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Optimising the Management of Repetitive System Defects:
Evaluation and Process Development within a CAMO Environment

Faculty of Engineering and Applied Sciences
Airworthiness

MSc
Academic Year: 2025 - 2026

Supervisor: Dr Wai Nang Chung

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This thesis is submitted in partial fulfilment of the requirements for
the degree of MSc Airworthiness

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Abstract

Repetitive system defects (RSD) demand urgent intervention to mitigate potential safety risks. In the absence of explicit regulatory guidance, Continuing Airworthiness Management Organisations (CAMOs) have developed disparate processes for managing such defects. Unlike deferred or carried-forward defects, which remain open and highly visible in technical logbooks, RSD are typically closed after each occurrence, reducing transparency. This raises a critical question: should the pilot-in-command, who has responsibility for accepting or rejecting an aircraft, be informed when an aircraft may not be fully technically airworthy, thereby introducing additional operational risk?

This study focuses on short-term actions for addressing RSD rather than long-term reliability monitoring. It examines effective handling of RSD from both CAMO and flight crew perspectives, highlighting deficiencies in process, terminology, and communication. A mixed-methods approach was employed, combining questionnaires and interviews for Maintenance Control Centre (MCC) engineers, while commercial pilots completed an online questionnaire.

Findings confirm inconsistent terminology and regulatory practices across CAMOs and authorities. MCC engineers regard pilots as key contributors to troubleshooting, recognising that information shared with cockpit crew can expedite technical resolution and support in-flight decision-making. Pilots, in turn, expressed a strong desire to be informed of their aircraft's technical status to assess risk and consider operational and technical factors in real time. The introduction of rogue components into aircraft affected by RSD is also a significant concern. This research underscores the criticality of effective RSD management. Several recommendations are made, including the definition of a repetitive system defect as 3 or more occurrences within 25 sectors. An optimal process framework for CAMOs is presented, alongside recommendations for National Aviation Authorities.

Keywords: repeat; recurring; recurrent; operational risk management; aircraft maintenance control; flight crew communication

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List of Abbreviations

AAIB	Air Accidents Investigation Branch
ACARS	Aircraft Communications Addressing and Reporting System
ACMI	Aircraft Crew Maintenance Insurance
ACMS	Aircraft Condition Monitoring System
ADIRU	Air Data Inertial Reference Unit
ADM	Air Data Module
AFS	Auto-Flight System
AMO	Approved Maintenance Organisation
AMP	Aircraft Maintenance Programme
AOC	Air Operator Certificate
AOG	Aircraft on Ground
BITE	built-in test equipment
CAA	Civil Aviation Authority
CAME	Continuing Airworthiness Management Exposition
CAMO	Continuing Airworthiness Management Organisation
CAR	Canadian Aviation Regulation
CASA	Civil Aviation Safety Authority (Australia)
CAT	Commercial Air Transport
CDL	Component Deviation List
CFDIU	Centralised Fault Display Interface Unit
CFDS	Centralised Fault Detection System
CFR	Code for Federal Regulations
CoA	Certificate of Airworthiness
CRS	Certificate of Release to Service
CURES	Cranfield University Research Ethics System
DAH	Design Approval Holder
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitor
EIS	Electronic Instrument System
EPAS	European Plan for Aviation Safety
ETOPS	extended twin range operations
FAA	Federal Aviation Administration (United States)

FADEC	Full Authority Digital Engine Control
FCOM	Flight Crew Operating Manual
GCU	Generator Control Unit
IATA	International Air Transport Association
IOSA	IATA Operational Safety Audit
LH	left hand
LRU	line replaceable unit
M&E	Maintenance & Engineering
MAA	Military Aviation Authority
MCC	Maintenance Control Centre
MEL	Minimum Equipment List
MOE	Maintenance Organisation Exposition
MVP	minimum viable product
n	number of responses
NAA	National Aviation Authority
NLP	natural language processing
No	number
NTSB	National Transportation Safety Board
PFR	post-flight report
PIC	pilot-in-command
RAF	Royal Air Force
RH	right hand
RSD	repetitive system defects
SMS	Safety Management System
TCAS	Terrain Collision Avoidance System
TCCA	Transport Canada Civil Aviation
T/S	Trouble Shooting
TSE	Technical Services Engineer
TSM	Trouble Shooting Manual

1 Introduction

Aircraft maintenance is critical in ensuring aircraft continuing airworthiness. According to Kinnison & Siddiqui (2013), “maintenance is the process of ensuring that a system continually performs its intended function at its designed-in level of reliability and safety”.

This definition underscores the point that all equipment on an aircraft was designed for a specific purpose, and maintenance encompasses far more than the routine, observable tasks typically associated with servicing an aircraft. It extends beyond the traditional inspections, restorations, adjustments or mere replacement of physical components and involves a comprehensive effort to ensure system integrity at the inherent level of reliability and safety. With the increasing complexity and integration of systems on modern airliners, maintenance has taken on an added dimension that demands deeper technical understanding (Kinnison & Siddiqui, 2013).

