flight. The AAIB has on record five instances where incorrect adjustment of a Boeing 737 elevator caused an uncontrolled pitch moment during the subsequent MCF.[326] The most significant of these instances is reviewed in the first of the following case studies.

3.10. Case studies

The following four MCF cases were extracted from Annex 1 and studied in detail because their final investigation reports contain safety recommendations for amendments to Air Law.

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[323] Airbus, op cit n 33 at 021.
[324] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40 Embraer Presentation, Page 7.
[325] *Boeing 737-600/700/800/900 Aircraft Maintenance Manual*, op cit n 185.
[326] Air Accidents Investigation Branch, op cit n 187 at 17.

3.10.1 Boeing 737-73V, G-EZJK[327]

An Elevator Power Off Flight Test was being conducted in accordance with the Boeing 737 AMM during an MCF. This procedure involves removal of hydraulic input to the elevator flight control surfaces and recording of the resultant control input required to restore level flight. These parameters are utilised by maintenance personnel for readjustment purposes, if necessary, after the MCF.

At the commencement of the procedure the aircraft pitched aggressively downward and commenced a rapid descent. The commander decided to abandon the check, but in so doing incorrectly banked the aircraft to a ninety-one-degree angle[328] before releasing the controls. In the subsequent recovery the nose pitched to thirty degrees below the horizon, while the aircraft encountered a rate of descent of twenty-thousand feet per minute at a speed of 447 knots. The aircraft's maximum certified speed is 340 knots. Control of the aircraft was regained after reactivation of the hydraulics, and a safe landing was performed. This flight is categorised by the AAIB[329] as a serious incident,[330] and is cited as the most serious of five similar incidents involving Elevator Power Off Tests of Boeing 737 aircraft in the United Kingdom.[331]

The underlying cause of this serious incident was a gross adjustment error of the control mechanism during the preceding maintenance. This adjustment error was premised upon inaccurate data collected after the previous Elevator Power Off Flight Test. The aggressive downward pitch moment was mishandled by the captain because of his unfamiliarity with recovery procedures, which precipitated a significant loss of control. These causal factors prompted the AAIB to issue two

[327] Air Accidents Investigation Branch, op cit n 187.

[328] Aircraft bank angle refers to the number of degrees between the lateral axis (wings) and the horizon. A 0-degree bank angle means the wings are level with the horizon, while a 91-degree bank angle means the wings are perpendicular to the horizon.

[329] The AAIB investigates civil aircraft accidents and serious incidents within the UK, its overseas territories and crown dependencies according to the AAIB Homepage available at: *https://www.gov.uk/government/organisations/air-accidents-investigation-branch*, accessed on 25 October 2022.

[330] A serious incident is defined by the AAIB as one involving circumstance indicating that there was a high probability of an accident and is associated with the operation of an aircraft. AAIB Definitions available at *https://www.gov.uk/government/publications/definition-of-aircraft-accident-and-serious-incident/definition-of-aircraft-accident-and-serious-incident*, accessed on 4 January 2023.

[331] Air Accidents Investigation Branch, op cit n 187 at 17.

safety recommendations for amendments to the Air Law. The first recommends the establishment of a controlled flight check schedule and a detailed procedure to record adverse findings during an MCF.[332] The second recommends the provision of guidance on pilot training and proficiency prior to being assigned an MCF.[333] The integration of these safety recommendations into Air Law will be detailed in the subsequent chapter. Despite the seriousness of this incident, it did not result in damage to the aircraft, which was not the case in the following case study.

3.10.2 Dassault Falcon 2000, CS-DFE[334]

The aircraft was undergoing troubleshooting for the correction of a defect with the wheel braking system. The flight crew performed several high-speed taxi trials to determine the performance of the brakes. During the eighth trial, excessive heat accumulation caused the left brake to catch alight, damaging the underside of the aircraft.

A subsequent investigation by the AAIB determined causal factors to be the pilots' lack of knowledge of mitigating actions required for high brake energy events, and a lack of training of maintenance personnel for the conduct of functional checks of this variety. The AAIB recommended an amendment of Air Law to require the provision of data to pilots on accumulated brake energy, as well as the specification of the roles of maintenance personnel and pilots when participating in maintenance checks.[335]

Despite the damage sustained to the aircraft and the safety recommendations made, no injuries or fatalities were sustained. The following two events demonstrate adverse critical outcomes during poorly regulated MCFs.

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332 Air Accidents Investigation Branch, op cit n 187 Safety Recommendation 2010-073.
333 Ibid Safety Recommendation 2010-075.
334 Air Accidents Investigation Branch AAIB Bulletin 12/2010, available at: *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/384839/Bulletin_12-2010.pdf*, accessed on 4 January 2023.
335 Ibid Safety Recommendation 2010-064.

3.10.3 Douglas DC-8-63 N827AX[336]

A Douglas DC-8 was destroyed in an accident which occurred during an MCF, resulting in the loss of 6 lives. This accident was investigated by the National Transportation Safety Board (NTSB), an independent Federal agency of the United States mandated by the Independent Safety Board Act of 1974 to investigate accidents and issue safety recommendations.[337] The NTSB report describes how the crew lost control of their aircraft after unintentionally entering an aerodynamic stall during an MCF. It is common practice to evaluate the operability of stall detection and warning systems during MCFs by approaching a stall condition, and immediately recovering upon activation of the warning.

The probable cause of this accident was an inoperative stall warning system which failed to activate during the MCF, and the subsequent inappropriate control inputs by the pilot during the stall recovery attempt.[338] The NTSB issued recommendations for the amendment of Air Law requiring operators to identify high risk operations (such as MCFs) and to specify pilot training and qualification requirements for these flights.[339] The NTSB further recommended the creation of regulatory guidance clarifying MCF operational procedures.[340]

These recommendations, at the time of writing, have not been incorporated into US Air Law but are addressed by Safety Alert for Operators 08024.[341] In stark regulatory contrast, EASA MCF Air Law underwent significant amendment in accordance with the safety recommendations of the Perpignan Accident report.

3.10.4 Airbus A320-232 D-AXLA (Perpignan Accident)[342]

The factors which led to the loss of an Airbus A320-232 off the coast of Perpignan, France were reviewed utilising James Reason's Swiss Cheese Model earlier in this chapter. This accident laid bare the elevated risks associated with MCF operations

[336] National Transportation Safety Board NTSB/AAR-97/05, 1997 available at: *https://libraryonline.erau.edu/online-full-text/ntsb/aircraft-accident-reports/AAR97-05.pdf*, accessed on 27 December 2022.
[337] Ibid at i.
[338] Ibid at 51.
[339] National Transportation Safety Board, op cit n 336 Safety Recommendation A-97-50.
[340] Ibid Safety Recommendation A-97-52.
[341] Federal Aviation Administration, FAA Document SAFO 08 24, op cit n 66.
[342] BEA, op cit n 9.

while revealing the inadequacy of Air Law to mitigate these risks. It is not surprising that several safety recommendations published by the investigating authority, France's BEA, called for amendments of EASA Air Law to reduce the probability of another Perpignan Accident.

The EASA Air Law in effect at the time of the accident required operators to identify general procedures for non-revenue flights in the company operations manual,[343] without specific reference to MCFs. In the absence of regulatory guidance, operators were able to define their own MCF operational constraints, without necessarily having evaluated all inherent risks.[344] The BEA cited this absence of a regulatory framework as a causal factor in this accident, as well as the use of a flight programme by the pilots for which they were inadequately trained.[345] The BEA thus recommended EASA Air Law should detail different types of non-revenue flights (as opposed to simply identifying them), and for operators to precisely describe non-revenue flight preparation, operational framework and pilot training requirements in their manuals.[346]

The BEA also indicated their support of the safety recommendations published by the AAIB after the serious incident explained in 3.11.1 above.[347] These safety recommendations prompted EASA to review and ultimately amend the Air Law governing MCF operations, which will be detailed in the next chapter.

The four case studies were selected from Annex 1 for their significance in the illustration of risk associated with MCFs, and for their contribution to the amendment of Air Law. The following statistical analysis endeavours to quantify this risk across multiple jurisdictions.

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[343] EU-OPS 1.1045 (Repealed and Succeeded by Regulation 965/2012).
[344] BEA, op cit n 9 at 99.
[345] Ibid at 98.
[346] Ibid at 99.
[347] Ibid at 100.

3.11. Accident statistics

Precise MCF accident and incident statistics are not readily available because MCF data is embedded within the non-revenue statistical category. Furthermore, statistical accident and incident data does not differentiate between MCF and test flight. The following analysis is therefore not exhaustive but intends to quantify the risk posed by non-revenue flights, and to identify the contribution made by MCF to this risk category.

Boeing's statistical summary of commercial jet aeroplane accidents reveals one hundred and twenty-four non-revenue accidents as having occurred between 1959-2020.[348] This represents 5.96% of accidents involving the worldwide commercial jet fleet, accounting for 274 fatalities. By comparison 30,937 fatalities were caused by air accidents during revenue operations within the same period.[349] On face value this data suggests non-revenue flight operations pose a minor risk to safety when compared to revenue flight operations. However, it must be understood that non-revenue flights account for a mere fraction of total flight operations and do not usually carry passengers, thereby creating a statistical bias. With valid context this non-revenue accident statistic is notable.

Of further significance are forty-five accidents which occurred between 1990 and 2005 during flight testing or checking activities.[350] This statistic was cited by EASA when proposing an amendment to the Air Law governing flight testing and checking in 2008,[351] three months before the Perpignan Accident. This reveals flight test and MCF safety were of concern to EASA prior to the Perpignan Accident. EASA was not the only regulatory authority to harbour a safety concern at this time. In the same year the Federal Aviation Administration (FAA) acknowledged that approximately twenty-five percent of accidents involving turbine powered aircraft in the previous decade occurred during non-revenue flight operations, including MCFs.[352]

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[348] Boeing, Statistical Summary of Commercial Jet Accidents, op cit n 56 at 8.
[349] Ibid.
[350] Mark Lacagnina 'Check Flight Checkup' (2011) *Flight Safety Foundation* 14–8 at 18 available at: *https://flightsafety.org/wp-content/uploads/2016/10/asw_mar11_p14-18.pdf*, accessed on 9 August 2022.
[351] EASA Notice of Proposed Amendment (NPA) 2008-20 29 August 2008,.
[352] Federal Aviation Administration, Safety Alert for Operators, op cit n 193.

Not all safety breaches lead to accidents or reportable incidents, meaning non-revenue safety statistics are likely incomplete. For example, the owner of a light aircraft is not required by Air Law to report all anomalies during non-revenue flights, meaning valuable safety information may be lost to the abyss of non-reporting. NASA identified the value in obtaining, analysing, and disseminating all aviation safety related information, and for this purpose established the ASRS database.

The ASRS database permits the anonymous reporting of unsafe or potentially unsafe acts or conditions, which allows identification of safety deficiencies without fear of retaliation or punishment within the US aviation sector.[353] A tailored search of the ASRS database revealed sixty-two MCF safety reports between 1988 and 2021.[354] These MCF reports may be broadly differentiated into two categories: in-flight technical defects attributable to the preceding maintenance activity; and a lack of preparedness for the MCF task by pilots. None of these reports resulted in an officially classifiable accident or incident.

Fifty-two ASRS reports concern technical defects noted by pilots during the MCF ranging from inoperative instrumentation to control difficulties, smoke inside the cabin and engine failures. For example, a Boeing 767 had loose fuel lines which caused an engine failure during an MCF,[355] and a Boeing 737 crew encountered control difficulties attributable to a missing wing panel.[356] In each reported case the aircraft landed safely, with aircraft damage occurring in only eight cases.

Ten ASRS reports identify a reduction in safety caused by the actions or inactions of the MCF pilots. In one instance the pilots simply refused to conduct an MCF due to lack of training, whilst in another an aircraft suffered a near miss[357] because the pilots were distracted by the MCF workload. A poorly trained MCF crew performed a functional check incorrectly which caused the loss of multiple aircraft systems

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[353] Speciale, op cit n 77 at 135.
[354] NASA Aviation Safety Reporting System (ASRS) Database, available at: *https://asrs.arc.nasa.gov/search/database.html*, accessed on 27 November 2022.
[355] Ibid Report ACN 1762614.
[356] Ibid Report ACN 1610715.
[357] A near-miss is the term used to colloquially describe when two aircraft avoid colliding by a margin less narrow than minimum air-traffic control separation.

required for a safe landing.[358] Yet another crew reacted incorrectly to a perceived engine anomaly, and accidentally shut down all the engines of their Boeing aircraft, requiring the declaration of an emergency to air traffic control.[359]

These ASRS reports are by no means exhaustive, but highlight the elevated risk associated with MCF operations.

3.12. The basis of risk

In 2012 EASA declared that the assumed ratio for accidents or serious incidents associated with MCF is higher than for regular operations.[360] This viewpoint was ubiquitous during the Functional Check Flight Symposium,[361] and has been echoed by individuals with a vested interest in MCF safety such as Poprawa in his article ‘Maintenance test flying – an accident waiting to happen.’[362] The prevalence of this heightened risk is therefore well documented, as are mitigatory countermeasures. However, it is necessary to interrogate this phenomenon to determine the reason for the heightened risk.

When the four case studies cited earlier in this chapter were analysed, it became evident the accidents were catalysed by two distinct factors: the failure of an aircraft component or system because of the preceding maintenance activity (maintenance error), and the flight crew’s incorrect management of the resultant malfunction, and unintended departure from the normal flight envelope. These causal factors share commonality with the two categories of ASRS report identified in the previous sub chapter.

Aircraft are maintained continuously throughout their operational life and do not undergo MCFs after every maintenance episode. Considering the acknowledgement in literature and Air Law of the ubiquity of human error during maintenance, we

[358] NASA, op cit n 354 Report ACN 1161766.
[359] Ibid Report ACN 825706.
[360] ‘EASA Notice of Proposed Amendment (NPA) 2012-08’, op cit n 30 at 9.
[361] ‘Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation’, op cit n 40.
[362] Poprawa, op cit n 1.

ponder whether the risk of maintenance error is higher during an MCF than during normal flight, or not.

An MCF is more likely to be required after heavy maintenance than after line maintenance. Heavy maintenance presents more opportunities for the commission of errors than line maintenance because of the significant quantum of tasks, and the number of maintenance personnel involved. Heavy maintenance activity also incorporates tasks on critical flight systems, such as control systems, which is not necessarily the case in line maintenance. Notwithstanding, very few flights which experience in-flight difficulties arising from maintenance error end in accidents, and most are recoverable using existing flight crew procedures and training.[363] This draws attention to the safety role played by the pilots during an MCF.

The NTSB cites two common contributory factors in non-revenue flight accidents: 'the flight crew's failure to adhere to standard operating procedures, and the flight crew's failure to operate the airplane within its performance limitations.'[364] The Perpignan Accident report identifies that the pilots were unfamiliar with the aim of certain manoeuvres required by the MCF programme because they had not received adequate training.[365] In a very similar theme, the AAIB report into the serious incident involving Boeing 737-73V G-EZJK identified that the commander lacked the depth of knowledge and understanding of a trained test pilot,[366] which contributed to his loss of aircraft control. The UKCAA suggests MCFs should be conducted by pilots with satisfactory experience using the check flight programme, after having received training in check flight techniques and safety precautions.'[367] It is imperative that an MCF pilot is equipped with the knowledge and skills necessary to prevent unintentionally departing from the flight envelope during MCF manoeuvres.

The role fulfilled by pilots in maintaining safety during MCFs is therefore critical. The pilots must fully understand the significance and intent of each functional check,

[363] Ibid at 783.
[364] Federal Aviation Administration, Safety Alert for Operators, op cit n 193.
[365] BEA, op cit n 9 at 98.
[366] Air Accidents Investigation Branch, op cit n 187 at 26.
[367] United Kingdom Civil Aviation Authority, op cit n 4 at 17.

the techniques to reduce the risk and methods to recover from an undesired aircraft state (UAS).[368] This understanding and knowledge may only be imparted via training and experience.

Historically, experience was a measurement of a pilot's logged flight hours, and it was accepted that a greater quantum of experience automatically enhanced safety. Nowadays, recognition is afforded to the quality of experience for the task at hand, and not simply the number of flight hours in a pilot's logbook.[369] Airbus's topical Safety First magazine article acknowledges the importance of task-specific experience in improving judgement, prioritisation, and risk evaluation during MCFs.[370]

The desirable experience quotient for an MCF pilot is achieved by combination of task-specific training, total flight experience and experience conducting MCFs.[371] Aircraft operators must adopt strategies to ensure the pilots performing MCFs possess the necessary knowledge, skills, and experience for the safe accomplishment of an MCF.

If MCF risk is analysed according to ICAO's safety management matrix which compares probability against severity, it will likely yield an intolerable risk level. The probability of a catastrophic MCF event is remote, as MCFs occur infrequently when compared to regular flight operations. However, the remoteness of probability is offset by the catastrophic severity of such an event, illustrated by the Perpignan Accident in which an airframe and seven lives were lost. ICAO states that intolerable risks are unacceptable,[372] yet Air Law is largely moot on this topic. This obliges safety-conscious stakeholders to develop their own MCF risk mitigation protocols in the absence of a regulatory framework.

[368] Ibid.
[369] Flight Safety Foundation 'Position Paper: Pilot training and competency'.
[370] Airbus, op cit n 33 at 014.
[371] Ibid at 011–4.
[372] ICAO, supra n 60 at 2–16.

3.13. Risk mitigation by stakeholders

The Functional Check Flight Symposium provided a platform for stakeholders to discuss protocols to mitigate MCF risks. It was emphasised that aircraft systems and components should only be checked in the air if they cannot be satisfactorily checked on the ground, to curb unnecessary MCFs.[373] Delegates from six international airlines explained how their organisations mitigate MCF risk using well-defined policies governing MCF pilot selection and training, as well as operational constraints with respect to procedures, weather, and daylight.[374] It must be noted that the EASA MCF Air Law had not been developed at the time, and these risk mitigation protocols were implemented at the behest of the airlines, not the regulatory authorities. This remains so for airlines operating outside of EASA jurisdiction.

In the absence of a rigid regulatory framework some operators' MCF protocols are evolutionary in nature, wherein procedures from previous experiences are simply reused because their past success or adapted because of past failure.[375] Some operators use a demonstration flight programme supplied by the OEM or lessor at the time of aircraft delivery, which may be outdated. Surprisingly, OEMs are unwilling to release MCF information without assurance that the resulting MCFs will be conducted by trained pilots,[376] thus reaffirming calls for Air Law to mandate MCF pilot training. Furthermore, some OEMs require a legal waiver to be signed by an operator prior to the release of any MCF information, stating that the user retains full responsibility for the use thereof, and all manufacturer reference should be removed from the document.[377] These constraints on the availability of information are not conducive to enhancing MCF safety, and prompted David Morgan's public request for more MCF information from OEMs at the Functional Check Flight Symposium.[378]

[373] Morgan, op cit n 205.
[374] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40.
[375] Morgan, op cit n 205.
[376] Burin, op cit n 168.
[377] Airbus, op cit n 33 at 018.
[378] Morgan, op cit n 205.

Airbus offers a manual called the In-Service Aircraft Technical Flight Manual (ISATFM) to support operators in the development of their own MCF manual. This document contains checks and manoeuvres which should only be flown by trained pilots.[379] The equivalent Boeing document is also intended for use by experienced pilots already trained in proper MCF techniques.[380] There is a presumption by OEMs that operators will ensure their MCF pilots are appropriately trained, which is not necessarily backed up by Air Law. Airbus offers a technical flight familiarisation course in which airline pilots are trained to safely conduct MCFs,[381] but enrolling pilots is costly to operators and not mandatory.

Pilot training and operational oversight for MCFs were historically poorly addressed at regulatory level until the implementation of the EASA MCF legislation in 2019. At the time of writing, they remain poorly addressed across other jurisdictions,[382] and responsibility for the safe conduct of MCFs is largely apportioned to operators who may find value in consulting freely available MCF media such as the Functional Check Flight (FCF) Compendium. [383]

The FCF Compendium contains generic information written by subject matter experts to reduce the risk of MCFs.[384] This Compendium describes how to plan an MCF, the recommended conditions of weather and light, crew preparation and roles throughout a check flight, generic system checks and protocols for management of undesired outcomes. The FCF Compendium owes its existence to the Flight Safety Foundation, an international body which champions flight safety,[385] which identified MCFs an area of concern.

The risk mitigation practices and protocols discussed in this section are fulfilled at the discretion of aircraft operators to improve MCF safety within their organisations, in line with their in-house safety management systems. These practices do not originate at regulatory level, and do not necessarily constitute an Air Law

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[379] Airbus, op cit n 33 at 018.
[380] Boeing, op cit n 119 at 3.
[381] Airbus, op cit n 33 at 014.
[382] Morgan, op cit n 205.
[383] 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 30 at 6.
[384] Flight Safety Foundation, op cit n 39 at 2.
[385] 'Flight Safety Foundation Website: About the Foundation', op cit n 26.

requirement. Despite this fact, some regulatory authorities are aware of the elevated risk associated with MCF operations and have consequently published guidance which may be used to manage this risk.

3.14. Risk mitigation by authorities

In response to two NTSB safety recommendations issued after the accident involving Douglas DC-8-63 N827AX,[386] the FAA published a document containing guidance on the safe conduct of non-revenue flights, Information for Operators (InFO) 08032 of 2008. This document, which is advisory and not regulatory, reminds stakeholders that non-revenue flight safety is the responsibility of the operators and pilots in command of aircraft.[387] The FAA reiterated this view during the consultative phase of the EASA MCF Air Law amendment process, stating that regulations are not required to manage MCF risk because operators' in-house safety protocols already fulfil this role.[388]

InFO 08032 recommends that operators should implement policies and procedures for the authorisation, control and conduct of non-revenue flights including pilot training.[389] The FAA recommends that non-revenue flight operations should be categorised in one of two groups premised upon the nature of the flight. Group one flights incorporate the use of normal procedures, which do not therefore require special pilot training or authorisation. Group two flights incorporate the use of emergency, alternate or abnormal procedures and should therefore require authorisation by the operator, as well as special pilot training.[390] These recommendations, although not regulatory are similar in nature to the EASA Air Law classification of MCFs using Level A and B nomenclature – which will be discussed in the next chapter.

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386 National Transportation Safety Board, op cit n 336 Safety Recommendations A-97-50 and A-97-52.
387 Federal Aviation Administration, Information for Operators 08032, op cit n 49.
388 'EASA Comment Response Document 2012-08', op cit n 69 at 51.
389 Supplement to Federal Aviation Administration, Information for Operators 08032, op cit n 49 at 2.
390 Supplement to ibid at 3.

Prior to the establishment of the EASA MCF Air Law, the United Kingdom Civil Aviation Authority published the *Check Flight Handbook.*[391] This publication is also non-regulatory but serves as a reference work for aircrew carrying out MCFs by describing practical techniques and recommended pilot experience. This document is intended to be used by experienced pilots who are trained in check flight procedures.[392]

Numerous sources cited in this chapter have referenced the requirement to train pilots to conduct MCFs, yet almost no information is available explaining how to practically do this. There is discontinuity between stakeholder expectation for MCF pilot training and operator implementation of MCF pilot training. This discontinuity may be attributable to the lack of Air Law governing MCF operations.

3.15. Conclusion

Aircraft maintenance is an elemental category of Air Law, intended to ensure aircraft airworthiness and safety in line with ICAO principles. Maintenance of aircraft remains a largely human-centric process, with numerous protocols which seek to minimise or trap human errors. Despite the existence of these protocols, human error remains ubiquitous in aircraft maintenance, and functional checks provide the last opportunity to detect and correct such errors before an aircraft returns to regular service.

MCFs are airborne functional checks which should only be performed when a system or component cannot be checked on the ground. Statistically MCFs carry more risk than regular flights, with several incidents and accidents having occurred during MCFs. This risk is attributable to latent maintenance error and improper application of in-flight procedures by pilots, with the latter seemingly causal in more accidents and incidents.

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[391] United Kingdom Civil Aviation Authority, op cit n 4.
[392] Ibid at 10.

MCF accident and incident investigation reports make several recommendations for amendments of Air Law seeking to reduce the likelihood of re-occurrence. Operational control and pilot training for non-revenue flights are salient in these recommendations. As a result, the FAA issued guidance on pilot training standards for non-revenue flights[393] whilst not addressing the subject at regulatory level, and EASA initiated a Rulemaking Task[394] to develop sui generis MCF Air Law. The next chapter will analyse the development and implementation of EASA's MCF Air Law.

[393] Federal Aviation Administration, Information for Operators 08032, op cit n 49 and Supplement.
[394] 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 30 RMT.0393.

CHAPTER 4: EASA MAINTENANCE CHECK FLIGHT LEGISLATION

4.1 Overview

The Perpignan Accident was a pivotal moment in the regulation of Maintenance Check Flight (MCF) in the EASA jurisdiction. Its importance lies in several safety recommendations published in the final accident report,[395] which triggered an EASA Air Law amendment process. This process commenced on 1 April 2011 with the establishment of EASA Rulemaking Task RMT.0393 seeking to amend MCF Air Law, and in-so-doing reduce the probability of future accidents and incidents.[396] The task was concluded on 24 July 2019 when Regulation (EU) 2019/1384 was published in the Official Journal of the European Union establishing the operational requirements for the conduct of MCFs.[397]

This chapter analyses the EASA MCF Air Law amendment process by first determining the applicable elements of Air Law which were in effect at the time of the Perpignan Accident (and prior to RMT.0393). Secondly, the MCF Air Law amendment process will be detailed from commencement to promulgation, with specific focus on the role played by industry stakeholders in the shaping of the final regulations. Thirdly, the resultant MCF Air Law enacted by the European Commission (and in effect at the time of writing) will be analysed to determine its role in the enhancement of MCF safety, and as a basis for comparative analysis against the South African MCF Air Law in the next chapter. Prior to examining the evolution of EASA MCF Air Law, it is necessary to understand the role played by EASA within the greater European Union (EU) legislative structure.

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[395] BEA 'Accident Report: Perpignan Accident During Maintenance Check Flight Final Report (English Translation)', 2010, at 99–100 available at: *https://bea.aero/docspa/2008/d-la081127.en/pdf/d-la081127.en.pdf,* accessed on 25 January 2022.

[396] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', 1 April 2011, available at: *https://www.easa.europa.eu/en/downloads/9494/en*, accessed on 14 October 2022.

[397] Regulation (EU) 2019/1384 of the European Commission.

4.2 The legislative role of EASA

The Treaty of Lisbon impacted the legal status of the EU by establishing a single legal personality for the region.[398] The European Commission (also referred to as the Commission) is at the epicentre of this legal personality and is the main administrative organ of the EU.[399] The Commission's primary roles are the proposal and implementation of legislation as well as to guard the founding treaties of the EU.[400] All regulations approved by the EU are published in the Official Journal of the European Union (OJ), which is the official gazette of record for the EU. An example of such a regulation affecting aviation is Regulation 300/2008 of the European Parliament and of the Council which establishes common rules to protect civil aviation against acts of unlawful interference that jeopardise the security of civil aviation.[401]

Considering the vast scope of the Commission, it has delegated certain administrative tasks to relatively independent, specialist bodies with the technical wherewithal to assist the Commission in fulfilling its greater mandate.[402] These bodies, also referred to as agencies, may be considered as 'specific components of the EU bureaucracy entrusted with various administrative and technical functions and tasks.'[403] The European Aviation Safety Agency (EASA) is one such agency which presides over matters of aviation and Air Law in the EU and European Free Trade Association.[404]

EASA was established in 2002 as the centrepiece of the EU's aviation safety system,[405] and is tasked with the drafting of aviation legislation and the provision of expert technical advice to the Commission in respect of Air Law.[406] EASA does not

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[398] Florin Coman-Kund *European Union Agencies as Global Actors: A Legal Study of the European Union Safety Agency, Frontex and Europol* (2018) at 60.
[399] Ibid at 17.
[400] Ruwantissa Abeyratne *Rulemaking in Air Transport: A Deconstructive Analysis* (2016) at 140.
[401] Regulation (EC) No 300/2008, OJ L 97/72 of 11 March 2008.
[402] Coman-Kund, op cit n 4 at 2.
[403] Ibid at 1.
[404] Regulation 1592/2002 of the European Parliament and Council.
[405] Coman-Kund, op cit n 4 at 126.
[406] Ibid.

formally regulate the aviation sector – this role is fulfilled by the Commission, which retains the formal regulatory powers. EASA's role is to provide technical input to the regulatory process driven by the Commission.[407] Additionally EASA's role is to maintain oversight of safety and regulatory compliance within member states,[408] while the member states retain a degree of legislative competence within their own sovereign legal systems.[409] Consequently, EASA has not sought ICAO membership despite being a participant in ICAO's work, and individual EASA member states possess ICAO membership in their own capacities.[410] EASA may therefore be referred to as a Regional Safety Oversight Organisation, while individual member states retain their own regulatory authorities.[411]

All EASA member states uniformly enforce the same Air Law under the oversight of EASA. This Air Law may be separated into components colloquially known as hard law, and soft law.[412] The hard law consists of regulations proposed by EASA and implemented by the Commission via publication in the OJ. The soft law consists of non-binding Acceptable Means of Compliance (AMC), Guidance Material (GM) and Certification Specifications (CS) which provide elaboration on how to achieve compliance with the regulations.[413] The soft law resides at EASA level and is approved by the Executive Director (ED) of EASA via an ED Decision.[414] The hard and soft law collectively constitute the EASA Air Law. For ease of reference, hard and corresponding soft law are published alongside each other in an *Easy Access* format, such as the Easy Access Rules for Air Operations which contains the MCF Air Law.

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[407] Regulation (EC) 216/2008 Article 18.
[408] Michael Pearson & Daniel Riley *Foundations of Aviation Law* (2015) at 324.
[409] Coman-Kund, op cit n 4 at 122.
[410] Paul Stephen Dempsey & Ram S Jakhu (eds) *Routledge Handbook of Public Aviation Law* (2017) at 30.
[411] Ibid at 76.
[412] Ronald IC Bartsch *International Aviation Law: A Practical Guide* 2nd edition (2018) at 68.
[413] EASA Management Board Decision Number 18-2015 15 December 2015, Article 2.
[414] Coman-Kund, op cit n 4 at 130.

4.3 MCF Air Law in effect on 27 November 2008

On this, the date of the Perpignan Accident, dedicated EASA MCF Law did not exist and MCFs were broadly categorised as non-revenue flights.[415] Despite the absence of specific MCF Air Law, these flights were required by maintenance regulations for the assurance of continued airworthiness.[416] MCFs were performed under the provisions of Commission Regulation (EC) 859/2008,[417] simply stating that non-revenue flights must be undertaken in compliance with the company operations manual defining the relevant procedures and limitations.[418] The crux of the matter is all protocols for the safe conduct of MCFs were left to operators to develop and implement in the absence of comprehensive regulatory guidance.

Let us first review the bare facts. All preparation for the ill-fated flight which was to become the Perpignan Accident occurred via email correspondence, during which the flight was referred to as a *check / acceptance flight* and thereafter a *ferry / training flight*, not an MCF. This ambiguity created confusion as to the exact nature of the flight.[419] The pilots had not undergone any specific MCF training yet decided to follow a flight programme developed for pilots trained in test flights, which led them to undertake potentially dangerous manoeuvres without an understanding of their aim or risk.[420] The captain's only prior experience with MCF was as an observer of a previous flight two and a half years prior. According to the accident report the flight was conducted without a well-defined framework, which required the crew to improvise to complete the task.[421] The accident report does not shy away from errors which were committed by the pilots but draws greater attention to the regulatory environment which enabled the commission of these errors.

The accident report therefore marked a sharp tempo in EASA's own regulatory work: faced with the Perpignan Accident the BEA did not shy away from issuing

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415 Commission Regulation (EC) 859/2008 Appendix 1 to OPS.1.1045.
416 Commission Regulation (EC) 2042/2003 Annex I (Part M) M.A.301.
417 Commission Regulation (EC) 859/2008.
418 Ibid OPS 1.1045 (a).
419 BEA, op cit n 1 at 83.
420 Ibid at 98.
421 Ibid.

safety recommendations to EASA. It called for an amendment of Air Law to mandate the precise description of non-revenue flights including their preparation, operational framework and training and qualification of pilots.[422] EASA acknowledged receipt of this recommendation on 6 July 2009,[423] and thereafter cited the Perpignan Accident as motivation for the amendment of MCF Air Law in its Rulemaking Task RMT.0393 on 1 April 2011.[424]

4.4 EASA rulemaking programme

The EASA rulemaking programme originates in the *Basic Regulation*, which is the compilation of general regulations on the common rules of aviation as well the regulation which establishes EASA.[425] Article 115 describes the procedures for the development of Air Law,[426] the co-called rulemaking programme. EASA's role in the rulemaking programme is to draft opinions on the scope and content of proposed regulations, which are considered by the Commission in the implementation of hard law. [427] EASA also publishes corresponding soft law to provide guidance on achieving compliance with regulations. Almost all EASA documentation is published in English, as this is the 'globally acknowledged working and vehicular language in the field of international aviation.'[428] Regulations gazetted in the OJ are published in the 24 official languages of the EU.[429]

The EASA rulemaking programme is required by law to draw on the expertise imbedded within the aviation community, and to consult all EASA member states in the process.[430] This rulemaking programme is established by the Executive Director of EASA, with the objective of harmonising and improving the quality of

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[422] Ibid at 99.
[423] Ibid at 100.
[424] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 2.
[425] Regulation (EU) 2018/1139 of the European Parliament and of the Council and subsequent amendments in the Official Journal of the EU.
[426] Ibid Article 115.
[427] EASA Management Board Decision Number 18-2015 15 December 2015, Article 2.
[428] 'EASA Language Policy', available at: *https://www.easa.europa.eu/en/easas-language-policy*, accessed on 17 May 2023.
[429] This research refers to official documentation published in English.
[430] Regulation (EU) 2018/1139 of the European Parliament and of the Council Article 115.

regulations.[431] Notably the rulemaking programme is empowered to 'consider the results of air accident investigations in so far as they relate to aviation safety'[432] as was done by considering the Perpignan Accident report in the Rulemaking Task RMT.0393. The changes in Air Law affected by the rulemaking programme are expected to increase aviation safety whilst ensuring continued alignment with ICAO SARPS.[433]

A rulemaking programme has three main components: a driving need for the amendment of rules, a strategic objective, and a timeline.[434] The rulemaking programme is initiated via the publishing of a Terms of Reference document which describes the three components listed above.[435] Terms of Reference MDM.0.97(a) and (b) established Rulemaking Task RMT.0393 seeking to amend the EASA Air Law on MCF via the introduction of a new section into existing Air Law governing Specialised Operations (Part-SPO).[436]

4.5 Terms of Reference and Notice of Proposed Amendment

The Perpignan Accident and serious incident involving Boeing 737-73V G-EZJK are cited as motivation for the amendment of MCF Air Law.[437] It should be recalled that both the Perpignan Accident and G-EZJK investigation reports make recommendations to EASA for the amendment of applicable Air Law. The Terms of Reference acknowledges that MCFs are non-revenue flights required for continuing airworthiness,[438] whilst admitting that Air Law does not contain specific requirements regarding MCFs. Consequently, non-uniform MCF practices exist among stakeholders which, according to EASA, represents a safety gap. These variances in MCF practices are contrary to ICAO's stated objective in Article 37 of

[431] EASA Management Board Decision Number 18-2015 15 December 2015, Article 3.
[432] Ibid Article 3.
[433] EASA Explanatory Note to Decision 2019/019/R.
[434] Abeyratne, op cit n 6 at 136.
[435] Ibid Article 4.
[436] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 2.
[437] Ibid.
[438] Commission Regulation (EC) 2042/2003 Annex I (Part M) M.A.301.

the Chicago Convention: uniformity of rules. This rulemaking task intended to harmonise MCF rules, and in so doing address the safety gap identified by EASA.[439]

The objectives of the rulemaking task were the establishment of law to help determine when an MCF should be performed and the protocols and responsibilities which relate thereto; to provide pilot training and competence criteria for MCFs; and in so doing to reduce the probability of future MCF accidents or incidents.[440] A working group of experts was assembled to drive the process, with a proposed timeline yielding a decision within approximately twenty-four months. The first step after establishing the rulemaking task was to draft the proposed Air Law and present it to stakeholders in a Notice of Proposed Amendment (NPA) document.

NPA 2012-08 was published by EASA on 30 July 2012 containing the draft regulations, Acceptable Means of Compliance and Guidance Material concerning MCFs. This NPA cites the UKCAA's Check Flight Handbook[441] and the Flight Safety Foundation's Functional Check Flight Compendium[442] as reference material used in support of this rulemaking task.[443] Lawmakers proposed that the Commission Regulation on Air Operations (which was itself still in draft form at the time) should identify MCF as a Specialised Operation within Part-SPO, a subpart of the regulations dealing with non-commercial aircraft operations of a specialised nature.[444] This would fulfil the so-called *hard law* element, while the proposed *soft law* would contain the Acceptable Means of Compliance outlining the contents of an MCF manual and pilot qualification and training requirements. Further proposed soft law included Guidance Material containing recommended MCF safety protocols, and guidance on the airworthiness status of an aircraft prior to undergoing an MCF.[445] A salient component of the proposed MCF Air Law was the differentiation between Level A and Level B MCFs, premised on their complexity and resultant risk

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439 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 2.
440 Ibid.
441 United Kingdom Civil Aviation Authority *Check Flight Handbook CAP 1038* (2017).
442 Flight Safety Foundation *Functional Check Flight Compendium - Introduction* (2011) available at*: https://skybrary.aero/sites/default/files/bookshelf/2473.pdf,* accessed on 14 January 2022.
443 'EASA Notice of Proposed Amendment (NPA) 2012-08', 30 July 2012, available at: *https://www.easa.europa.eu/en/downloads/584/en*, accessed on 14 October 2022.
444 Regulation (EU) 2019/1384 of the European Commission Article 2 - Definitions.
445 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 47.

level. Level A MCF's were initially intended by EASA to incorporate the use of standard operating procedures while Level B MCFs were 'other than Level A MCFs',[446] implying the use of non-standard operating procedures. Only the Level B MCF's would be subject to exacting provisions, including advanced pilot training. For clarity it should be noted that EASA subsequently amended the definitions of Level A and B MCFs, as explained in 4.6 below.

The NPA contained a Regulatory Impact Assessment (RIA) evaluating the effect the proposed Air Law would exert on the aviation sector. The RIA identified gaps in the present regulatory framework including the absence of specific MCF procedures, the inconsistent application of published guidance material and the assumption of a consequent higher accident ratio for MCFs.[447] The NPA did not introduce new requirements specifying when MCFs are required, and therefore did not envision an increase in the number of annual MCFs thus not burdening operators with additional costs. However, the NPA did acknowledge that MCF pilot training requirements would bear a cost for operators, albeit with a relatively low economic impact. The RIA stated that no conflict would exist with any ICAO SARPS as MCF was (and still is) not addressed at ICAO level.[448]

The NPA thereafter presented the proposed MCF Air Law, including relevant draft Commission Regulations, Acceptable Means of Compliance and Guidance Material alongside an invitation for affected stakeholders to submit comments to EASA within three months.

4.6 Stakeholder comments

Comment Response Document (CRD) 2012-08 was released on 10 October 2013 addressing comments received on the proposed implementation of MCF Air Law. This document contained three hundred and sixty-two comments submitted by

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[446] Ibid Draft Opinion.
[447] Ibid.
[448] Ibid Part V: Regulatory Impact Assessment.

stakeholders as well as EASA's responses thereto, which assisted the working group in their development of agreeable MCF Air Law.[449]

Majority of the comments were submitted by aircraft operators, including some seventy comments from the general aviation sector. The term general aviation refers to non-commercial aircraft operation,[450] most often involving non-complex aircraft[451] for private, recreational, or air-sport purposes. These stakeholders expressed concern about possible over regulation of their operations by the proposed MCF Air Law, with an associated increase in costs.[452] They also argued that compliance with the proposed regulations would, in some cases, be impossible in their aircraft types. For instance, the carriage of a task specialist is impossible in a single seat aircraft. This group requested EASA to revisit the proportionality of the proposed Air Law as it appeared to be aimed at operators of complex aircraft. They believed a set of blanket regulations governing MCF was not enforceable at all levels, and therefore requested EASA to exempt operators of non-commercial and non-complex aircraft from the proposed MCF Air Law.

As a result of these objections, and far from dismissing the concerns of this group, EASA amended its proposed MCF regulations. The amended regulations completely excluded European Light Aircraft (ELA)[453] from applicability, while less stringent provisions were introduced for the operators of non-complex aircraft. EASA also used the CRD to amend the definitions of Level A and B MCFs with a view to brevity and clarity. Amended Level A MCFs incorporate the use of abnormal or emergency procedures to prove the functionality of a backup system, while Level B MCFs are those other than Level A MCFs,[454] applying to both aeroplanes and helicopters.

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[449] 'EASA Comment Response Document 2012-08', available at: *https://www.easa.europa.eu/en/downloads/16489/en*, accessed on 14 October 2022.

[450] ICAO *Annex 6: Operation of Aircraft Part II* 10 ed (2018) at 1.1-4.

[451] A complex motor-powered aircraft is defined by Regulation (EC) 216/2008 Article 3 as weighing more than 5700kg, carrying more than 19 passengers, possessing a jet engine or more than two turbo-propeller engines.