An aircraft system must perform its intended function, and in this regard, questions arise when a latent fault manifests only intermittently. Under such circumstances, can the system still be regarded as reliable and safe at the level envisioned in its original design? Could such a fault lead to an in-flight failure that imposes additional workload on the flight crew? Ultimately, does the aircraft remain safe for continued operation?

1.1 Context and Background

Traditionally, discussions of reliability focus on long-term technical performance trends. Many Continuing Airworthiness Management Organisations (CAMOs) assess reliability data on a monthly or quarterly basis, producing periodic reports. As a result, reliability actions frequently become non-urgent measures aimed at improving technical dispatch rates and contributing to the long-term technical enhancement of fleet performance. However, such intervals are often too long to enable timely detection and action as required for repetitive system defects (RSD).

It is therefore critical to distinguish between long-term reliability monitoring, which is well supported by existing regulatory frameworks, and the short-term, urgent interventions required to address RSD. These immediate actions are essential not only for preventing further degradation of system performance, but also for ensuring the continued safety of aircraft operations.

The absence of explicit regulation or regulatory guidance has resulted in CAMOs developing their own processes and procedures in dealing with such defects. Unlike deferred or carried-forward defects, which remain open, are highly visible in the technical logbook, and subject to constant monitoring, repetitive defects are typically closed after each occurrence once maintenance actions have been carried out in accordance with approved data. As a result, these defects become far less visible, appearing only within the logbook history. When the underlying fault subsequently reappears, it is recorded as a new entry. This creates a repeating cycle of maintenance action without necessarily addressing the root cause.

Because maintenance personnel operate in rotating shifts and may work across multiple aircraft, they may not readily recognise the repetitive nature of such faults. Without systematic oversight and proactive analysis by the CAMO, these repeated occurrences can remain undetected. When such defects involve critical systems, the lack of visibility and timely intervention poses the risk of escalating into a safety concern (EASA, 2024b).

1.2 Problem Statement

The concept of airworthiness can be understood as comprising two distinct elements (Hieminga, 2017):

1. Technical airworthiness, and
2. Legal airworthiness

Technical airworthiness refers to the physical condition of the aircraft and addresses the fundamental question of whether the aircraft is safe to operate without harm to its occupants or the public. It encompasses considerations such as the absence of outstanding defects, the completion of required maintenance

tasks, adherence to approved procedures, the timely performance of scheduled work, and the quality and correctness of the workmanship involved.

In daily operations, when an aircraft develops a technical issue, such as defect or a fault, a corresponding entry is made in the logbook. This entry must be actioned and certified by a licensed engineer. Once the required maintenance action is complete, the aircraft may be considered technically airworthy again, provided no additional open pilot or maintenance reports remain.

On the other hand, legal airworthiness concerns matters such as the proper certification of documentation, the validity of personnel authorisations, compliance with airworthiness directives, and the possession of a valid Certificate of Airworthiness and Airworthiness Review Certificate. Although discrepancies in these areas may render an aircraft legally unserviceable, they do not necessarily imply that the aircraft is physically unsafe to operate. Nevertheless, because this cannot be established with complete certainty, any such finding is treated as though it were a newly identified technical discrepancy (Hieminga, 2017).

From a CAMO perspective, there is generally no justification for keeping an aircraft grounded if it is deemed both technically and legally airworthy at that moment, based on all available information. However, there exists a situation “where the paperwork declares an aircraft to be airworthy but the technical state of an aircraft is such that it cannot fall back on all of the redundancy or safety that has been designed into it” (Hieminga, 2017).

Consequently, in the context of operation with RSD, an aircraft may be legally airworthy (holding official certification for each logbook entry), yet potentially technically unairworthy; a condition this is neither immediately evident nor known.

This mandates the need for the effective management of RSD. If the CAMO does not intervene to identify and address the recurring nature of these faults, this situation may give rise to the discrepancy becoming a safety concern,

rather than merely a reliability issue (Arshadi, 2024). At this stage, therefore, the matter extends beyond a mere technical defect.

Finally, the pilot-in-command (PIC) has the ultimate responsibility to accept or reject an aircraft prior to flight (EASA, 2025). Should the PIC be informed that although the aircraft is legally airworthy, it is possible that it is not fully technically airworthy, thereby introducing additional operational risk?

This study investigates the effective handling of repetitive system defects, not only through the lens of a CAMO as the driving body, but also from the flight crew's perspective. It addresses process and terminology deficiencies, and communication elements between the CAMO and the PIC.

1.3 Motivation

The motivation behind this project stems from the absence of any formal requirement or guidance within EASA regulations for the effective management of repetitive defects.

Furthermore, the findings of Arshadi (2024) underscore existing gaps within organisational practices, reinforcing the need for improvement; and inconsistent terminology across the industry. These findings stress that a unified approach is required, with an emphasis on developing standard practices, and focusing on the element of communication.