[452] 'EASA Comment Response Document 2012-08', op cit n 53.

[453] ELA are defined in Commission Regulation 748/2012 to be non-complex motor-powered aircraft with a mass of 2000kg or less, which means a small aircraft not containing a jet engine more than one turbo-propeller engine.

[454] 'EASA Comment Response Document 2012-08', op cit n 53 at 6 Footnote 6.

Several helicopter operators expressed concern that the proposed MCF Air Law would be onerous in its application to offshore operations. They also emphasised that no helicopter accidents were used as justification for the RMT, and thus requested an exemption unless accident data could reveal a need for MCF Air Law applicable to helicopters. EASA referred these operators to the amended definition of Level A and B MCFs which allow more helicopter MCFs to be classified as Level B, with resultant less onerous requirements.[455]

The process of integration of the new Air Law was questioned by some business aviation operators, with a request for the issuance of grandfather rights in lieu of compulsory training for pilots. EASA indicated that pilots with prior experience in Level A MCFs would not be required to attend the MCF training course required by regulation, but the flight hour experience requirement would remain unaltered.[456]

The placement of the MCF Air Law within Part-SPO (Specialised Operations) was questioned by some commercial transport operators because Part-SPO does not ordinarily apply to them, and the inclusion of MCF in Part-SPO would create administrative complexity. These operators further indicated that Part-SPO is often less exacting than Part-ORO (the part governing commercial operations) and performing MCFs under Part-SPO could result in the application of less stringent operational criteria than desired. Non-commercial operators expressed similar concern, questioning whether they would forthwith need to seek EASA Part-SPO approval prior to conducting an MCF. EASA cited the need to apply the most stringent legal principles, whether Part-ORO or Part-SPO, and that non-commercial operators are not required to obtain Part-SPO approval for MCFs. EASA's stance was that placement of MCF within Part-SPO ensures proportionality of rule, with generally less strict provisions for commercial operators and more stringent provisions for non-commercial operators.[457]

The United States aviation regulator, the FAA, submitted a comment disagreeing with the need for MCF Air Law. The FAA's position was that the risk of MCF's did

[455] Ibid.
[456] Ibid at 8.
[457] Ibid at 10.

not require regulatory control, as this risk was mitigated by operators' in-house safety assurance programs.[458] Presentations by US based American Airlines and United Airlines at the Functional Check Flight Symposium confirmed this, as both operators described tightly controlled in-company MCF practices.[459] However, it cannot be presumed that all operators employ similar MCF practices in the pursuit of safety when not legally required to do so. Light aircraft manufacturer Diamond pointed out that this rulemaking task was premised upon one accident (the Perpignan Accident) and questioned whether this presented sufficient ground to commence a rulemaking task. Diamond felt that discrepancies within existing regulations and lapses of airmanship caused the Perpignan Accident, and the application of additional regulations would have a negligible effect on safety while creating additional administration and costs.[460] This view is in opposition to EASA's regulatory impact assessment, which considered several serious MCF incidents and was catalysed by the safety recommendations contained in the Perpignan Accident report.

EASA's MCF review group considered all comments, and where appropriate amended the proposed MCF Air Law to establish a workable set of hard and soft laws, with the resulting rule text published in Chapter 3 of the Comment Response Document.[461] EASA issued a further invitation for comments by stakeholders prior to submitting the final regulatory proposal to the Commission.

4.7 Promulgation of amended MCF Air Law

On 7 March 2017 EASA submitted Opinion 01/2017 to the Commission containing the draft MCF regulations, Acceptable Means of Compliance and Guidance Material as the basis for the preparation of an EU Regulation. This document proposed an MCF pilot training syllabus and general safety protocols while differentiating between MCFs on complex aircraft and non-complex aircraft.[462] The proposal

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[458] Ibid at 51.
[459] 'Functional Check Flight (FCF) Symposium Presentations - Flight Safety Foundation', op cit n 40: American Airlines and United Airlines.
[460] Ibid at 33.
[461] 'EASA Comment Response Document 2012-08', op cit n 53 Chapter 3.
[462] EASA Opinion No 01/2017 Executive summary.

sought amendment of Regulation (EU) 965/2012 governing air operations to address the issue of MCF safety identified in the Terms of Reference.

EASA acknowledged how input from general aviation stakeholders influenced the final proposal, specifically the introduction of less stringent requirements for MCFs on non-complex aircraft.[463] EASA considered this approach to be balanced, as the requirements are proportional to the complexity of the aircraft on which the MCF is intended. This approach intended to regulate MCFs on complex aircraft, such as the Airbus A320-232 involved in the Perpignan Accident to a degree which measurably enhances safety whilst not over burdening operators of small private aircraft with impractical regulatory requirements.

The Commission considered and adopted EASA's proposal as Implementing Regulation (EU) 2019/1384 of 24 July 2019 in the Official Journal (OJ) of the EU.[464] This regulation entered into force on the twentieth day following publication in the OJ, and became binding upon all EU Member States, and those under EASA jurisdiction.[465] The regulation includes MCF as a Specialised Operation within Part-SPO,[466] defines Level A and B MCFs, specifies the requirement for operators to develop an MCF manual of procedures and to provide pilot training.[467] Furthermore, allowance is made for the recognition of prior experience held by pilots having conducted Level A MCFs prior to 20 August 2019. Specifically, such pilots are not required to undergo the MCF training required by regulation but must be briefed on any procedural differences which have arisen from the implementation of Regulation 2019/1384.[468] The adoption of this regulation by the EC fulfilled the *hard law* requirement of MCF, which enabled EASA to proceed with the formalisation of the corresponding *soft law*.

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[463] Ibid at 9.
[464] Regulation (EU) 2019/1384 of the European Commission L228 of the Official Journal of the European Union dated 9th of April 2019.
[465] Annex to EASA Opinion No 01/2017 Article 7.
[466] The Official Journal of the European Union L228 9 September 2019, at 107.
[467] Ibid at 137–9.
[468] Ibid at 108.

EASA's Executive Director Decision 2019/019/R of 16 September 2019 legitimises the Guidance Material (GM) and Acceptable Means of Compliance (AMC) regarding MCF,[469] pursuant to Commission Regulation (EU) 2019/1384. The soft law specifies the pilot training syllabus and the required contents of the MCF manual of procedures. The hard and soft laws are collectively published in the Easy Access Rules for Air Operators[470] and constitute the EASA MCF Air Law in existence at the time of writing.

4.8 General provisions of EASA MCF Air Law

EASA rulemaking task RMT.0393's stated objective was the establishment of minimum requirements to be met when conducting MCFs, thereby addressing the safety gap identified in the Terms of Reference.[471] The MCF provisions reside within the greater body of Air Law governing air operations, which lays down the technical requirements and administrative procedures for the commercial and non-commercial operation of aircraft. [472] MCF falls under the ambit of a part of the Air Law dedicated to Specialised Operations, Part-SPO. A Specialised Operation is any operation other than a commercial operation where an aircraft is used for a specialised activity such as agriculture, construction, photography, surveying, observation and patrol, aerial advertisement or MCF.[473]

Although MCFs are required by aircraft maintenance Air Law[474] they are carried out under the control and responsibility of aircraft operators.[475] This explains why the MCF provisions reside in the Air Law governing aircraft operations, and not the Air Law governing aircraft maintenance. Interestingly, pilot training for MCFs is an operator requirement not a licensing requirement. Thus, no MCF provisions are found in the EASA Air Law governing flight crew licensing, Part-FCL. Part-SPO

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[469] EASA Executive Director Decision 2019/019/R 16 September 2019.
[470] EASA Easy Access Rules for Air Operators October 2019.
[471] EASA Opinion No 01/2017 at 5.
[472] Commission Regulation (EU) 965/2012.
[473] EASA Easy Access Rules for Air Operators October 2019, at Article 2-Definitions.
[474] EASA Annex 1 (Part M) to Regulation (EU) No 1321/2014 (''Annex 1 (Part M) to Regulation (EU) No 1321/2014'') M.A.301.
[475] Ibid.

therefore contains all MCF provisions, the most foundational of which is the differentiation between MCF levels.

4.9 Levels of MCF

Air Law classifies MCFs either Level A or B depending on the in-flight procedures which are required. Level A MCFs incorporate the use of abnormal or emergency procedures to verify the correct functioning of a backup system which would not operate under normal conditions.[476] Level B MCFs are those other than Level A MCFs, which implies the exclusive use of normal procedures. Via way of example, an MCF involving an Elevator Power Off Test in a Boeing 737 is classifiable as Level A because this check requires the use of an abnormal procedure.[477] Whereas an MCF which seeks to determine if an aircraft's automatic landing system is functioning correctly does not involve the use of abnormal or emergency procedures, and is classifiable as a Level B. Importantly, Level A MCFs are more technically complex than Level B MCFs and therefore possess more stringent Air Law requirements.

Level A MCFs on complex motor-powered aircraft require the development of a flight programme by the operator,[478] which Air Law recommends being based upon the Flight Safety Foundation's Functional Check Flight Compendium.[479] An operator intending to perform a Level A MCF shall develop a comprehensive MCF manual containing, inter alia, policies, aircraft status requirements, crew selection, minimum weather conditions and procedures for the recording of results.[480] The pilot in command of a Level A MCF must possess at least 1000 hours of flight experience on similar aircraft to the one requiring the MCF, and to have attended a training course consisting of theoretical and practical elements trained in a flight simulator or on a real aircraft.[481] If the aircraft configuration allows, a task specialist

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[476] EASA Easy Access Rules for Air Operators October 2019, SPO.SPEC.MCF.100.
[477] Boeing 737-600/700/800/900 Aircraft Maintenance Manual Task 27-31-00-710-803 of the Candidate's Personal Library, 15 February 2018.
[478] EASA Easy Access Rules for Air Operators October 2019, SPO.SPEC.MCF.105.
[479] Flight Safety Foundation, op cit n 46.
[480] EASA Easy Access Rules for Air Operators October 2019, at AMC1 SPO.SPEC.MCF.110.
[481] EASA Easy Access Rules for Air Operators October 2019, SPO.SPEC.MCF.120.

is required on board Level A MCFs to provide technical assistance to the pilots, and to record results.[482] The task specialist is considered an essential member of the MCF crew.

Air Law stipulates the carriage of essential personnel during MCFs,[483] meaning no passengers may be carried. The reason for this is not stated in law but is understood to expose a minimum number of people to elevated risk.[484] With the exception of the requirement to carry essential personnel, Level B MCFs share none of the other prescriptions of Level A MCFs. Thus, one may deduce that Level A MCF's possess an intrinsically higher quantum of risk than Level B MCFs which the Air Law seeks to mitigate.

4.10 Applicability of MCF Air Law

MCFs involving complex motor-powered aircraft engaged in commercial operations are conducted under the stringent Air Law provisions of Part-SPO described in paragraph 4.8. However, MCF operations involving non-complex motor-powered aircraft which are not engaged in commercial activity are conducted under the ambit of Part-NCO, the Air Law governing non-commercial operations.[485] The Part-NCO MCF requirements are significantly less exacting than the Part-SPO requirements. Part-NCO does not require the development of an MCF manual and flight programme, and there is no minimum pilot experience or MCF training requirement.[486]

The provisions of Part-NCO unburden general aviation operators from onerous and impractical MCF requirements, whilst tightly regulating MCF operations on complex aircraft types, such as the Airbus A320-232 involved in the Perpignan Accident and the Boeing 737-73V G-EZJK involved in the serious loss of control incident.

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482 Ibid SPO.SPEC.MCF.125.
483 Ibid GM1 SPO.SPEC.MCF.125.
484 Flight Safety Foundation, op cit n 46 at 9.
485 EASA Easy Access Rules for Air Operators October 2019, Article 5.
486 Ibid NCO.SPEC.MCF.125.

4.11 Impact of amended MCF Air Law

The Perpignan Accident drew considerable attention to MCF operations, and the subsequent years gave rise to numerous fora which discussed and deliberated on MCF safety, such as the Functional Check Flight Symposium. It is during this period that rulemaking task RMT.0393 proceeded, which drew further attention to MCF safety. Following the implementation of the EASA MCF Air Law in 2019, all operators of complex motor-powered aircraft under EASA jurisdiction are required to comply with the applicable MCF Air Law provisions. The EASA Annual Safety Review for the year 2022 contains statistical data on accidents and incidents for the period 2011 to 2021,[487] which is the period under discussion. During the years 2011-2021 sixty-three fatal accidents and seventy-nine serious incidents occurred during Specialised Operations, under the ambit of Part-SPO.[488] However, not one of these occurred during an MCF. This statistical data, albeit of low fidelity, hints at the possibility of a reduced MCF accident and incident rate since the Perpignan Accident, and during the time of RMT.0393. Further evidence is required over the forthcoming period to determine if this hypothesis holds true or not.

4.12 Conclusion

The EASA Air Law governing MCF operations is, at the time of writing, the most comprehensive MCF Air Law in any civilian aviation legal system. This exacting Air Law owes its origin to the Perpignan Accident which destroyed an Airbus A320-232 and claimed the lives of seven crew members. The resultant safety recommendations made by the BEA alongside similar recommendations by the AAIB following a serious incident on a Boeing 737-73V were considered by EASA as the basis for a rulemaking task to establish a regulatory framework to better govern MCFs.

This rulemaking task, RMT.0393 proceeded from April 2011 through July 2019, and incorporated significant stakeholder participation from within the EASA

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[487] *EASA Annual Safety Review* (2022) available at: *https://www.easa.europa.eu/en/document-library/general-publications/annual-safety-review-2022.*
[488] Ibid at 53.

aviation community to draft an agreeable body of MCF Air Law. EASA addressed a burgeoning concern of possible overregulation of MCF operations for general aviation aircraft by exempting non-complex motor-powered aircraft from such stringent MCF Air Law provisions. General aviation MCFs are conducted under the less stringent Part-NCO, while commercial aviation MCFs are conducted under the exacting Part-SPO. The Part-SPO requirements for a Level A MCF are notably more exacting than for a Level B MCF, because the use of unconventional procedures during Level A MCFs introduces elevated risk which Air Law seeks to mitigate.

EASA's MCF Air Law consists of Regulations, Acceptable Means of Compliance and Guidance Material which will be comparatively analysed against the corresponding South African MCF Air Law in the next chapter.

CHAPTER 5: SOUTH AFRICAN MAINTENANCE CHECK FLIGHT LEGISLATION

5.1 Overview

In South African Air Law, the term "Post Maintenance Test Flight" (PMTF) is used to describe a Maintenance Check Flight (MCF). Despite the salient differences between test flight and check flight as explained in the first Chapter, South African Air Law universally refers to both activities as test flights. The objective of this Chapter is to extract and analyse the excerpts of test flight legislation which apply to MCF in South Africa, and to determine how these principles are applied by aircraft operators and owners.

An aircraft operator is a natural or artificial entity holding necessary authorisation to conduct scheduled and non-scheduled air services for reward, such as an airline or air charter organisation; while an owner is the person in whose name the aircraft is registered.[489] Aircraft owners who fly their aircraft for private use typically conduct their own MCFs, while operators' MCFs are performed by pilots in the employ of the operator. All MCFs are conducted in compliance with the Civil Aviation Regulations (CARS) and presided over by the South African Civil Aviation Authority (SACAA).

5.2 The legislative role of the SACAA

The SACAA is empowered by the Civil Aviation Act of 2009 to control, regulate and promote aviation safety and security, oversee the functioning and development of civil aviation, develop regulations, and ensure compliance with the Act and the Chicago Convention.[490] Specifically, the Minister of Transport has the authority to develop aviation regulations[491] and appoints a Director of Civil Aviation to lead the SACAA[492] and oversee the implementation and enforcement of Air Law in South

[489] CAR 1.01.1 For brevity's, I refer to a regulation within the South African Civil Aviation Regulations (2011) as CAR followed by the regulation number.
[490] Civil Aviation Act of 2009 Chapter 6 section 72.
[491] Ibid section 155.
[492] Philippe-Joseph Salazar *Air Law* (2019) at 13.

Africa. The South African Air Law consists of Civil Aviation Regulations (CARS) which are promulgated via publishment in the Government Gazette, and corresponding Civil Aviation Technical Standards (CATS) issued by the Director of Civil Aviation.[493] The CATS and CARS governing test flight trace their origin to a repealed body of Air Law, the Air Navigation Regulations of 1976.

5.3 Origin of test flight in Air Law

The Air Navigation Regulations (ANRS) of 1976[494] state that a test flight shall be carried out for one of two purposes: for issuing or rendering effective a Certificate of Airworthiness (CoA), or after any major modification to an aircraft.[495] A test flight proves airworthiness to the SACAA by demonstrating that the aircraft conforms to its original type certificate while being in a condition for safe operation.[496] This demonstration may be required to obtain an initial CoA when a new airframe is imported, or following the revocation of a CoA by the SACAA, or after a post-production modification. The ANRs were amended in 1995 to include, for the first time, reference to pilot qualifications to conduct test flights.

Two classes of test pilot rating were inserted into the ANRs permitting the holder to act as pilot-in-command of prototype aircraft engaged in experimental test flying.[497] A class two test pilot rating restricted these privileges to aircraft with a maximum mass of 2700kg or less, while a class one test pilot rating did not bear a mass restriction.[498] An applicant for a class two test pilot rating was required to satisfy the Commissioner of Civil Aviation (now called the Director) that he possessed adequate knowledge of test flying techniques while a class one applicant was required to have successfully completed a recognised test pilot's course.[499] Aeronautical Information Circular (AIC) 30.6 provided an explanation of the rather

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[493] Civil Aviation Act of 2009 section 162(2).

[494] Air Navigation Regulations, 1976 Government Gazette 2273 GN 141 and Subsequent Gazetted Amendments (Repealed) 30 January 1976.

[495] Ibid15.9.

[496] ICAO *Annex 8: Airworthiness of Aircraft* 12 ed (2018) at I–1.

[497] Thirty First Amendment of the Air Navigation Regulations, 1976 Government Gazette 16807 GN 1747(Repealed) 10 November 1995, Regulation 2.34.

[498] Ibid.

[499] Ibid Regulation 3.16D.

vague requirement to satisfy the Commissioner of possession of adequate knowledge of test flying techniques. It was stated that 'a written recommendation to that effect from a qualified Test Pilot class one will constitute compliance with this requirement.'[500] This AIC was withdrawn in 1997 when the ANRs were repealed. These test pilot ratings bear little applicability to MCF or any post maintenance flight activity, but were carried over to the first iteration of the CARS, the Civil Aviation Regulations 1997 which superseded the ANRs.[501] The CARS 1997 make provision for class one and two test pilot ratings as well as for a "post maintenance test flight rating."[502] The specifics of these ratings were never developed in law, thus they existed in name only until the promulgation of the CARS 2011,[503] the regulations which are in effect at the time of writing

5.4 Test flight Air Law

The CARS 2011 define several similar sounding yet practically different test flight activities: "experimental / prototype test flight, initial test flight, import test flight, maintenance test flight, test flight, post maintenance test flight (PMTF)", and "systems acceptance flight". "Experimental" and "prototype" are dealt with as a single yet somewhat compound lexical unit, using a forward slash sign. One may ask: are "prototype" and "experimental" identical, and how do they differ from other test flight activities? The following paragraphs will contextualise these various types of test flight according to their definition and applicability.

"Experimental test flights" investigate the airborne properties of new and untested aircraft, components, or postproduction modifications. They are conducted to either determine or expand the flight envelope[504] with the view to eventual certification by a regulatory authority. When experimental test flights are conducted on the first

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[500] Aeronautical Information Circular 30.6 (Withdrawn) of the Candidate's Personal Library 15 September 2002.
[501] Civil Aviation Regulations 1997, Government Gazette 18286 GN 1219 of 26 September 1997, and Subsequent Gazetted Amendments.
[502] Ibid Subparts 27-29.
[503] South African Civil Aviation Regulations, 2011 Government Gazette GN 35398 GN 425 of 1 June 2012 and Subsequent Gazetted Amendments.
[504] Corda, op cit n 46 at 162.

example of a newly designed aircraft, this aircraft is said to be the prototype.[505] The Oxford English Dictionary defines a prototype as 'the first or primary…; an original on which something is modelled or from which it is derived.'[506] A manufacturer will use data gathered during test flights of the prototype to improve the design of subsequent airframes as the design proceeds toward certification.

When a certified aircraft is modified by the installation of new and untested equipment, experimental test flights investigate the properties of this new equipment. In this instance the aircraft serves as a testbed since the equipment is under scrutiny not the aircraft itself. The first test flight within a greater test flight campaign is called the "initial test flight."[507] Experimental, prototype and initial test flights involve new designs, which lie beyond the purview of this writing.

"Test flight" on the other hand does involve a new design and is defined as 'flight for the purpose of issuing, validating or rendering effective a certificate of airworthiness for an [already certified] aircraft.'[508] Test flight incorporates the terms "import test flight" and "maintenance test flight." An import test flight is required to validate a CoA issued by the regulatory authority of another state[509] while a maintenance test flight is required to validate a CoA previously issued by the SACAA.[510] A test flight is also required after a major repair or modification prior to reissuance of the CoA.[511]

A major repair or modification may appreciably affect weight, balance, structural strength, performance, powerplant operation or flight characteristics of an aircraft; or incorporates the use of unconventional maintenance practices.[512] Major repairs are associated with accidents.[513] The scope for modifications to a type certified aircraft is limited, as a modification risks altering the aircraft's inherent characteristics which

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505 CAR 1.01.1.
506 *Oxford English Dictionary [Online], accessed via UCT credentials* on 19 May 2023.
507 CAR 1.01.1.
508 Ibid.
509 Ibid.
510 CAR 1.01.1.
511 CAR 43.02.16.
512 CAR 1.01.1.
513 Ibid.

will invalidate the CoA. In this case, a Supplemental Type Certificate (STC) may be awarded by the SACAA to an organisation who does not hold a type certificate, authorising the alteration of an aircraft component by 'introducing a major change in the type design which is not great enough to require a new application for a type certificate.'[514] SACAA may require a test flight to be performed during the STC approval process, but this is not always the case.

Import and maintenance test flights demonstrate to the SACAA that an aircraft is safe to fly[515] and that it complies with its type certificate or STC, thereby confirming its airworthiness status. A test flight is not mandatory in all applications for a CoA and will be a point of discussion between the SACAA and the applicant.[516] Import and maintenance test flights support the CoA and should not be confused with a "post maintenance test flight" (PMTF) which verifies system functionality after maintenance in support of the certificate of release to service; and is of particular significance to this writing.

A PMTF is 'a flight for the purposes of investigative test flying to confirm the release to service following regular maintenance.'[517] *Regular* is understood to mean *scheduled* within the aircraft maintenance program. An aircraft is released to service by the issuance of a Certificate of Release to Service (CRS) after scheduled maintenance, or after the completion of an appropriate entry in the aircraft logbook after line maintenance,[518] colloquially referred to as the aircraft being 'signed out'. The objective of a PMTF is to assess flight characteristics and performance by performing in-flight functional checks after the completion of maintenance tasks.[519] A pilot conducting a PMTF must assess whether a component or system which has been maintained is functioning correctly or not. For example, if maintenance was performed on the flap system, the flaps should be checked during the PMTF. Certain manufacturers of complex aircraft provide specific procedures for PMTFs,

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[514] CAR 1.01.1.
[515] SACAA 'Guidance Material for Airworthiness Inspectors: Issuance of a Certificate of Airworthiness' at 16.
[516] Ibid at 7.
[517] CAR 1.01.1.
[518] Ibid.
[519] CATS 43.02.16 (1).

which Air Law recommends the use of.[520] A complex aircraft is distinguished by its retractable landing gear, constant speed propeller and adjustable flaps.[521] If no PMTF procedures are provided by a manufacturer, the pilot and maintenance personnel must determine the procedures needed for in-flight functional checking.

The principle of functional checking is repeated in the definition of "systems acceptance flight," which tests the operation or functioning of an aircraft system not affecting flight characteristics.[522] A PMTF and systems acceptance flight are thus very similar activities which share a common objective: the verification of aircraft system operability. However, the definition implies that a PMTF verifies systems which are likely to affect flight characteristics, whereas a systems acceptance flight does not. This is reiterated in CAR 61.19.2, which also states a PMTF shall be carried out when stipulated in an aircraft maintenance manual.[523] A PMTF which investigates an aircraft's flight characteristics is assumed to be more procedurally demanding than a systems acceptance flight which simply verifies system operability. For this reason, a PMTF shall be flown by a pilot holding a post maintenance test flight rating issued in accordance with Part 61,[524] whereas a systems acceptance does not require the pilot to hold such a qualification.

5.5 Post maintenance test flight rating

A rating is an authorisation entered onto a license, stating special conditions, privileges or limitations relating to the license.[525] The holder of a rating is said to possess an additional set of skills which allows the fulfilment of a special purpose,[526] such as perform test flights on aircraft as the holder of a post maintenance test flight (PMTF) rating.

The class one and class two PMTF ratings in Part 61 of the CARS are largely unamended from test pilot ratings introduced in the ANRS. An applicant for a class

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[520] Ibid.
[521] CAR 1.01.1.
[522] Ibid.
[523] CAR 61.19.2.
[524] CAR 61.19.3(2).
[525] CAR 1.01.1.
[526] Salazar, op cit n 102 at 93.

one PMTF rating must have completed no less than 1000 hours of flight experience and have attended a recognised test pilot course as compulsory requirements for the issuance of the rating.[527] A recognised test pilot course is a course in experimental test flight, consisting of a detailed academic syllabus and practical flight training which develop a pilot into a specialist aviator, much the same as the medical profession's definition of a specialist.[528] Test pilots are trained to fly outside of the normal flight envelope, and to recover an aircraft to within its normal flight envelope. There are only nine major test pilot schools in the world,[529] many of which are governmental. The holder of a class one PMTF rating may act as pilot in command during an experimental / prototype test flight, as well as on any other test flight provided the appropriate aircraft type or class rating is held.[530] The privileges of a class one PMTF rating clearly extend beyond MCF operations and into experimental / prototype test flight, which is outside the scope of this writing. The class two PMTF rating is held by most pilots conducting MCFs in South Africa.

An applicant for a class two PMTF rating must have logged a minimum of 500 hours of flight experience, of which not less than 300 hours shall be as pilot in command of an aircraft. Additionally, the applicant must satisfy the Director of Civil Aviation that he has acquired adequate knowledge of test flying techniques.'[531] Air Law does not provide any technical guidance on how an applicant should meet this indistinct requirement, so the question was posed to the Personnel Licensing Department at the SACAA. The respondent indicated each application is considered by a review board on behalf of the Director of Civil Aviation, with no further information provided.[532] The holder of a class two PMTF rating may act as pilot in command during any experimental / prototype test flight on an aircraft weighing less than 2700kg, as well as on any other test flight provided the appropriate aircraft type or class rating is held.[533] It is clear that the privileges of a class two PMTF rating

[527] CAR 61.19.1.
[528] Desmond Barker & Alan Sutherland *Flight Test Guidelines for Homebuilt / Experimental Aircraft* 1 ed (2014) at 40.
[529] Stephen Corda *Introduction to Aerospace Engineering with a Flight Test Perspective* First (2017) at 164.
[530] CAR 61.19.5.
[531] CAR 61.19.1.
[532] SACAA Personnel Licensing Department Reply to Candidate Email Requesting Clarity on CAR 61.19.1, 10 December 2021.
[533] CAR 61.19.4 (a) and (b).

extend beyond MCF operations into experimental / prototype test flight of small aircraft. Worryingly, this privilege exists despite no requirement to have attended a test pilot course or have undergone test flight training, prompting military test pilot Desmond Barker to remark:

> 'The reasonable man test, however, asks whether this is adequate oversight to conduct exploratory test flights, especially considering that no formal training is presented to class two test pilots.'[534]

When an aircraft emerges from maintenance, it must be determined whether a test flight is required or not. If the maintenance is likely to have affected flight characteristics or if a maintenance manual mandates a flight test, the flight is most certainly a test flight which may only be flown by the holder of a PMTF rating. The same applies if the flight intends to validate a CoA. A systems acceptance flight, however, does not need to be flown by the holder of a PMTF rating. Furthermore, if verification of system operability is not desired, the aircraft may immediately be returned to regular service. The determination of whether a flight is a test flight or not is important as passengers may not be carried on test flights, and a test flight must return to the aerodrome of departure.[535] The application of the test flight Air Law to post maintenance cases is dependent on the nature of maintenance work performed, and whether the aircraft's CoA is valid or not.

5.6 Application of test flight Air Law

The application of Air Law to a post maintenance flight will be evaluated in four cases to illustrate which cases satisfy the definition of a test flight and which do not.

The first case is a privately owned four seat single-engine aeroplane which possesses a valid CoA, having undergone its annual service in the form of a Mandatory Periodic Inspection (MPI). The aircraft has not been modified, nor has it been repaired, and no AMM procedure exists for the inflight testing of an aircraft system. The first flight after maintenance does not satisfy the Part 43 and Part 61 circumstances requiring a test flight, meaning it need not be flown by the holder of a

[534] Barker & Sutherland, op cit n 137 at 40.
[535] CAR 43.02.16.

PMTF rating. Upon completion of the MPI, the maintenance organisation issues a CRS certifying the maintenance has been completed in accordance with Part 43 and that the aircraft is fit for release from maintenance and may return to service.[536] On this basis the aircraft may immediately be flown by a pilot who does not hold a PMTF rating, on condition that the pilot is satisfied with aircraft's airworthiness.[537]

If the aircraft's CoA has expired, however, it does require a maintenance test flight to be performed by the holder of a PMTF rating for the reissuance of the certificate.[538] This maintenance test flight will be conducted without a valid CoA, which appears to be in contradiction to Air Law which mandates a valid CoA for aircraft engaged in domestic flights.[539] However, test flights may be conducted without a valid CoA with the written permission of the owner or operator provided the aircraft is registered in South Africa, an application for the reissuance of the CoA is lodged with the SACAA, the applicable fee has been paid and the aircraft has been certified as safe for its intended flight by a licensed maintenance engineer.[540]

The second case involves the very same aircraft which has undergone a structural repair following accident damage to its wings. This aircraft requires a test flight by the holder of a PMTF rating for two reasons. The first reason is the structural accident damage revokes the CoA[541] which requires a maintenance test flight to render the previously issued CoA effective.[542] The second reason is that the aircraft has undergone a major repair as defined in Part 1 and therefore requires a test flight in accordance with Parts 43[543] and 61 to determine whether its flight characterises have been altered.[544] Although a test flight is ordinarily performed by a pilot holding a PMTF rating, the Director of Civil Aviation may issue approval for the test flight to be carried out by a non-PMTF rating holder if the pilot's experience is considered adequate.[545] This test flight must include a climb performance test, wherein the time

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[536] CAR 43.04.2.
[537] Salazar, op cit n 102 at 131.
[538] CAR 21.08.5.
[539] CAR 91.03.1 (b).
[540] CAR 21.08.5.
[541] CAR 43.02.17.
[542] CAR 61.19.2 (b).
[543] CAR 43.02.16 (1).
[544] CAR 61.19.2 (c).
[545] CATS 43.02.16 (1).

to gain altitude is measured and recorded on SACAA form CA21.19[546] and forwarded to the SACAA within 48 hours of the completion of the test.[547]

The third case involves a Boeing 737 which has undergone a D-check in accordance with its maintenance programme, during which maintenance was performed on the elevators. The AMM specifies the need for an Elevator Power Off Flight Test because the maintenance can affect the flight characteristics of the aeroplane.[548] Air Law requires pilots performing the Elevator Power Off Flight Test to hold a PMTF rating because it is an AMM mandated flight test, and the maintenance task may have affected flight characteristics.[549] It must be recalled that the loss of control incident suffered by Boeing 737-73V G-EZJK occurred during an Elevator Power Off Flight Test. The Boeing 737 is a multi-crew aircraft as the aircraft flight manual requires a minimum of two pilots.[550] Each flight crew member is required by law to hold the appropriate valid crew licences, ratings and certificates needed for any flight,[551] which implies both pilots must hold a PMTF rating for this 737's PMTF.

The Elevator Power Off Flight Test is specific to a Boeing 737 which has undergone maintenance adjustment to its elevator flight control surface and is not illustrative of the need to do such a test following every D-check. However, a D-check or equivalent may require non-load-bearing aircraft surfaces to be removed for inspection before being replaced. Whilst this does not constitute a firm requirement for a PMTF, incorrect reinstallation could affect cabin pressurisation. Thus, an operator may consider performing a systems acceptance flight prior to releasing the aircraft to regular service, in line with engineering best practise and for the assurance of quality. In his case the flight is a "systems acceptance flight."

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[546] Form CA21.19 has been replaced by form CA 21-18 available on the CAA website at https://caasanwebsitestorage.blob.core.windows.net/airworthiness-forms/CA%2021-18.pdf, accessed on 20 May 2023.
[547] CATS 43.02.16 (1) 2.(1)(b).
[548] *Boeing 737-600/700/800/900 Aircraft Maintenance Manual*, op cit n 185 Task 27-31-00-710-803.
[549] CAR 61.19.7.
[550] Boeing *737-600/700/800/900 Airplane Flight Manual* (1999) Section 1 Page 3.
[551] CAR 91.02.1 (3)(b).

The fourth case involves a Boeing 737 which suffered a loss of cabin pressure due to an inflight technical malfunction. Following the completion of necessary maintenance tasks to rectify the defect, the operator may wish to verify normal system operation before releasing the aircraft to service. This aircraft has not undergone a major repair or modification, has not had its CoA revoked and is not bound by an AMM procedure to be tested in flight. The first flight after maintenance is therefore not classifiable as a test flight and does not need to be crewed by the holders of PMTF ratings. Instead, this flight is also a systems acceptance flight which can be performed by any pilot suitably qualified on the aircraft type.

The qualification requirements for pilots conducting test flights are a topic of debate among members of the South African aviation community and became pressing during an Air Law amendment process in 2016.

5.7 Air Law amendment process

The SACAA, as empowered by the Civil Aviation Act of 2009, develops regulations and monitors these regulations to ensure compliance with the Chicago Convention as an ICAO contracting state.[552] Although the Chicago Convention and ICAO SARPS form the foundation of the CARS, the SACAA allows aviation stakeholders to propose amendments to Air Law.[553] Any interested person may submit a proposal on the introduction, amendment or withdrawal of an element of Air Law to the Civil Aviation Regulations Committee (CARCom)[554] who, after scrutiny thereof, will advise the Minister of Transport and Director of Civil Aviation.[555]

The CARCom may reject any proposal which it deems to lack sufficient merit, refer the proposal to a subcommittee of experts for scrutiny, or direct that the proposal be published in the Government Gazette (in the case of CARS) or on the SACAA website (in the case of CATS) for comment by interested parties.[556] The

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552 Civil Aviation Act of 2009 Chapter 6 section 72.
553 Salazar, op cit n 102 at 15.
554 CAR 11.03.1 (1).
555 CAR 11.02.1 (1).
556 CAR 11.03.2(5).

Secretariat thereafter submits the comments to the CARCom for consideration in the drafting of the final regulatory proposal, or referral to the relevant subcommittee for further deliberation or rejection.[557] This process was followed by the Flight Test Society of South Africa (FTSSA) in collaboration with the Test Flying Academy of South Africa (TFASA) who submitted a proposal for the amendment of Air Law regulating test pilot qualifications in 2016.

5.8 Proposal for amendment of Air Law[558]

The Flight Test Society of South Africa (FTSSA) is a non-profit organisation comprising of experimental test pilots who hold class one PMTF ratings.[559] TFASA is one of two civilian test pilot schools in the world, whose instructors are graduates of various international test pilot schools and are members of FTSSA.[560] These organisations are symbiotic and aim to involve themselves within all matters pertaining to test flight in South Africa as subject matter experts. Their submission to CARCom in 2016 proposed that both classes of PMTF rating should be removed from Subpart 19 of CARS Part 61 and replaced with an entirely new set of dedicated CARS in Part 70,[561] alongside corresponding CATS.

The proposed Part 70 defines test flight as an activity for the development and evaluation of a new design, and specifically excludes post maintenance functional checking. Three categories of test flight are proposed alongside a corresponding test pilot rating. Category one test flights intend to define the flight envelope of a new aircraft design, while category two test flights measure flight characteristics and performance within the defined flight envelope. Applicants for category one and two test pilot ratings must possess certain flight experience quanta and have attended a test pilot training course as detailed in the proposed CATS. The third category is post-production test flight, in which factory new airframes of certified aircraft types are flown for the first time. Applicants for a post-production flight test rating are

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[557] Ibid.
[558] Flight Test Society of South Africa Proposal for the Addition of Part 70 to the Civil Aviation Regulations 2011 (‘‘Proposal for the Addition of Part 70 to the Civil Aviation Regulations 2011’’).
[559] Ibid Item 5.1.2.
[560] Ibid.
[561] Ibid.

required to meet a less stringent experience quantum than for categories one and two; but are also required to have attended a training course.

The proposer suggests a "grandfather rule," which is a restriction on the application of new law to legal activities having occurred prior to the change,[562] or in this case the awarding of credit to existing holders of test pilot ratings. Specifically, a pilot holding a class one PMTF rating should be issued with a category one flight test rating. It is further proposed that all class two PMTF ratings should be revoked and reissued as "post maintenance ratings" because the holders thereof have not undergone formal test pilot training under current Air Law.

A "post maintenance rating" is not included in the proposed Part 70, thus it is unclear where this rating should reside in Air Law. At the time of writing, Part 61 governs all aspects of pilot licensing. No pilot may act as a pilot of a South African registered aircraft without a license and ratings issued in terms of Part 61.[563] The addition of Part 70 to Air Law would therefore require a concurrent amendment of Part 61 to prevent overlapping test pilot regulations, and to enable the issuance of a rating outside of Part 61.

The proposal to add Part 70 to Air Law was motivated by the PMTF ratings being unamended since their first appearance in the ANRS, which was intended to be a temporary measure until new test flight regulations could be developed.[564] The proposer states that prior to the repealing of the ANRS, ANR 3.16D referenced AIC 30.6 (subsequently withdrawn) which provided guidance on training towards a test pilot rating, while the CARS and CATS provide no such guidance. According to the proposer, the CARS represent an inadequate regulatory framework for the issuing of test pilot ratings.[565] The proposed Part 70 thus intended to establish a rigid regulatory framework for the issuance of test pilot ratings.

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[562] 'Britannica Academic Online (Accessed via UCT Credentials)', available at: *https://academic-eb-com.ezproxy.uct.ac.za/levels/collegiate/article/grandfather-clause/37707*, accessed on 20 May 2023.
[563] South African Civil Aviation Regulation (2011) 61.01.1.
[564] Flight Test Society of South Africa Proposed Addition of Part 70 to the Civil Aviation Regulations 2011.
[565] Ibid 1.1 Motivation.

On 4 April 2016 the proposed Part 70 was submitted to the CARCom in accordance with CARS Part 11 and was published on the SACAA website[566] for comment. The proposal was subsequently rejected by CARCom with a request to the proposer to review the submission and resubmit.[567] The CARCom Secretariat denied the Candidate's request to view the minutes of the CARCom meeting as this information is privileged. However, the SACAA Senior Manager: Consistency and Standardisation for Aviation Safety Operations indicated disagreement among CARCom members on which aircraft types would be subject to the proposed Part 70. Stakeholders also objected to the fact that the proposer (TFASA) was the only organisation in South Africa able to facilitate the training proposed in Part 70, and that this training would be prohibitively expensive.[568] No further proposals on the subject were submitted to CARCom within the terminus ad quem of this writing, thus the Air Law governing PMTF ratings remains unamended.

5.9 Summary

South African Air Law does not differentiate between test flight and check flight activity, with these differing flight operations occurring under the ambit of the term "test flight". PMTF is the South African Air Law equivalent of MCF. The test flight regulations have their origin in the ANRS of 1976 and are largely unamended in the CARS at the time of writing. The pilot qualification for the conduct of a test flight and MCF is a PMTF rating, which may be issued as one of two classes. The class two PMTF rating is relevant within the scope of this writing as it privileges the holder to conduct PMTFs as well as experimental test flights on small prototype aircraft. No formal training is required for the issuance of a class two PMTF rating, which was of concern to subject matter experts belonging to TFASA and FTSSA. These organisations followed legal channels by proposing an Air Law amendment to establish a comprehensive framework for the regulation of test pilot qualifications. This proposal was objected to by industry stakeholders and ultimately rejected by the

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[566] 'SACAA Website, Legislation, Proposed Amendments', available at: *https://www.caa.co.za/legal-notices-2/,* accessed on 10 March 2023.
[567] SACAA CARCom Secretariat Reply to Candidate Email Requesting 2016 CARCom Meeting Minutes, 22 February 2022.
[568] SACAA Senior Manager: Consistency and Standardisation Aviation Safety Operations reply to Candidate email requesting 2016 CARCom meeting minutes, op cit n 240- permission granted to cite this email response by individual in question.

Civil Aviation Regulations Committee. Therefore, the Air Law governing test flight activity in South Africa remains (at the time of writing) largely identical to the Air Law of the ANRS, in which experimental test flight and post maintenance test flight are categorised as one and the same, despite their salient differences.

The following chapter will comparatively analyse the EASA and South African test flight and MCF Air Law to identify the differences and similarities which exist across these jurisdictions.

CHAPTER 6: COMPARATIVE ANALYSIS OF EASA AND SOUTH AFRICAN MCF AIR LAW

6.1 Introduction

A comparative analysis of the relevant components of EASA and South African Air Law reveals considerable variance in the regulation of MCF. The MCF concept is not addressed at ICAO level,[569] meaning the ICAO principle of uniformity in standards is not enjoyed by South African and EASA MCF Air Law, despite South Africa and the EASA members being ICAO signatories. It should be recalled that Article 38 of the Chicago Convention accommodates departures from ICAO SARPS and variations in state rules provided ICAO is notified of such differences.[570] No such variances are on record for any MCF legislation. Notwithstanding, one of the foremost differences is in the terminology used by EASA and South African Air Law to describe MCF.

6.2 Terminology

Historically the term test flight was used in EASA Air Law to describe an activity associated with airworthiness,[571] including experimental test flying of a prototype aircraft, postproduction test flying of new airframes, and maintenance check flying. South African Air Law incorporates a similarly broad use of the term test flight to describe these varied flight activities. In 2008 EASA Law makers identified the semantic differences between these flight operations and foresaw the need to provide alternative terms to adequately differentiate between testing and checking.[572] Amended EASA Air Law therefore uses the term “flight test” to describe experimental testing of new, uncertified products;[573] while “maintenance check flight” (MCF) verifies the functionality of a certified aircraft.[574] Importantly, flight testing seeks new information about an aircraft and may require the pilot to fly the

[569] ‘EASA Notice of Proposed Amendment (NPA) 2012-08’, op cit n 47.
[570] Convention on International Civil Aviation 7 December 1944, Article 38.
[571] United Kingdom Civil Aviation Authority, op cit n 45 at 13.
[572] EASA Notice of Proposed Amendment (NPA) 2008-20 29 August 2008, at 14.
[573] Regulation (EU) 748/2012.
[574] Regulation (EU) 2019/1387.

aircraft to or beyond the limits of its flight envelope, while an MCF is intended to occur within the flight envelope.

The South African Air Law equivalent of flight test is “experimental / prototype test flight,” and the equivalent of MCF is “Post Maintenance Test Flight” (PMTF). While EASA Air Law clearly differentiates between “flight test” and MCF, the CARS ambiguously use the term “test flight” to describe both activities.

6.3 Process for amending Air Law

EASA and the SACAA acknowledge that aviation is dynamic and will require occasional Air Law amendments to accommodate new ICAO requirements, evolving technologies, and in response to safety concerns. The process for the establishment and amendment of Air Law is thus detailed in both EASA and South African legislation.

The EASA rulemaking process, as defined in Article 115 of the Basic Regulation allows EASA’s opinions to be considered by the European Commission in the development of regulations. After due consideration, an EASA draft regulation may be enacted via publishment in the Official Journal of the European Union as ‘hard law’. Following which EASA’s Executive Director will publish Acceptable Means of Compliance and Guidance Material in support of the regulations as ‘soft law.’

This process is not unlike the South African procedure for making regulations and issuing technical standards, as defined in Part 11. Any interested person may submit a proposal to the Civil Aviation Regulations Committee (CARCom) for the amendment of Air Law. After scrutinising the proposal, CARCom may issue a recommendation for the publishment of the proposal in the Government Gazette, whereafter it will be promulgated as a regulation by the Minister of Transport as ‘hard law.’ The Director of Civil Aviation will thence publish the relevant Technical Standards in support of the regulations as ‘soft law.’ Both the EASA and South African Air Law amendment processes consider the input of stakeholders and expert committees to develop practicable, sensible regulations which agree with ICAO SARPS. The comments to EASA’s proposed MCF Air Law helped shape the outcome of RMT.0393, while negative stakeholder sentiment resulted in the outright rejection of the proposed Part 70 amendment to South African Air Law.

6.4 History of MCF Air Law

Prior to the completion of rulemaking task RMT.0393, the EASA Air Law governing non-revenue flights, including MCFs, was inherited from the Joint Aviation Regulations and was not particularly exacting. Responsibility for the safe conduct of MCFs was apportioned to aircraft operators,[575] who were required to develop and enforce their own risk management protocols despite the absence of a formal regulatory framework. This contributed to the Perpignan Accident,[576] and is not dissimilar to South African Air Law governing PMTF.

The South African Air Law governing the issuance of a PMTF rating was inherited from the thirty-first amendment of the Air Navigation Regulations (ANRS) and remains largely unamended to the present day. For instance, the experience requirements for a PMTF rating in the CARS 2011 are identical to the requirements for a test pilot rating gazetted in the ANRs in 1995, and much like historical EASA Air Law require no pilot training for MCFs. Unlike historic EASA Air Law, South African operators are not required to develop and document MCF risk mitigation procedures.

The EASA Air Law prior to the completion of rulemaking task RMT.0393 and the South African Air Law at the time of writing represent a passive approach to the regulation of MCF. In the absence of substantive Air Law, operators are reliant on their own past experiences and third-party resources like the Functional Check Flight Compendium to achieve a level of safety during MCFs. EASA identified these circumstances as a prevailing 'safety gap' which contributed to the Perpignan Accident, and which it sought to address in rulemaking task RMT.0393.[577] It is most unfortunate that an accident with loss of life underscored this safety gap, and that the risk to safety was not pre-emptively managed. After all, safety management 'seeks to proactively mitigate safety risks before they result in aviation accidents and

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[575] EU-OPS 1.1045 (Repealed and Succeeded by Regulation 965/2012).
[576] BEA, op cit n 9 at 98.
[577] 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 29.

incidents.'[578] However, it must be borne in mind that in 2008 safety management was a relatively juvenile aviation concept. The fourth edition of ICAO's Safety Management Manual, Document 9859, which intends to assist states in the development of effective state safety management programs[579] was released a decade after the Perpignan Accident.

This dissertation questions whether a latent safety gap exists within South African aviation for the same reasons as it did in the states under EASA jurisdiction at the time of the Perpignan Accident, by considering the general absence of an MCF regulatory framework. An elementary step in addressing MCF safety is to stop unnecessary testing, by clearly defining in Air Law when MCFs are required.[580]

6.5 Requirement for an MCF

EASA and South African Air Law agree that an MCF (or PMTF) fulfils an important practical purpose: the verification of aircraft serviceability after maintenance action. However, these bodies of Air Law differ on the administrative role of an MCF, specifically with respect to the Certificate of Airworthiness (CoA) and Certificate of Release to Service (CRS). EASA Air Law requires aircraft undergoing an MCF to possess a valid CoA, but to not necessarily possess a valid CRS. On the contrary, South African Air Law allows for a PMTF to occur without a valid CoA, while a valid CRS is mandatory for all flights, including test flights. The crux of this difference rests on the point at which the maintenance is considered to be complete.

When an Aircraft Maintenance Manual (AMM) requires an MCF to verify satisfactory completion of a maintenance task, EASA's view is that the maintenance remains incomplete until completion of the flight.[581] Therefore a CRS cannot be issued until after the MCF, meaning the aircraft is flown without a valid CRS. In this case a "limited release to service" is issued by the maintenance organisation specifying the need for an MCF, thereby allowing the MCF to proceed on the

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[578] ICAO, supra n 60 at 1–1.
[579] Ibid at iii.
[580] Lacagnina, op cit n 2 at 16.
[581] EASA Easy Access Rules for Continuing Airworthiness (Regulation (EU) 1321/2014) GM1 ML.A.301(f).

authority of the CoA.[582] The aircraft may not be flown for any purpose other than the MCF, and an entry shall be inserted in the aircraft's technical logbook by a technician identifying the need for an MCF. After successful completion of the MCF the CRS is issued by the aircraft maintenance organisation and the aircraft is returned to service.

Unlike EASA, South African Air Law requires all aircraft to hold a valid CRS prior to flight.[583] To comply with this regulation a CRS must be issued after completion of the final maintenance task, and prior to the PMTF. This implies that the maintenance is considered complete after the last maintenance step performed by the technician and the role of the PMTF is, as per the definition, confirmation of the release to service.[584] An entry must be inserted into the aircraft technical logbook by a technician indicating the need for the PMTF. After successful completion of the PMTF the aircraft logbook is updated, and the aircraft is returned to service. A test flight may also be required by the SACAA to validate or render effective a CoA,[585] meaning it is possible to perform a test flight without a valid CoA. The test flight of an aircraft without a valid CoA is allowed with the written permission of the owner or operator, and once the aircraft has been certified as safe by a licensed aircraft technician,[586] which is understood to mean that a valid CRS has been issued.

The procedures and manoeuvres to be performed by pilots conducting MCFs vary depending on the underlying need for the flight. In certain cases, the execution of normal procedures by the pilots is sufficient to determine the aircraft's serviceability, while in other cases pilots must execute unconventional procedures to verify system operability. EASA Air Law differentiates between these cases according to procedural complexity and associated risk level, while South African Air Law does not.

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[582] EASA Executive Director Decision 2020/002/R.
[583] CAR 91.03.1 (b) (v).
[584] CAR 1.01.1.
[585] Ibid.
[586] South African Civil Aviation Regulation (2011) 21.08.5.

6.6 Levels of MCF

All MCF incident and accident case studies cited in this research occurred during the application of unconventional flight procedures by pilots. The application of these procedures was necessary to determine correct system functionality, even though they would not ordinarily be performed during normal flights. Prior to the Perpignan accident the crew decelerated the aircraft to a lower than usual airspeed to verify correct operation of the low-airspeed protection feature of the A320-232, which did not operate due to frozen sensors. In the Boeing 737-73V G-EZJK serious incident, the crew deactivated the hydraulic flight control system in accordance with an AMM procedure, causing the aircraft to pitch downward. Prior to the accident involving Douglas DC-8-63 N827AX the crew intentionally performed an approach-to-stall manoeuvre to test the stall warning system, which did not function. In all three cases the aircraft response during the manoeuvre was contrary to expectation, which precipitated the loss of aircraft control by startled pilots. History has shown the predominant cause of fatal accidents during MCFs is a complex loss of control scenario, which is either not correctly recovered by the pilots, or simply not recoverable.[587]

In its proposal for the amendment of MCF Air Law, EASA acknowledged the higher level of risk associated with the application of unconventional procedures and proposed two levels of MCF depending on the procedures required. Level A MCFs incorporate the use of abnormal or emergency procedures to prove the functionality of a backup system which would not ordinarily function during normal flight operations.[588] Whereas Level B MCFs incorporate the exclusive use of normal procedures to confirm system functionality.[589] Level A MCFs carry more legal prescriptions than Level B MCFs, including the need for pilot training, because they are more procedurally complex. South African Air Law does not differentiate PMTFs according to their complexity, meaning all PMTFs are considered equal. This binary approach over-simplifies the variables involved PMTFs of complex aircraft. The CARS do, however, allow for a “systems acceptance flight” to test

[587] Poprawa, op cit n 21 at 781.
[588] Regulation (EU) 2019/1387 SPO.SPEC.MCF.100.
[589] Ibid.

aircraft systems which have no effect on flying characteristics,[590] which implies the use of normal procedures. A systems acceptance flight is therefore loosely comparable to an EASA Level B MCF.

Interestingly United States Air Law does not regulate MCFs to any level, yet the FAA guidance on non-routine flight operations (NRFOs) identifies two groups of NRFO depending on procedural complexity. Group One NRFOs are comparable to Level B MCFs in which normal procedures are used while Group Two NRFOs are comparable to Level A MCFs which employ emergency, abnormal or alternate procedures.[591] The FAA acknowledges the need for additional pilot training prior to conducting Group Two NRFOs, much like EASA Air Law requiring the same for Level A MCFs.

6.7 Pilot training and ratings

South African and EASA Air Law shares several similarities in the regulation of experimental flight testing. EASA requires pilots performing “flight tests” on aircraft weighing in excess of 2000kg to hold a flight test rating issued in accordance with Part FCL regulations, the regulations governing flight crew licensing.[592] It should be recalled that a rating is issued to an applicant meeting specified requirements of knowledge, flight instruction and skill.[593] The training syllabus for a flight test rating is extensive, and must be conducted at an EASA approved training organisation. Similarly, South African Air Law requires pilots performing “experimental / prototype test flights” on aircraft weighing more than 2700kg to hold a class one PMTF rating, which includes attendance of a recognised test pilot course.[594] Applicants for both ratings are required to possess a minimum of 1000 hours of flight experience, with differing requirements for the number of hours flown as pilot-in-command (PIC).

EASA requires 400 PIC hours while the CARS require 700. These experience requirements indicate that a test pilot rating is intended to be held by comparatively

[590] CAR 1.01.1.

[591] Supplement to Federal Aviation Administration Information for Operators 08032, 16 May 2008 available at: *https://www.faa.gov/sites/faa.gov/files/InFO08032Sup.pdf*, accessed on 8 January 2023.

[592] FCL.820 (a).

[593] ICAO, supra n 109 at 1–7.

[594] CAR 61.19.1 (2) (e).

experienced pilots. This is where the similarities end, as EASA and South African Air Law concerning pilot training for MCFs and PMTFs are notably different.

EASA Air Law further mandates pilot training prior to the performance of Level A MCFs on complex motor-powered aircraft, although this training is not credited towards a flight test rating. MCF training is conducted by operators, and the resultant certification resides with the operator and is not included on a pilot license as a rating. Whereas South African Air Law requires pilots conducting MCFs to hold a post maintenance test flight (PMTF) rating, which is included on a pilot license. Most South African pilots performing PMTFs hold a PMTF rating class two, for which no formal training is required. Thus, a South African pilot holding a PMTF rating class two, having received no formal training, is legally authorised to perform MCFs incorporating the use of abnormal or emergency procedures on complex aircraft. A reasonable person may ask whether this is safe or not. EASA believes not, and mandates pilot training for Level A MCFs.

Several literature sources studied during this research agree that the training of pilots is a key component to enhancing MCF safety.[595] Boeing's Post Delivery 737NG Flight Profile states that 'only highly experienced, properly trained crews should be at the controls while performing the manoeuvres outlined in this document.'[596] The Flight Safety Foundation recommends the selection of pilots with an aptitude suited to MCF operations, followed by comprehensive training before these individuals are allowed to perform MCFs.[597] The AAIB suggests regulators establish guidance on minimum pilot training and proficiency requirements prior to undertaking MCFs.[598] The EASA MCF pilot training course for Level A MCFs is conducted according to a detailed syllabus comprising theoretical and practical elements,[599] which is in stark contrast to South African Air Law requiring no training for a PMTF rating.

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595 BEA Perpignan Accident report, AAIB serious incident report, Functional Check Flight Compendium, Airbus Safety First Magazine, EASA NPA 2012-08, Poprawa *Maintenance test flying – an accident waiting to happen.*

596 Boeing *Post Delivery 737NG Flight Profile* (2017) at 3.

597 Flight Safety Foundation, op cit n 46 at 18.

598 Air Accidents Investigation Branch, op cit n 187 Safety recommendation 2010-075.

599 Regulation (EU) 2019/1384 SPO.SPEC.MCF.120.

The development of a training programme addressing the competencies and skills required to perform MCFs prepares pilots to deal with situations where the aircraft response is unexpected or undesirable,[600] as was so in the case studies cited in this dissertation. This training is an important component of the MCF risk mitigation strategy proposed and implemented by EASA and is notably absent in South African Air Law. In addition to pilot training, MCF safety is also bolstered by the development and implementation of robust policies and procedures.

6.8 MCF policies

In the aftermath of the Perpignan Accident the aircraft owner, Air New Zealand, remarked that MCF operations are often an evolutionary process based on modified experiences and previous occurrences,[601] rather than well-designed safety-orientated protocols. One of EASA's key objectives in the development of MCF Air Law was the establishment of a rigid policy framework to enhance safety and reduce the probability of future incidents and accidents during MCF operations.[602] EASA consulted existing literature when drafting the regulatory text, including the UKCAA Check Flight handbook and the Functional Check Flight Compendium to determine which policies and procedures should be included in Air Law.[603] Several of these recommended policies and practices became enforceable by their inclusion in EASA's MCF Air Law. One of the notable inclusions is the requirement to develop a comprehensive MCF manual by operators intending to perform Level A MCFs on complex motor-powered aircraft.[604]

An MCF manual is a written record of safety measures and procedures employed in an operator's MCF operations and must be submitted to the presiding aviation authority for scrutiny and approval. An MCF manual specifies in detail every aspect pertaining to MCF operations including pilot selection and training, minimum conditions of weather and light, the MCF flight sequence, and debriefing

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600 David Morgan 'Functional Check Flight Symposium Keynote Address' available at: *https://flightsafety.org/toolkits-resources/functional-check-flights/functional-check-flight-fcf-symposium-presentations/,* accessed on 14 January 2022.
601 Ibid.
602 'EASA Terms of Reference (ToR) MDM.097(a) & (b)', op cit n 2.
603 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 47.
604 Regulation (EU) 2019/1384 SPO.SPEC.MCF.110.

methodologies.[605] These requirements force operators to identify risks and adopt risk mitigation strategies well in advance of an MCF, as opposed to the evolutionary process identified by Air New Zealand. In stark contrast, South African Air Law requires none of the above safety protocols, leaving operators to self-determine which (if any) safety protocols should be incorporated. Thus, it is argued that PMTF operations occurring under South African Air Law may expose stakeholders to a greater level of risk than MCFs occurring under EASA jurisdiction.

A point on which EASA and South African Air Law do concur is the carriage of personnel during an MCF. Both bodies of Air Law preclude the carriage of passengers,[606] while EASA Air Law mandates the carriage of a task specialist for Level A MCFs in complex motor-powered aircraft.[607] The exclusion of passengers limits the exposure of risk to a minimum number of personnel while the task specialist assists the pilots with the reading of checklists, monitoring proceedings and recording relevant parameters.[608] This crew member is essentially a 'third set of eyes' in the cockpit and is often well positioned to accurately record quantitative data such as climb performance required by the CARS.[609] The task specialist ideally maintains a high level of situational awareness by not being immersed in flying duties. For this reason, Air New Zealand's view is that a well-qualified task specialist is arguably more important to safety than the pilots.[610]

In both jurisdictions the crew contingent on an MCF may never be less than the minimum specified in the aircraft flight manual,[611] and may include several aircraft maintenance technicians. These technicians are considered essential by their familiarity with the maintenance work carried out, thereby equipping them with technical knowledge which may be of assistance in the event of an in-flight technical malfunction.

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605 EASA Executive Director Decision 2019/019/R 16 September 2019, AMC1 SPO.SPEC.MCF.110.
606 CAR 43.02.16 (2).
607 Regulation (EU) 2019/1384 SPO.SPEC.MCF.123.
608 EASA Executive Director Decision 2019/019/R 16 September 2019.
609 South African Civil Aviation Technical Standards 43.02.3.
610 Morgan, op cit n 221.
611 CAR 91.02.1 (1).

The qualitative and quantitative data obtained during an MCF is used by aircraft maintenance personnel to perform necessary adjustments or repairs to restore an aircraft to an airworthy condition. EASA Air Law requires pilots to be trained in procedures for post-flight analysis,[612] and methods for post flight debriefing are included in the MCF manual.[613] The CARS contain no requirement for correspondence between maintenance personnel and the pilots performing the MCF, although this correspondence often happens informally. The need for a comprehensive post-flight debriefing is highlighted in the investigation report involving B737-73V G-EZJK. After a previous Elevator Power Off Flight Test 'the commander verbally recounted the results of the test and reportedly suggested this was something that needed to be addressed.'[614] Specific results of the test were not officially recorded, meaning maintenance personnel affected an adjustment based on a suggestive verbal report alone. The adjustment was performed in the wrong direction which unwittingly exacerbated a control problem, manifesting as a violent pitch down during the subsequent Elevator Power Off Flight Test.

The complexity of an MCF, and the resultant post flight data analysis is largely dependent on the type of aircraft undergoing an MCF. A complex motor-powered airliner equipped with four engines, designed to fly long distances over uninhabitable spaces is equipped with numerous systems and backups, many of which require functional checking during an MCF. This results in a prolonged flight which may last several hours and conclude with numerous data points requiring post flight analysis. By comparison the MCF of a non-complex aircraft powered by one engine is appreciably shorter in duration, with little post flight data requiring analysis. Thus, proportionality of rule was called into question during the consultative phases of the EASA MCF Air Law amendment process as well as the Part 70 proposal to CARCom.

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[612] EASA Executive Director Decision 2019/019/R 16 September 2019, at AMC2. SPO.SPEC.MCF.120.
[613] EASA Executive Director Decision 2019/019/R 16 September 2019, AMC1 SPO.SPEC.MCF.110.
[614] Air Accidents Investigation Branch AAIB Bulletin 9/2010, at 16 available at: *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/384837/Bulletin_9-2010.pdf*, accessed on 25 October 2022.

6.9 Proportionality of risk and rule

Statistical evidence suggests MCFs involving complex motor-powered aircraft carry more risk than MCFs involving non-complex aircraft. This narrative was upheld by non-complex aircraft operators during the consultative phase of EASA's MCF Air Law amendment process. They expressed concern about overregulation of their sector by impracticable MCF legislation, such as the need to carry a task specialist in a single-seat aircraft.[615] Further concern was expressed over the cost of pilot training by stakeholders who lack access to the flight simulators which are available to operators of complex motor-powered aircraft. These stakeholders argued that the rules governing experimental / prototype flight tests do not apply to aircraft below 2000kg, and that MCF Air Law should follow the same logic.[616] Similarly, South African stakeholders disagreed on which aircraft types should be subject to the proposed Part 70 regulations while also objecting to the cost of the associated training.[617]

Far from dismissing these concerns, EASA excluded operators of European Light Aircraft (ELA) from the MCF Air Law and provided notably less stringent MCF provisions for the operators of non-complex aircraft in Part-NCO.[618] South African stakeholders were unable to resolve these concerns via the CARCom process, which contributed to the outright rejection of TFASA and FTSSA's Part 70 Air Law proposal. As a result, South African Air Law makes little differentiation between MCFs on complex and non-complex aircraft other than allowing the use of manufacturer test flight procedures in complex aircraft.[619]

EASA concluded that their proportionate application of MCF Air Law would not place onerous provisions upon operators of non-complex aircraft, while the exacting Air Law in Part-SPO would enhance safety during MCFs on complex motor-powered aircraft. This conclusion is logical when considering the MCF incident and

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615 'EASA Comment Response Document 2012-08', op cit n 53.
616 Ibid.
617 SACAA Senior Manager: Consistency and Standardisation Aviation Safety Operations Reply to Candidate Email Requesting 2016 CARCom Meeting Minutes, op cit n 181.
618 Regulation (EU) 2019/1384.
619 South African Civil Aviation Technical Standards 43.02.16.

accident case studies cited in this research all involved complex motor-powered aircraft. The proportionality of the EASA MCF Air Law establishes clear policies and procedures which are applicable to aircraft of different complexities, unlike the blanket approach to test flight regulation contained in the CARS.

6.10 Summary

Historically EASA and South African Air Law governing MCF flight activities were not dissimilar. Both bodies of law provided scant regulation of these flight operations which exposed a safety gap in an otherwise safety conscious industry. It was the loss of seven lives in an accident off the coast of Perpignan, France which drew EASA's attention to this safety gap and precipitated an Air Law amendment process seeking to enhance MCF safety and reduce the likelihood of another accident or incident.

A comparative analysis of the EASA and South African Air Law governing MCF may be likened to an 'apples and oranges' comparison, in which the CARS simply do not offer much to compare against the highly evolved EASA MCF legislation. The reason for this apparent incompatibility in legislation is because EASA Air Law clearly differentiates between test flight, and maintenance check flight while South African Air Law does not. EASA's well defined MCF training requirements are contrasted against the South African PMTF rating which applies to all test flights, in a 'one-size fits all' approach. EASA Air Law clearly outlines circumstances in which MCFs are required and differentiates MCF levels according to their procedural complexity. This framework is juxtaposed against the CARS which describe several ambiguous variations of test flight including "post maintenance test flight," as well as "systems acceptance flight" which are loosely comparable to EASA Level A and B MCF's respectively.

Despite numerous differences in the regulation of MCF and PMTF, South African and EASA Air Law concur that no passengers should be carried aboard these flights, while EASA Air Law requires the carriage of a task specialist to assist the pilots. Both bodies of Air Law acknowledge the importance of obtaining accurate flight data for engineering purposes, and therefore require post flight data to be retained and in the case of the CARS submitted to the SACAA for analysis.

As regulators, EASA and SACAA share a common mandate which is the enhancement and promotion of air safety. The inclusion of MCF and PMTF provisions in EASA and South African Air Law are an acknowledgement by both regulators that these operations require additional rules over and above those required for normal flights. However, the respective rules represent a different approach to MCF safety by these regulators.

All Air Law is assembled with safety in mind, as safety remains ICAO's most fundamental objective. However, the absence of ICAO SARPS addressing MCF operations has allowed non-uniform regulatory protocols to develop within the Air Laws of contracting states, as described in this comparative analysis. It is argued that the poor regulation of MCF in South Africa creates a safety gap, specifically with respect to PMTFs of complex motor-powered aircraft. David Morgan urged attendees at the functional check flight symposium to review and if necessary, overhaul MCF rules to close this safety gap.[620] EASA is to date the only regulatory body to acknowledge and address this safety gap via the establishment of exacting MCF Air Law.

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[620] Morgan, op cit n 221.

CHAPTER 7: CONCLUSION

7.1.The role of ICAO

This dissertation sought to determine what legislative framework exists across jurisdictions to promote safety during Maintenance Check Flight (MCF), a statistically high-risk flight operation associated with several noteworthy air incidents and accidents. Whilst there exists concordance amongst stakeholders that MCF operations require tactical safety protocols, the regulatory approach is largely inconsistent. This inconsistency in the regulation of MCF is contrary to the International Civil Aviation Organisation (ICAO) objective of 'securing the highest practicable degree of uniformity in regulations…'[621] as stated in Article 37 of its founding charter, the Convention on International Civil Aviation or Chicago Convention.

The Chicago Convention of 1944 has been described as the 'magna carta' of international Air Law,[622] establishing the foundational principles of international aviation legislation as well as ICAO, the body tasked with the development and oversight of the rules governing international Air Law. The promotion of safety is ICAO's most fundamental role,[623] as set out in Article 44 of the Chicago Convention.[624] Safety is a condition in which the associated risks are reduced and controlled to an acceptable level, if not eliminated entirely.[625] The numerous risks associated with aviation are controlled by a plethora of international rules underpinned by the principle of uniformity.[626] These uniform aviation rules, or Air Laws are compiled in general congruence with the Standards and Recommended Practices (SARPS) set down by ICAO in its nineteen (at the time of writing) Annexes to the Chicago Convention. Law is generically defined as 'a body of rules of action or conduct prescribed by [a] controlling authority, and having binding legal force…'[627] It is accepted that ICAO SARPS are themselves not laws, but are highly

[621] Convention on International Civil Aviation 7 December 1944, Article 37.
[622] Dempsey & Jakhu, op cit n 35 at 1.
[623] Bartsch, op cit n 20 at 56.
[624] Convention on International Civil Aviation 7 December 1944, Article 44.
[625] Francesca Pellegrino *The Just Culture Principles in Aviation Law* (2019) Preface.
[626] Scott & Trimarchi, op cit n 43 at 5.
[627] *Black's Law Dictionary* 5 ed (1979).

authoritative in practice and are formally binding upon the 193 ICAO member states.[628] The SARPS are given legal effect within a member state's legal system via an act or statute which ratifies the Chicago Convention and empowers a state aviation regulator to draft regulations in concordance with the SARPS.[629]

Despite ICAO's mandate to achieve uniformity in aviation regulations, international Air Law governing MCF is notably non-uniform. The international regulatory environment surrounding MCF remains in flux,[630] with sub-optimal and inconsistent MCF Air Law provisions across multiple jurisdictions.[631] The reason MCF is not the beneficiary of uniform regulations is because this topic is not specifically addressed at ICAO level.[632] While MCF activity occurs under the general ambit of ICAO provisions, there exist no SARPS identifying training or operational practices in support of MCF activity. As a result, the conduct of MCFs by aircraft operators is largely an evolutionary process, based on lessons learnt from previous experiences, occurrences, and accidents. The normalisation of this evolutionary process is a notable outlier in an industry characterised by an international collaborative effort to achieve safety via uniformity.

The absence of uniformity surrounding MCF is evidenced at the most elementary level: terminology. No international consensus exists on the correct term to describe a flight in which operability is verified after maintenance. The concept is known as maintenance check flight, functional check flight, functional evaluation flight, post maintenance test flight, or simply test flight. Despite the use of these synonyms, there exists a semantic difference between a test flight and a check flight.

7.2.Distinguishing between test flight and check flight

Test flights are necessary during the development of a newly designed aircraft or component.[633] The objectives of test flights are establishment of the flight envelope,

[628] Abeyratne, op cit n 89 at 124.
[629] Bartsch, op cit n 20 at 48.
[630] Poprawa, op cit n 1 at 788.
[631] Morgan, op cit n 205.
[632] 'EASA Notice of Proposed Amendment (NPA) 2012-08', op cit n 30 at 10.
[633] EASA Notice of Proposed Amendment (NPA) 2008-20 29 August 2008,.

determining flight characteristics and aircraft performance, acquisition of in-flight data and ultimately demonstration to a regulatory authority that a new design is compliant with airworthiness regulations.[634] Test flights are inherently dangerous as they pursue and sometimes exceed the aircraft design limitations or flight envelope, and should therefore be crewed by highly skilled, specialist aviators specifically trained to perform flight testing – test pilots.

MCFs do not involve a new design with unknown flight characteristics, nor should they ever depart the normal flight envelope. On the contrary, an MCF seeks to demonstrate that an existing design remains compliant with its certified flight characteristics after maintenance activity. This demonstration is made by pilots operating the aircraft according to published procedures, and verifying the results remain as expected via reference to certified aircraft flight manuals. However, an aircraft may unintentionally depart the normal flight envelope during an MCF when unconventional procedures are employed. MCF pilots should be trained to avoid and, if necessary, to recover from such a departure. But this training should not be confused with the specialist training required for a test pilot.

Despite these semantic differences, the South African Air Law does not differentiate between test flight and check flight, with the ubiquitous use of the term test flight to describe both activities. In stark contrast, EASA Air Law provides clear differentiation between test flight and maintenance check flight, with each activity benefitting from dedicated Air Law provisions which seek to mitigate the associated risks.

7.3.Risk associated with MCF

One of the key objectives of this research was to determine whether MCF presents a higher quantum of risk than a normal flight, and what the source of this risk might be. Annex 1 lists one hundred and sixty-three incidents and accidents which are known to have occurred during MCF activity. The most pivotal of these, from an Air Law perspective, is the Perpignan Accident which occurred on 27 November 2008.

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[634] Corda, op cit n 46 at 161.

This accident was investigated by France's Bureau d'enquêtes et d'analyses (BEA) and led to the proposal of several safety recommendations for the amendment of Air Law. When the Perpignan Accident report is compared to other BEA accident reports in Annex 1, it becomes evident that not all BEA investigations are conducted to the same level of granular detail. This is because BEA adapts its investigative resources and eventual report according to the perceived level of risk and envisaged lessons to be learnt after the fact.[635] The Perpignan Accident is a category 1, major investigation because the mass of the Airbus A320-232 exceeded 5700kg and involved fatalities. Category 1 reports utilise the full structure proposed in ICAO Annex 13 and generally give rise to safety recommendations. Category 1 investigations benefit from a large quantum of accident data, including the aircraft's flight data and cockpit voice recorders, which contribute to a highly detailed final report. Whereas category 2 and 3 investigations are characterised by limited in-depth analysis and give rise to a simplified report, often lacking safety recommendations.[636]

Collectively, accident data suggests that MCFs are one or two orders of magnitude more risky than regular commercial flights.[637] The relationship between the probability and severity of an MCF hazard yields an intolerable risk index when examined according to ICAO's safety management matrix. To comprehend the magnitude of this risk, it was first necessary to determine its origin. Our hypothesis was that additional risk is introduced into MCF by two sources: maintenance errors committed during maintenance tasks; and pilot errors committed during the application of unconventional procedures while conducting MCFs.

Maintenance error is a well-documented phenomenon, classified by numerous taxonomies such as Boeing's Maintenance Error Detection Aid (MEDA). The 2003 International Air Transport Association Safety Report cited maintenance error as

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[635] Bureau d'enquêtes et d'analyses BEA Activity Report 2020, at 15 available at: *https://bea.aero/fileadmin/documents/rapport.annuel/Activity_report_2020.pdf*, accessed on 3 December 2023.
[636] Ibid at 76.
[637] Poprawa, op cit n 1 at 781.

causal in a quarter of air accidents.[638] Stakeholders are well aware of this phenomenon, and encourage a just culture wherein blame is not apportioned to individuals for errors, and voluntary dissemination of safety related information is encouraged.[639] Air Law supports the mitigation of maintenance error by requiring maintenance personnel to be trained in human factors and error mitigation,.

Aircraft maintenance is a continuous process, incorporating both scheduled and non-scheduled maintenance tasks of varying complexity. This means that maintenance is not constrained to the time immediately preceding an MCF, but is an activity which regularly occurs before flights, including routine operations. Therefore, the risk of human error in maintenance is not unique to an MCF and may be present in any flight. Illustrative of this point is the fact that neither the Air Astana Embraer E190-100LR accident nor the Lufthansa Airbus A320-200 incident cited in this research occurred during an MCF.

Aircraft maintenance procedures mandate an MCF when satisfactory post-maintenance analysis cannot be achieved on the ground. An example of this is the Elevator Power Off Flight Test required by the Boeing 737 Aircraft Maintenance Manual, where the results cannot be determined to sufficient level of accuracy without an in-flight check.[640] Such maintenance tasks are generally associated with scheduled (heavy) maintenance, in which numerous maintenance tasks are performed. A greater number of maintenance tasks introduces more opportunities for the committal of maintenance error. This means an aircraft undergoing an MCF after multi-tasked heavy maintenance may suffer more maintenance errors than after the completion of a single maintenance task. Therefore, the risk of maintenance error is assumed to be greater in an MCF than a regular flight.

All the MCF accident and incident case studies cited in this research were precipitated by a maintenance error. However, it was pilot error which proved to be the catalyst. The use and misuse of unconventional procedures by pilots conducting MCFs plays a significant role in degrading MCF safety. An unconventional

[638] Rankin, op cit n 176 at 16.
[639] Pellegrino, op cit n 53 at vii.
[640] *Boeing 737-600/700/800/900 Aircraft Maintenance Manual*, op cit n 185 Task 27-31-00-710-803.

procedure may be necessary during an MCF to verify the correct operation of a system. If the aircraft response is contrary to the pilots' expectations and the recovery is mishandled, the aircraft may unintentionally depart from the normal flight envelope and control may thus be lost. This was indeed the case in the Perpignan and Douglas DC-8-63 N827AX accidents and G-EZJK Boeing 737-73V serious incident. EASA MCF Air Law acknowledges the use of unconventional procedures by MCF pilots may elevate risk, and thus defines MCF levels according to the procedural complexity.

Level A MCFs incorporate the intentional use of unconventional procedures by pilots and are thus classified as the highest risk MCFs. Pilots performing Level A MCFs are required to undergo specialist theoretical and practical training,[641] while Level A MCFs are subject to exacting constraints published in an MCF manual of procedure. By comparison, pilots performing Level B MCFs (which do not incorporate the use of unconventional procedures) are not required to have undergone specialist training, nor is adherence to a procedure manual required.

If our hypothesis is examined within the South African Air Law context, there exist no provisions to mitigate the risk associated with the use of unconventional procedures during MCFs on complex aircraft. This is not dissimilar to the EASA Air Law in existence at the time of the Perpignan Accident and G-EZJK serious incident. Therefore, the risk of MCFs in South Africa at the time of writing may be equated to the risk noted by EASA when the MCF rulemaking task was initiated in 2011. EASA Air Law acknowledges that MCFs are not only differentiated according to procedural complexity, but also by the complexity of the aircraft types in question.

7.4.Regulation of MCF according to aircraft complexity

Specific parts of Air Law are required to regulate the different types of air operations which involve aircraft of varying complexity. For example, a privately owned two-seat aircraft flown in daytime and fair weather cannot be expected to adhere to the

[641] Regulation (EU) 2019/1384.

same Air Law which governs the commercial operation of a 500-seat jet airliner flying in all conditions of weather and light. The same may be said of MCFs, as these flights differ according to aircraft technical complexity, performance capability and operating procedures. Therefore, the imposition of a single set of MCF regulations upon all aircraft operators would be impracticable, and in some cases impossible. This notion was raised by stakeholders during the consultative phase of the EASA MCF Air Law amendment process and was dutifully acknowledged by EASA lawmakers. The result of these objections was a reworded EASA MCF Air Law proposal in which the regulatory provisions are proportional to aircraft complexity.

A 2016 proposal for the amendment of South African test flight Air Law was rejected by the Civil Aviation Regulations Committee (CARCom) for reasons including a lack of consensus on which aircraft types would be subject to the proposed Air Law (much like the EASA scenario), and concern over the impracticality of training pilots. Unlike the EASA scenario, South African lawmakers employed no countermeasures to resolve these objections, which led to the outright dismissal of the proposal. From this we conclude that the imposition of a blanket set of MCF regulations upon all operators is unlikely to yield a satisfactory solution, as MCF Air Law must account for operations of different complexity.

7.5.The overarching need for MCF regulations

Regulatory authorities and subject matter experts agree that MCFs carry an elevated level of risk when compared to regular operations. The FAA acknowledges this in document InFO 08032,[642] while EASA assumes the ratio for accidents and incidents during MCFs is higher than for regular operations.[643] These stakeholders disagree on the appropriate methods to manage and mitigate this risk, with some calling for risk management via regulation and others arguing against over-regulation.

642 Federal Aviation Administration, Information for Operators 08032, op cit n 49.
643 ‘EASA Notice of Proposed Amendment (NPA) 2012-08’, op cit n 30.

In the argument against over-regulation, stakeholders question whether there exists an existential need for MCF regulations in the first place. The FAA does not believe that the risk posed by MCF warrants regulatory control, as operators' own safety management systems (which are themselves an Air Law requirement) ought to manage this risk satisfactorily.[644] Participants at the Functional Check Flight Symposium which operate under FAA jurisdiction, American and United Airlines explained well developed in-house MCF risk management protocols which largely mimic the EASA MCF Air Law. Furthermore, the Functional Check Flight Compendium[645] and Check Flight Handbook[646] are freely available resources describing MCF risk management strategies, which any operator may electively reference to enhance safety.

Rigid regulation of MCF has the potential to bear a significant financial and logistical burden upon aircraft operators who will need to develop procedures, protocols, manuals, and training syllabi. Pilot training is particularly costly, especially for operators without access to certified flight simulators who will be forced to train pilots on actual aircraft. Therefore, lawmakers considering the regulation of MCF must appreciate that MCFs differ significantly depending on the type of aircraft.

The four case studies cited in this research involved complex aircraft in which pilots applied unconventional procedures to verify the operability of a system. The evidence suggests that MCFs on complex aircraft carry a higher level of risk than MCFs on non-complex aircraft; and are therefore appropriate beneficiaries of exacting MCF risk mitigation protocols. While safety conscious operators (such as those present at the FCF Symposium) acknowledge this, it cannot be presumed that all operators fully appreciate the risk of MCFs on their complex fleets. This lack of appreciation of risk, coupled with the fact that MCF risk mitigation carries a cost, may dissuade some operators from implementing effective MCF risk mitigation procedures unless compelled to do so by Air Law.

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[644] 'EASA Comment Response Document 2012-08', op cit n 69 at 51.
[645] Flight Safety Foundation, op cit n 39.
[646] United Kingdom Civil Aviation Authority, op cit n 4.

The overarching need for MCF Air Law is to compel operators, specifically those who operate complex aircraft, to adopt proactive protocols to mitigate MCF risk, and in so doing enhance safety. Sensible, practicable MCF Air Law represents the first safety defence tier in a multi-tiered safety system. This elementary safety defence tier should originate at regulatory level, whether it be from ICAO or state a regulatory authority like EASA or SACAA.

7.6.MCF pilot training

James Reason's Swiss Cheese Model explains how an accumulation of failures across multiple safety defence layers precipitates an incident or accident. As long as aircraft maintenance remains a human-centric process, human errors can be expected during the maintenance process. While regulations governing aircraft maintenance are robust, errors do penetrate this safety defence layer, meaning aircraft will carry defects into the sky. If such a defect is exposed during a regular flight, it is assumed that a reasonable and proficient pilot should be able to handle the defect and land the aircraft safety using knowledge and skills acquired during training. The difference between a pilot conducting a regular flight and a pilot conducting an MCF is the MCF pilot actively seeks out such defects via the application of unconventional procedures. Herein lies the risk: the application of an unconventional procedure upon a defective system may precipitate the unintended departure from the normal flight envelope, sometimes referred to as an undesired aircraft state (UAS). Non-test pilots are ordinarily not trained for flight outside of the normal flight envelope.

If a pilot conducting an MCF discovers an aircraft defect during the application of an unconventional procedure, the said pilot will face simultaneous challenges: recovering the aircraft from the resultant UAS using defective systems. For instance, if an Elevator Power Off Test goes awry, the aircraft will pitch aggressively into a UAS. The pilots will need to recover from the UAS using degraded flight controls, because the test required deactivation of the hydraulic power control units. The MCF pilots' ability to recover from a UAS is the final safety defence layer which is augmented by training for this very situation. For this reason, EASA Air Law requires pilots conducting Level A MCFs on complex motor-powered aircraft to have undergone a training course, including practical elements in a flight simulator.

Pilot training is the area of greatest variance between EASA and South African MCF Air Law.

7.7.Variance in the regulation of MCF

This research has sought to demonstrate that legislation governing MCFs is non-uniform across jurisdictions, with little consensus on the appropriate means to mitigate this risk. On one end of the scale is the FAA which does not regulate MCF at all, while on the other end lies EASA which presides over the most exacting MCF Air Law in existence at the time of writing. The SACAA regulatory approach is tepid at best, as the Air Law does not clearly differentiate between MCF and experimental test flying and does not regulate either operation to a particularly exacting degree.

This non-uniform status quo highlights the importance of ICAO's mandate, which is to oversee that each state undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, and procedures.[647] The absence of such uniformity at ICAO level is the enabler of such notable variance of the regulation of this statistically high-risk operation.

7.8.Concluding remarks

Maintenance Check Flights are a necessary measure for the aviation industry to maintain its exceptional safety standards.[648] This is so because MCFs seek out aircraft defects in a controlled environment while exposing a minimum number of essential personnel to elevated levels of risk. Timely correction of these defects reduces the possibility of serviceability issues once the aircraft resumes regular operations, which enhances operational safety and reliability.

However, MCF's themselves are demonstrably more risky than regular flights, primarily because MCF pilots may be required to apply unconventional procedures to verify the correct operation of aircraft systems. When aircraft behaviour is

[647] Convention on International Civil Aviation 7 December 1944, Article 37.
[648] Poprawa, op cit n 1 at 781.

contrary to expectation, a complex loss of aircraft control situation may occur unless the pilots are familiar with the necessary recovery techniques.

The need to familiarise pilots with procedures for the safe conduct of an MCF is well documented in several non-regulatory documents, and many safety-conscious operators elect to perform MCF pilot training. This training, alongside the formalisation of a structured approach to conducting MCFs is a logistically challenging and costly process for operators, and it cannot be assumed that all operators will adopt such measures unless compelled to.

This is where Air Law is required. The present MCF regulatory framework remains in flux and is sub-optimal across multiple jurisdictions. For the enhancement of safety, the aviation industry requires a more effective and consistent regulatory framework with clearly defined rules to govern MCF preparation, personnel training, and operational procedures. This analysis of legislation governing MCF concludes that to date, EASA is the only regulatory authority to have adopted comprehensive Air Law which enhances MCF safety. There remains much work to be done to achieve uniformity in the regulation of MCF across ICAO member states.

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ANNEX 1: INCIDENTS AND ACCIDENTS DURING MCF OPERATIONS[649]

The following non-exhaustive list describes incidents and accidents which have occurred during MCF operations within the terminus a quo and terminus ad quem of this research.

Date	Aircraft Type	Description	Investigating Authority
11 May 1976	Bell 47G-2	Helicopter crash during MCF.	Germany: Bundesstelle für Flugunfalluntersuchung
30 June 1976	Antonov An-2R	Newly fitted propeller blade failure, partial engine separation caused engine to rotate left. Remaining propeller blades cut wing spar causing in-flight structural failure.	Soviet Union: State Supervisory Commission for Flight Safety
26 August 1976	Beechcraft D95A Travel Air	During an MCF the aircraft entered an unintended spin, which was not recovered resulting in a crash.	United Kingdom: Air Accidents Investigation Branch
6 September 1976	Piper PA-34-200 Seneca	Aircraft design stress limits exceeded during MCF which resulted in wing separation.	United States of America: National Transportation Safety Board
1 October 1976	Brantly 305	Helicopter was on an MCF to investigate excessive vibration. Extreme vibration led to loss of control and a crash.	United Kingdom: Air Accidents Investigation Branch
18 April 1977	Beechcraft 200 Super Kingair	Aircraft struck water during an unauthorised MCF.	United States of America: National Transportation Safety Board
7 March 1978	Dornier Do-27A-3 Dror	Crashed after take-off during an MCF after repairs. Flight controls were reversed.	Israeli Air Force
23 May 1978	Tupolev Tu-144D	Aircraft underwent MCF prior to delivery to Aeroflot airline. Fuel leak caused in-flight fire, two engines were shutdown, cockpit filled with smoke. Aircraft performed a forced landing in a field.	Soviet Union: State Supervisory Commission for Flight Safety
4 September 1978	Cessna 421B Golden Eagle	Starboard engine failure during MCF. During a missed approach the pilot did not retract flaps, and the aircraft stalled and crashed.	United Kingdom: Air Accidents Investigation Branch
29 December 1978	Bell 212	Powerplant failure during MCF requiring an autorotation and forced landing.	United States of America: National Transportation Safety Board
28 January 1979	Fokker F-27 Friendship 500	Following repairs to ailerons, aircraft underwent MCF.	France: Bureau d'enquêtes et d'analyses (BEA)

[649] Flight Safety Foundation 'Aviation Safety Network', available at: *https://aviation-safety.net/database/*, accessed on 26 October 2023.

		Aircraft struck terrain due to pilot altimetry error.	
7 February 1979	Cessna 414	During an MCF another aircraft positioned underneath the accident aircraft to inspect the aircraft underside. The pilots failed to maintain adequate separation and a mid-air collision occurred.	United States of America: National Transportation Safety Board
15 March 1979	Cessna 340A	Aircraft crashed during an MCF to determine if previous technical defects were repaired.	Colombia: Unidad Administrativa Especial de Aeronáutica Civil
15 May 1979	Douglas DC-4	Control locks were not removed before an MCF, and the aircraft was unable to lift-off the runway and overran the runway end before colliding with an embankment.	United States of America: National Transportation Safety Board
27 June 1979	De Havilland DH-82 Tiger Moth	Aircraft suffered an engine failure during an MCF and collided with power lines.	United Kingdom: Air Accidents Investigation Branch
28 June 1979	Consolidated PBY-6A Catalina	The seaplane was undergoing taxi tests in the Tagus River to test for a leaking hull when it nosed over and broke up.	Portugal: Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários
24 January 1980	Douglas DC-3A	Aircraft underwent systems acceptance flight after not flying for 5 months. Engine number 2 failed, yet pilots incorrectly secured operable engine number 1. Co-pilot was not qualified to fly a DC-3A	Colombia: Unidad Administrativa Especial de Aeronáutica Civil
14 March 1980	Cessna 421B	During an MCF the pilots lost control of the aircraft because elevator balance weights had not been reinstalled during maintenance, which caused tailplane flutter and control rod separation.	United States of America: National Transportation Safety Board
23 March 1980	Cessna 414	During MCF pilot used a steep turn to align aircraft with the runway which caused an accelerated stall and spin which was not recovered before impacting a forest.	United Kingdom: Air Accidents Investigation Branch
11 April 1980	Douglas DC-3	After not flying for 11 months the aircraft underwent a maintenance inspection and an MCF. Shortly after take-off the left engine failed, and the aircraft crashed into trees.	United States of America: National Transportation Safety Board
10 August 1980	Piper PA-31-350 Navajo Chieftain	During take-off for an MCF the undercarriage retracted prematurely, and the aircraft settled onto the runway. Both occupants were killed.	United States of America: National Transportation Safety Board

5 January 1982	Cessna 414A	During an illegal MCF the left engine lost power, the pilot failed to maintain directional control and the aircraft collided with a structure 455m east-northeast of the runway.	Australia: Australia: Australian Transport Safety Bureau
9 July 1983	De Havilland DH.104 Dove 2A	During an MCF to test a replacement right engine, the engine failed, and the aircraft was unable to maintain altitude, crashing into the river Adur.	United Kingdom: Air Accidents Investigation Branch
19 September 1983	Beechcraft 80 Queen Air	Shortly before landing during an MCF the left engine failed, and the aircraft cartwheeled into a ditch next to the runway.	United States of America: National Transportation Safety Board
3 February 1984	Piper PA-31 Navajo	After installation of a replacement right engine, the engine had failed during two successive MCFs with safe landings being made. On the third MCF the engine once again failed, followed shortly thereafter by the left engine due to a defective fuel valve.	Australia: Australia: Australian Transport Safety Bureau
21 August 1984	Piper PA-32R-300 Cherokee	Aircraft was undergoing an MCF following repairs to the oil cooler. The engine failed, and the aircraft struck a tree killing two occupants.	Tanzania Civil Aviation Authority
22 April 1985	Beechcraft E90 King Air	During an MCF the pilots elected to perform an engine inoperative approach, which was discontinued due to gusty wind. During the overshoot the aircraft rolled over and impacted the ground.	United Kingdom: Air Accidents Investigation Branch
7 July 1985	Southdown Sailwings Puma Sprint	After rectification work to correct an engine fault, the aircraft lost engine power during an MCF and hit trees.	United Kingdom: Air Accidents Investigation Branch
6 October 1985	Skycraft Scout Mk III	An MCF was carried out following replacement of the aircraft propeller. Shortly after take-off the propeller failed, the aircraft stalled and impacted the ground.	Australia: Australia: Australian Transport Safety Bureau
22 November 1985	De Havilland DH-82a Tiger Moth	The aircraft was test flown following refurbishment work. After take-off it veered sharply and the right wing dropped, with corrective control inputs having no effect. The wing and propeller struck the ground. Suspected incorrect wing rigging caused the loss of control.	Australia: Australian Transport Safety Bureau
8 December 1985	Jodel D.9 Bebe	During the first flight after major repair and reassembly structural failure occurred in	New Zealand: Transport Accident Investigation Commission

		the aileron system and the aircraft entered a spin and crashed.	
27 February 1986	Aero Commander 500S Shrike Commander	An MCF intended to evaluate the functionality of on-board survey equipment. Faulty fuel gauges caused the pilot to be unaware of remaining fuel quantity, and the aircraft ran out of fuel and crashed.	Australia: Australian Transport Safety Bureau
26 March 1986	Cessna 402C	During the first flight following a landing gear replacement the nose landing gear became jammed in a partially extended position due to mis-rigging by maintenance. The aircraft was damaged during the landing with the nose landing gear partially extended.	Australia: Australian Transport Safety Bureau
17 May 1986	Yakolev Yak-40	During an MCF the pilot elected to perform a barrel roll which over stressed the airframe causing the left wing to separate from the airframe.	Soviet Union: State Supervisory Commission for Flight Safety
26 September 1986	Hiller UH-12E-360	The helicopter suffered an engine failure during an MCF and crashed.	United Kingdom: Air Accidents Investigation Branch
13 January 1987	NAMC YS-11A-213	During a training / MCF the pilots performed an approach to stall. During the recovery the engines malfunctioned and stopped producing thrust. The pilots performed a forced landing in a cornfield.	United States of America: National Transportation Safety Board
5 December 1987	Fairey AS-6 Firefly	During an MCF following several months of maintenance the engine oil system failed, causing partial engine seizure. The aircraft was substantially damaged during the subsequent forced landing.	Australia: Australian Transport Safety Bureau
29 December 1987	Pilatus B4 PC11	During an MCF the glider suffered tailplane buffet because of the inexperienced pilot accidentally exceeding the maximum certified speed and overstressing the airframe.	Australia: Gliding Federation of Australia
14 January 1988	Enstrom 280C-UK	During an MCF the tail rotor pedal control ceased functioning resulting in a forced landing which damaged the helicopter. Previous damage to the tail rotor input gear system was undetected during maintenance.	United Kingdom: Air Accidents Investigation Branch
4 July 1988	Cessna 310G	During an MCF the landing gear failed to extend using normal procedures and was extended using emergency	United Kingdom: Air Accidents Investigation Branch

		procedures. According to maintenance the fault was rectified yet reoccurred during the second MCF. This time the landing gear would not extend using emergency procedures, and a partial wheels-up landing was performed.	
3 March 1989	Cessna 404 Titan	During an MCF the undercarriage was cycled and indicated ‘down and locked.’ On touchdown the right main landing gear collapsed.	United Kingdom: Air Accidents Investigation Branch
31 March 1989	Boeing 737-3K2	Engine runup checks were performed on the ground following an engine change. During this check a piece of pavement broke away in the jet-blast and damaged the horizontal tail plane.	Portugal: Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários
24 July 1989	Boeing Chinook HC1	Incorrect maintenance on rear transmission caused rear engine failure during the hover check phase of an MCF. The helicopter crashed.	United Kingdom: Royal Air Force
15 September 1989	Piper PA-31T Cheyenne II-XL	During an MCF air traffic control asked the pilot to perform an orbit to obtain necessary traffic spacing, during which the pilot allowed the airspeed to decay, and the aircraft stalled, spun and crashed.	United States of America: National Transportation Safety Board
10 October 1989	Socata TB20 Trinidad	The emergency landing gear extension system was checked during an MCF, during which mechanical failure caused the landing gear to fail to extend correctly and it collapsed on landing. The cause was traced to an incorrect maintenance action.	Australia: Australian Transport Safety Bureau
21 February 1990	Piper PA-31-350 Chieftain	An MCF was required to evaluate structural repairs to the right aileron control system. Incorrect installation of this component by maintenance personnel caused the MCF pilot to lose control shortly after take-off and crash.	United States of America: National Transportation Safety Board
22 February 1991	Mitsubishi MU-2B-60 Marquise	During an MCF power was lost on the right engine. The pilot employed improper emergency procedures causing loss of aircraft control, and a fatal crash.	United States of America: National Transportation Safety Board
12 April 1991	Piper PA-31-310 Navajo	During an MCF the left engine cowlings came loose and	Sweden: Swedish Accident Investigation Authority

		detached, damaging the tailplane.	
17 July 1991	Percival P.6 Mew Gull	During an MCF for renewal of the aircraft permit to fly, the engine malfunctioned and the subsequent forced landing severely damaged the aircraft.	United Kingdom: Air Accidents Investigation Branch
20 November 1991	Bell 206B Jet Ranger II	An MCF was carried out to determine the source of an oil leak. During the MCF the engine lost power, and an autorotation resulted in a hard landing. The helicopter rolled over, caught alight and was destroyed in the fire.	Canada: Transportation Safety Board of Canada
1 March 1992	Cessna 207A Stationair 8 II	During an MCF to troubleshoot a rough running engine the engine failed, and the aircraft was damaged during the forced landing.	New Zealand: Transport Accident Investigation Commission
29 April 1992	Boeing 707-315C	During an MCF the pilot performed an unintentional wheels-up landing.	Nigeria: Nigerian Safety Investigation Bureau
25 August 1992	Fairchild SA227-AC Metro III	Incorrect application of a maintenance procedure caused the aileron controls to operate in reverse on the MCF, leading to loss of aircraft control and an accident.	United States of America: National Transportation Safety Board
2 November 1992	Douglas DC-3	Following replacement of the right engine an MCF was performed, during which the left engine caught alight and was shut down. Unable to maintain altitude, the pilots performed a forced landing.	Bolivia: Unidad de Investigación y Preventión de Accidented e incidents de Aviación de Bolivia
15 May 1993	Douglas DC-6BF	During an MCF to test engine operability, the aircraft descended in poor weather and impacted the sea.	Mexico: Directorate of Analysis of Aviation Accidents and Incidents
25 October 1993	Embraer EMB-110P2 Bandeirante	The left wheel separated during take-off on an MCF, requiring a landing gear up landing.	Thailand: Aircraft Accident and Incident Investigation Commission
19 November 1993	deHavilland Canada DHC-1B-2 Chipmunk	Engine failure during an MCF caused by a sponge which was forgotten in the fuel inlet passage during maintenance. During the attempted forced landing the pilot stalled and crashed.	United States of America: National Transportation Safety Board
4 April 1994	North American P-51D Mustang	During restoration work two oil cooler lines were inadvertently crossed, which caused catastrophic engine failure during the MCF.	United States of America: National Transportation Safety Board
29 April 1994	Aérospatiale / BAC Concorde 102	During an MCF three cabin windows shattered at Mach 2.0, which damaged the surrounding fuselage structure.	United Kingdom: Air Accidents Investigation Branch

3 September 1994	Mitsubishi MU-2B-60 Marquise	An MCF programme required each engine to be shut down and restarted in sequence. During the shutdown of the right engine the pilot lost control of the aircraft due to significant asymmetric thrust caused by the windmilling propeller, which resulted in a crash.	BFU Switzerland
16 June 1995	Bell 206B Jet Ranger II	During an MCF the helicopter lost power and was damaged in the autorotation landing. The maintenance organisation had reinstalled a previously faulty engine component which was overhauled and deemed serviceable.	United Kingdom: Air Accidents Investigation Branch
26 July 1995	Cessna S550 Citation S/II	During the landing roll of an MCF the primary braking system failed, and the pilot did not employ the emergency braking system, causing a runway overrun.	United States of America: National Transportation Safety Board
22 October 1995	Boeing 737-236	During an MCF an electrical short caused by a fluid spill during maintenance caused unintended Dutch-roll, and the crew declared an emergency. After slowing the aircraft airspeed, control was regained, and the situation downgraded to ‘urgent’. A normal landing followed.	United Kingdom: Air Accidents Investigation Branch
19 January 1996	Mitsubishi MU-2B-60 Marquise	During an MCF the left engine was intentionally shut down but could not be restarted. The pilot failed to maintain adequate airspeed and lost control on final approach.	United States of America: National Transportation Safety Board
29 February 1996	Beechcraft S35 Bonanza	Engine failure during an MCF caused by pebbles in the fuel system. Unsuccessful forced landing attempt resulted in a fatal crash.	Australia: Australian Transport Safety Bureau
30 May 1996	Cessna 340A	Aircraft suffered partial loss of power to both engines during an MCF, followed by loss of all power from the left engine. A forced landing was performed in a crop field.	United Kingdom: Air Accidents Investigation Branch
17 August 1996	De Havilland Canada DHC-8-103	During an MCF the nose landing gear did not extend using normal and emergency procedures. The aircraft was damaged during the partial gear-up landing. The cause was an incorrectly manufactured component	Australia: Australian Transport Safety Bureau

		installed during preceding maintenance.	
4 October 1996	Boeing CH-46A	During an MCF the helicopter flight control system malfunctioned due to failure of maintenance personnel to install a mandatory component. The helicopter crashed and all 3 occupants were killed.	United States of America: National Transportation Safety Board
22 December 1996	McDonnell Douglas DC-8-63F	The stall warning did not activate during the approach-to-stall phase of an MCF. The pilots unintentionally stalled the aircraft and did not apply correct stall recovery procedures which led to loss of aircraft control and caused the aircraft to crash.	United States of America: National Transportation Safety Board
11 March 1997	Bell UH-1B	During a troubleshooting flight to determine track and balance of the rotor blades, a rotor blade separated from the helicopter due to undetected fatigue cracks.	United States of America: National Transportation Safety Board
25 October 1997	Skyfox CA25N	During an MCF after maintenance to correct a flooding carburettor, the engine failed resulting in a forced landing.	Australia: Australian Transport Safety Bureau
31 March 1998	Piper PA-30-160 Twin Comanche C	During an MCF to troubleshoot a minor vibration the aircraft became almost uncontrollable due to stabiliser flutter, and a forced landing was performed. The investigation revealed that a component had been omitted during preceding maintenance.	United Kingdom: Air Accidents Investigation Branch
18 June 1998	Hawker Hunter T Mk 8	During an MCF following aircraft restoration the aircraft ran out of fuel because faulty fuel gauges incorrectly overread the remaining fuel quantity. The pilot ejected from a low altitude and did not survive.	United States of America: National Transportation Safety Board
4 November 1998	Mitsubishi MU-2B-60 Marquise	During an MCF at night in poor weather the left engine was intentionally shutdown, during which the pilot did not maintain control of the aircraft resulting in a crash.	United States of America: National Transportation Safety Board
28 November 1998	De Havilland Canada DHC-7-102	During an MCF to evaluate 3-engine climb performance, the outer left engine was shutdown. The pilots allowed the aircraft to enter an unintended stall, from which recovery was attempted with	United Kingdom: Air Accidents Investigation Branch

		asymmetric engine power. This resulted in loss of control and a crash.	
14 December 1998	Bell 54G-5	Engine failure during an MCF, autorotation with resultant hard landing damaged the helicopter.	United States of America: National Transportation Safety Board
6 May 1999	Canadair CL-600-2B16 Challenger 601-3R	During a high-speed taxi test to troubleshoot a fault with an engine thrust reverser the aircraft unintentionally became airborne, followed by a hard nose-low touchdown which broke the nose wheel off.	No intention for flight existed, therefore no NTSB investigation was authorised. FAA report 199905060215901 refers
20 January 2000	Bell UH-1H	During an MCF the engine lost power and the helicopter was damaged by a hard landing during autorotation	United States of America: National Transportation Safety Board
7 July 2000	Piper PA-46-350p Malibu Mirage	The aircraft ran out of fuel during an MCF due to the pilot being unfamiliar with the fuel indicating system.	United Kingdom: Air Accidents Investigation Branch
19 October 2000	Beechcraft 300 Super King Air 350	During an MCF a component within the left main landing gear failed, meaning normal and emergency landing gear extension procedures were unable to extend the left landing gear. The aircraft was damaged in the resultant partial gear landing.	Transport Safety Investigation Bureau, Singapore
24 November 2000	Beechcraft F90 King Air	Incorrect rigging of propeller assemblies during maintenance caused both propellers to feather shortly after take-off. The aircraft was substantially damaged in subsequent forced landing.	United States of America: National Transportation Safety Board
18 December 2000	Aérospatiale SA 365N1 Dauphine 2	Failure of maintenance personnel to fill tail rotor gearbox oil to correct quality during maintenance caused seizure of the tail rotor anti-torque pedal, and control of the helicopter was partially lost during an MCF. The helicopter was substantially damaged in the crash landing.	United States of America: National Transportation Safety Board
28 February 2001	Bell 412SP	A pilot not correctly trained in MCF procedures allowed rotor speed to decay during an intentional autorotation in an MCF, resulting in loss of control of the helicopter.	United States of America: National Transportation Safety Board
15 October 2001	Cessna 414	Partial landing gear collapse during an MCF caused by component failure after maintenance.	Canada: Transportation Safety Board of Canada

2 January 2002	Beechcraft 58P Baron	Immediately after take-off on an MCF fire was noticed in the left engine. The aircraft was immediately landed and evacuated. The source of the fire was maintenance related: improper clearance between engine accessory components.	United States of America: National Transportation Safety Board
21 March 2002	Republic P-47N-20-RE	The aircraft underwent an MCF following replacement of the engine. Incorrect installation of an exhaust tube caused an intense in-flight engine fire.	United States of America: National Transportation Safety Board
28 March 2002	Boeing S.307 Stratoliner	The aircraft ran out of fuel during a systems acceptance / training flight and ditched in a nearby bay. The flight crew had not adequately determined and communicated the fuel quantity before departure.	United States of America: National Transportation Safety Board
22 April 2002	Cessna A185F Skywagon	The aileron flight control cables were inadvertently crossed during maintenance, which caused the controls to operate in reverse. The aircraft departed the runway during take-off and was damaged.	Canada: Transportation Safety Board of Canada
15 June 2002	De Havilland Canada DHC-8-311	A landing gear component was incorrectly installed during maintenance. During the subsequent MCF the right main landing gear failed to lock down despite the use of normal and emergency procedures, resulting in the gear collapsing during landing.	Dutch Safety Board
29 October 2002	Curtiss C-46	During taxi-in after an MCF the right landing gear collapsed because of a failure of the locking device.	United States of America: National Transportation Safety Board
16 December 2002	Sikorsky S-61N Shortsky	During maintenance a bearing was over-torqued which caused an engine component to fail resulting in loss of engine power and an engine fire during an MCF.	Canada: Transportation Safety Board of Canada
19 March 2003	Aero Commander 500S Shrike Commander	Improper installation of an engine fuel fitting caused an engine fire during an MCF, which required an off field forced landing.	United States of America: National Transportation Safety Board
21 March 2003	Socata TB10 Tobago	During an MCF after a 100-hour inspection the engine throttle became stuck at maximum.	France: Bureau d'enquêtes et d'analyses (BEA)
24 March 2003	Rockwell Aero Commander 695 Jetprop 980	Following a partial engine failure during an MCF, the pilot lost control of the aircraft	Japan Transport Safety Board

		which entered an irrecoverable spin.	
5 April 2003	Cessna 207	The aircraft ran out of fuel during a cross-country MCF intending to run-in a new engine and was severely damaged during the forced landing.	United States of America: National Transportation Safety Board
16 September 2003	Piper PA-28R-200	Incorrect installation of an engine component during engine overhaul caused engine failure during an MCF.	United States of America: National Transportation Safety Board
18 November 2003	Westland Gazelle HT2	During a hover manoeuvre to check a compass anomaly the pilot’s seatbelt became jammed in the cyclic control resulting in the pilot’s inability to control the helicopter. The helicopter was damaged beyond economical repair in the hard landing.	United Kingdom: Air Accidents Investigation Branch
21 November 2003	Beechcraft 55 Baron	Debris entered the fuel system during maintenance and caused loss of engine power during an MCF. The pilot did not correctly apply the requisite emergency procedure, and the aircraft crashed into a building.	United States of America: National Transportation Safety Board
1 July 2004	Eurocopter AS 350B2	Improper installation of an engine component during maintenance caused an uncontrolled descent during an MCF. After a hard landing the helicopter was destroyed by a fire.	United States of America: National Transportation Safety Board
22 July 2004	Piper PA-34-200 Seneca	During an airworthiness test flight, the left engine was intentionally shut down prior to the evaluation of single engine climb performance using the right engine. During the manoeuvre the right engine failed, and the aircraft crash landed.	United Kingdom: Air Accidents Investigation Branch
17 June 2005	Cessna 340A	During taxiing after an MCF the right main landing gear collapsed, caused by improper installation of components during maintenance.	United States of America: National Transportation Safety Board
5 February 2006	Shorts 360-100 (2 aircraft)	Both aircraft were undergoing MCFs to evaluate maintenance on the fuel system when the pilots decided to fly in formation. Neither pilot was trained for formation flying, and the aircraft collided mid-air.	United States of America: National Transportation Safety Board

12 October 2006	Beechcraft 200 Super King Air	Right main landing gear collapsed on landing after an MCF because of improper maintenance on a landing gear component.	United States of America: National Transportation Safety Board
22 March 2007	Aérospatiale SA 342J Gazelle	An unqualified pilot performed a systems acceptance flight and ran out of fuel. The helicopter was wrecked in the resultant forced landing.	Swedish Accident Investigation Authority
27 July 2007	Luscomb-8	The elevator control cables were installed incorrectly during reassembly, causing the elevator pitch control to operate in reverse. This went unnoticed during pre-flight checks, and the pilot attempted an MCF. During take-off the aircraft responded in reverse to elevator control inputs, causing it to nose over and come to rest inverted.	France: Bureau d'enquêtes et d'analyses (BEA)
23 June 2008	Cessna 177RG Cardinal	Forced landing performed because of a loss of engine power during an MCF.	Spain: Comisión de Investigación de Accidentes e Incidentes de Aviación Civil
1 September 2008	Convair CV-580	During heavy maintenance the elevator trim mechanism was unintentionally reversed, causing the pilots to experience control difficulties during an MCF. The aircraft crashed in a cornfield.	United States of America: National Transportation Safety Board
9 September 2008	Gippsland GA-8 Airvan	The engine lost power during an MCF and the aircraft was damaged during the resultant forced landing.	Australia: Australian Transport Safety Bureau
15 October 2008	Mudry Cap-10	The windshield was removed and reinstalled during maintenance. The pilot performing the MCF accelerated the aircraft towards its maximum certified speed whereupon the windshield shattered, causing injury to the pilot. The pilot decelerated the aircraft and preformed a safe landing.	France: Bureau d'enquêtes et d'analyses (BEA)
27 November 2008	Airbus A320-232	Aircraft stalled and crashed during the low airspeed check phase of an MCF because frozen angle of attack sensors inhibited activation of stall protection system.	France: Bureau d'enquêtes et d'analyses (BEA)
12 January 2009	Boeing 737-73V	Aircrew temporarily lost control during an elevator power off test during an MCF and applied incorrect recovery	United Kingdom: Air Accidents Investigation Branch

		techniques. The aircraft landed safely.	
27 January 2009	Cessna 210A	Failure of the hydraulic power system caused the landing gear to not fully extend during an MCF. The aircraft was substantially damaged during the landing.	United States of America: National Transportation Safety Board
19 May 2009	Boeing 737-73V	During an elevator power off test the crew unintentionally omitted some steps, causing a significant nose-down pitch and right roll. The rudder PCU remained unpowered meaning the pilots' attempts to correct the roll moment with rudder were unsuccessful. The pilots regained control and landed safely.	United Kingdom: Air Accidents Investigation Branch
16 July 2009	Robin DR-400	During an MCF the fabric skin of the upper wing surface separated, causing control difficulties. The pilot performed a successful emergency landing. The fabric was damaged during a previous maintenance task during which a fuel tank was removed and reinstalled.	France: Bureau d'enquêtes et d'analyses (BEA)
8 August 2009	Mooney M20F Executive	Nose wheel collapsed during the landing roll of an MCF to evaluate landing gear maintenance. A component was installed upside down during the preceding maintenance.	United Kingdom: Air Accidents Investigation Branch
23 October 2009	Daher Socata TB 10	Incorrect installation of a fuel pipe caused a hole to wear in the pipe, through which air was drawn. During an MCF this air caused a loss of engine power requiring an immediate landing, during which the aircraft vacated the runway.	France: Bureau d'enquêtes et d'analyses (BEA)
9 November 2009	Beechcraft B200 King Air	Pilot performing an MCF did not evaluate the fuel quantity before departure, and the aircraft ran out of fuel during the flight.	United States of America: National Transportation Safety Board
11 November 2009	Dassault Falcon 2000	An aircrew performed multiple high speed taxi checks to identify the cause of a braking defect. An accumulation of heat in the brakes caused a fire which damaged the aircraft underside.	United Kingdom: Air Accidents Investigation Branch
2 March 2010	Beechcraft A90 King Air	Upon touchdown after an MCF the left main landing gear separated due to torsional	United States of America: National Transportation Safety Board

		overload caused by improper maintenance, and the pilot's decision to perform the flight with an over-extended gear strut.	
16 April 2010	Bell 412EP	The engine input shaft fasteners failed during an MCF causing a loss of engine power. The helicopter was damaged during the resultant autorotation landing.	Nigeria: Nigerian Safety Investigation Bureau
17 May 2010	Cessna P206B	Engine failure during an MCF caused by fuel contamination.	United States of America: National Transportation Safety Board
13 August 2010	Dassault Falcon 50	Aircraft departed the runway during landing on an MCF because the hydraulic lines supplying fluid to the emergency brake system were reversed.	France: Bureau d'enquêtes et d'analyses (BEA)
20 December 2010	Diamond DA-42	During an MCF the left engine started vibrating excessively. This engine was voluntarily shutdown by the pilot, who thereafter made a procedural error which caused the right engine to fail. The pilot corrected his error and restored power to the right engine before landing safely.	France: Bureau d'enquêtes et d'analyses (BEA)
27 January 2011	Fokker F-27 Friendship 500CRF	Pilots performing an MCF aborted the take-off. The aircraft overran the runway which caused the nosewheel to collapse.	Kenya: The Chief Investigator of Air Accidents, Kenya
14 February 2011	Gulfstream G-V-SP	A systems acceptance flight was performed following fitment of the aircraft's cabin. During approach a hydraulic system failed, and the pilots continued to land despite insufficient landing distance available to accommodate the hydraulic failure. The aircraft overran the runway, and the left main gear collapsed.	United States of America: National Transportation Safety Board
4 March 2011	McDonnell Douglas MD-82	During a high-speed taxi manoeuvre to evaluate aircraft systems the aircraft inadvertently became airborne at an airspeed inadequate for sustained flight, causing the aft fuselage to contact the runway.	United States of America: NTSB on behalf of the Civil Aviation Authority of Barbados.
8 March 2011	De Havilland Canada DHC-6 Twin Otter 100	An MCF was performed following replacement of both engines, during which the pilot unintentionally stalled the aircraft which crashed, killing both pilots.	United States of America: National Transportation Safety Board

24 May 2011	Beechcraft C90 King Air	Following extended storage, the aircraft underwent a systems acceptance flight prior to being ferried to a maintenance base for maintenance. During the flight engine power was lost, the aircraft crashed, and both occupants were killed in the post impact fire. The OEM 'return from storage' procedure was not adhered to.	Nigeria: Nigerian Safety Investigation Bureau
12 September 2011	Piper PA-31P-425 Pressurised Navajo	Aircraft suffered loss of engine power during an MCF and crashed.	Mexico: Directorate of Analysis of Aviation Accidents and Incidents
19 November 2011	ATR 42-320A	During an MCF and change of operator demonstration flight, aircraft control was lost when the pilots stalled the aircraft during an approach to stall manoeuvre to test the stall warning system. Control was regained and the aircraft landed safely.	Brazil: Centro de Investigação e Prevenção de Acidentes Aeronáuticos
20 July 2012	Piper PA-28-180	During an MCF the aircraft suffered total loss of engine power due to oil exhaustion. The maintenance personnel had not applied correct torque to the oil filter which caused oil leakage.	United States of America: National Transportation Safety Board
7 August 2012	Boeing 757-2K2	A fuel leak developed during an MCF because of a damaged O-ring seal which was installed during the preceding maintenance. An engine was shut down in accordance with published emergency procedures and the aircraft landed safely.	United Kingdom: Air Accidents Investigation Branch
15 March 2013	Piper PA-31T Cheyenne II	Aircraft experienced an unknown emergency during an MCF, during which the pilot stalled the aircraft and lost control. The aircraft was destroyed, and pilot killed in the resulting crash.	United States of America: National Transportation Safety Board
21 May 2013	Rockwell Commander 114	The left wingtip was damaged during landing from an MCF when the pilot's seat came loose and slid full aft while he continued to hold the control stick.	United States of America: National Transportation Safety Board
25 June 2013	McDonnell Douglas MD 500E	A rag was forgotten in the helicopter's engine inlet duct during maintenance. The rag was ingested during the MCF which caused the total loss of engine power.	United States of America: National Transportation Safety Board

25 August 2013	Airbus A300B4-622R	A 4x1 foot external panel separated from the aircraft during an MCF.	United Kingdom: Air Accidents Investigation Branch
6 December 2013	Embraer ERJ-170LR	An MCF was required to test the ram-air-turbine (RAT) backup electrical generator. After the RAT operation was verified, the crew flew the approach and landing using only RAT power, without restoring normal AC electrical power. When the aircraft airspeed reduced during the landing roll, RAT RPM decayed, and all electrical power was lost. With no electrical power to supply aircraft steering, the aircraft departed the runway and was damaged.	Libya: Libyan Ministry of transport
14 January 2014	Gulfstream G200	The APU access door was not correctly latched during maintenance and separated during an MCF causing damage to the aft aircraft structure.	United States of America: National Transportation Safety Board
16 March 2014	Canadair CL-600-2B16 Challenger 604	Pilots performing an MCF were required to configure the aircraft in a simulated electrical emergency state, to verify operation of a backup system. After completion of this task the pilots did not restore normal electrical configuration and landed the aircraft with several systems inoperative causing overheated brakes, deflated tyres and damage to the wheels.	United Kingdom: Air Accidents Investigation Branch
24 March 2015	Cessna 208B Supervan 900	Installation of non-conformal gears in the fuel pump during maintenance caused a loss of engine power during an MCF. The aircraft was substantially damaged in the resultant forced landing.	United States of America: National Transportation Safety Board
30 May 2015	Cessna 207 Skywagon	During an MCF intended to ‘break-in’ a new engine the pilot became incapacitated by carbon monoxide gas which leaked from the engine compartment into the cockpit and collided with terrain.	United States of America: National Transportation Safety Board
3 November 2015	Eurocopter AS 365N3 Dauphin 2	A spanner was left in the helicopter rotor head area by maintenance personnel, which caused damage to a main rotor blade during the MCF.	Australia: Australian Transport Safety Bureau

6 September 2016	Sikorsky S-61N	Dual engine loss of power during rearward flight manoeuvre of an MCF, possibly attributable to a compressor stall. The helicopter was damaged beyond economic repair.	United States of America: National Transportation Safety Board
29 January 2017	Cessna 402 Falcon	Shortly after take-off following scheduled maintenance work the engine lost power, and the aircraft was substantially damaged in a forced landing.	South Africa: Civil Aviation Authority
13 May 2017	Cessna T188 Ag Husky	Engine failure during an MCF caused by inadequate maintenance of the fuel system.	Spain: Comisión de Investigación de Accidentes e Incidentes de Aviación Civil
15 November 2017	Aérospatiale AS 355F2 Écureuil II	During the hover check phase of an MCF the pilot accidentally pushed an incorrect button which caused the helicopter to abruptly descend onto the tarmac, causing substantial damage.	Malaysia: Air Accident Investigation Bureau Malaysia
16 March 2018	Pilatus PC-6/B2-H2 Turbo Porter	During an MCF the rudder bar became disconnected rendering the rudder unusable. Consequently, directional control was lost during the landing, and the aircraft was damaged when the wingtips and propeller contacted the ground.	France: Bureau d'enquêtes et d'analyses (BEA)
28 June 2018	Beechcraft C90B King Air	The aircraft crashed into a building site during an MCF because pilots became spatially disorientated in poor weather with asymmetric engine power.	India: Aircraft Accident Investigation Burau.
17 August 2018	Cessna 525B Citation Jet CJ3	During a troubleshooting flight which sought an autopilot defect, the pilot exhibited poor flight path management by not adhering to published air traffic procedures which endangered other traffic. This was attributed to his lack of familiarity with the use of the autopilot system, and resultant unpreparedness for the MCF.	Switzerland: Swiss Transport Safety Investigation Board.
29 November 2018	Piper PA-30-160 Twin Comanche	The aircraft crashed during an MCF following loss of power from the left engine and poor flight path management by the pilot, which caused a stall and loss of control.	United States of America: National Transportation Safety Board
8 March 2019	Piper PA-31-325 Navajo	While taxiing in after an MCF the right main landing gear collapsed because the relevant	United States of America: National Transportation Safety Board

		actuators had been improperly rigged during the annual maintenance inspection,	
19 September 2019	ATR 42-600	During a pre-delivery test flight, the aircraft experienced a loss of engine power caused by a modification to the engine oil system and exacerbated by in-flight manoeuvres. The aircraft landed safely at its aerodrome of departure.	France: Bureau d'enquêtes et d'analyses (BEA)
2 February 2020	Cessna U206 Skywagon	The aileron control cables were incorrectly installed during maintenance, causing control reversal which was undetected in pre-flight checks. During take-off for an MCF directional control was lost, and the left-wing tip contacted the ground. The aircraft was substantially damaged.	France: Bureau d'enquêtes et d'analyses (BEA)
8 July 2020	Piper PA-34-200 Seneca 1	During an MCF the nose landing gear failed to extend because of a component failure in the nose gear system. The aircraft was damaged in the resultant partial gear landing.	South Africa: Civil Aviation Authority
23 December 2020	Airbus Helicopters H125	The helicopter struck terrain during an MCF when the pilot lost depth perception flying at low level over featureless snow-covered terrain.	Russia: Interstate Aviation Committee, Accident Investigation Commission
2 April 2021	De Havilland Canada DHC-8-102	During an MCF a system check of the left engine was carried out, during which the left propeller exceeded operating limitations. The normal feathering system failed to actuate which required use of the alternate feathering system. The aircraft landed safely, but a similar malfunction occurred during a subsequent MCF 2 days later.	Canada: Transportation Safety Board of Canada
28 May 2021	Airbus A320-232	During a preservation flight in the Covid 19 pandemic a fault occurred with the right engine, which lost power and was shut down. The aircraft landed safely. The cause of the fault was erroneous activation of the engine's overspeed protection valve.	United Kingdom: Air Accidents Investigation Branch
6 July 2021	Eurocopter AS 350B3 Écureuil	During an MCF debris in the fuel cell caused a loss of engine power. The helicopter	Canada: Transportation Safety Board of Canada

		suffered structural damage in the resultant forced landing.	
13 July 2021	Airbus A319-111	The aircraft undertook a non-scheduled flight after not having flown for several weeks. A blockage in the pitot tube caused an unreliable airspeed indication which was detected during take-off, and a high speed rejected take-off manoeuvre was performed.	United Kingdom: Air Accidents Investigation Branch
2 August 2021	Piper PA-34-200T Seneca II	During the landing phase of an MCF the nose landing gear collapsed because a component in the nose gear mechanism had broken. The aircraft was damaged.	Canada: Transportation Safety Board of Canada
23 August 2021	Piper PA-18A-150 Super Cub	Engine failure for undermined reasons during an MCF. The pilot performed a successful forced landing.	South Africa: Civil Aviation Authority
14 September 2021	Beechcraft 18	The aircraft underwent an MCF following rectification of a previous defect. The pilot accidentally selected a fuel tank which contained insufficient fuel for the MCF. Once the fuel in the tank was exhausted both engines failed, and the aircraft crashed into trees.	France: Bureau d'enquêtes et d'analyses (BEA)
8 October 2021	Airbus A320-214	Excessively hard landing during an operational check flight to assess autopilot performance during a new approach procedure.	Colombia: Unidad Administrativa Especial de Aeronáutica Civil