In addition, this subject is already under the scrutiny of EASA, listed in the European Plan for Aviation Safety (EPAS), Volume III, within the proposed Safety Risk Portfolios 2025 Edition (EASA, 2024b). Specifically, the Airworthiness Portfolio SI-9001, titled "Inadequate management of repetitive defects" remains an active initiative. It addresses the safety implications of recurring issues in critical aircraft systems and considers whether flight crews should be informed of such defects. This would enable more accurate risk assessment and improved situational awareness in the event of a system failure.

This project therefore presents a valuable opportunity to contribute by recommending terminology, developing a standardised process, and integrating best practices observed across various CAMOs, based on the research conducted. It is anticipated that establishing a consistent, best-practice framework for all CAMOs could enhance the overall approach to managing RSD, ultimately contributing to improved safety and more effective airworthiness oversight. The critical nature of this issue, and its role in maintaining safe and reliable operations, should not be underestimated.

In contrast to the research of Arshadi (2024), whose dataset comprised individuals in various management roles within the CAMO, this study focuses on data obtained from Maintenance Control Centre (MCC) Engineers, who serve as front-line personnel within the CAMO. To strengthen the validity of the findings, it was deemed essential to maintain a consistent baseline; and to engage with those directly involved in day-to-day operations, thereby capturing the most accurate and practical snapshot of current practices.

Given the limited research on communication between CAMO and the flight crew (particularly in this research area), it was also recognised early in the project that it was immensely beneficial to examine pilots' perspectives too. Consequently, while the primary focus of this study concerns the engineering aspect, the considerations and insights of flight crew are also explored and analysed. As will be demonstrated in the subsequent chapters, the inclusion of the pilots' study proved particularly beneficial, yielding valuable information; especially for topics where engineering stakeholders' views were potentially divided and lacked a general consensus.

The terms pilots, aircraft flight crew, crew members and cockpit crew will be used interchangeably throughout this study.

1.4 Aim

This study aims to evaluate current practices and regulatory frameworks related to the management of repetitive system defects within CAMO environments,

identify key gaps and challenges, and develop an optimal, standardised process that enhances defect tracking, analysis, resolution and continuous oversight.

1.5 Objectives

The objectives of this research are:

1. To compare current EASA and other national aviation authority (NAA) regulations, guidance materials and other available literature regarding the management of repetitive defects.
2. To assemble a comparative table outlining how terms like *repeat*, *repetitive* and *recurrent* defects are defined and interpreted across different NAAs, highlighting any inconsistencies.
3. To evaluate and assess findings from research involving CAMO personnel and commercial air transport pilots, detailing practical challenges and current handling methods; together with the strengths and weaknesses of current processes for repetitive defect management, including different software aids.
4. To design a clearly defined, optimal process model for identifying, tracking and managing repetitive defects within a CAMO, incorporating best practices and stakeholder feedback.
5. To propose a set of recommendations to EASA and other NAAs, concerning handling of repetitive defects; presenting proposed enhancements and guidance material to address the identified gaps.

1.6 Thesis Structure

This thesis is structured into four additional chapters beyond this Introduction.

Chapter 2 provides a comprehensive literature review, examining existing research on this topic including regulatory requirements, accidents and incidents, and highlighting gaps that this study aims to address. Chapter 3 details the methods and tools used for this research.

In Chapter 4, in study's results are presented alongside an integrated discussion that interprets the findings in relation to the research objectives. This chapter also details the recommendations arising from this study.

Finally, Chapter 5 concludes the thesis by summarising its principal contributions, acknowledging its limitations and proposing directions for future research.

2 Literature Review

2.1 Introduction

This chapter provides a focused literature review on the effective management of repetitive defects in commercial aviation. As direct research on repetitive defect management is limited, this review draws on related fundamental areas, including the critical role of aircraft maintenance in ensuring airworthiness, a critical review of terminology used to describe repetitive defects, and historical accident cases that illustrate the significant safety risks posed by unresolved or recurring technical issues.

2.2 Airworthiness

The concept of airworthiness lacks a universally accepted definition, with interpretations varying across regulatory agencies. At first glance, this divergence may appear to be a matter of terminology; however, the implications of these definitions go beyond semantics. A comprehensive review of airworthiness definitions was undertaken by Lacey (2023) in a doctoral thesis at Cranfield University, which provides valuable insight into these variations.

While the Oxford Dictionary offers a simplistic interpretation of airworthiness as “safe to fly”, Lacey (2023) demonstrates that regulatory definitions are more intricate. For instance, the European Defence Agency defines airworthiness as “the ability of an aircraft... to operate in flight and on ground without a significant hazard to aircrew, ground-crew, passengers (where relevant) or to third parties”. This definition emphasises operational safety. Lacey’s analysis, however, introduces a critical dimension: airworthiness is not solely about the aircraft’s fundamental capability but also about the processes underpinning its maintenance and operation. Specifically, she argues that work should be “undertaken by competent and authorised individuals, according to approved procedures and instructions” (Lacey, 2023). This addition shifts the focus from a purely technical construct to one that integrates organisational competence and procedural integrity. This highlights the systemic nature of airworthiness and its

dependence on the interplay between technical standards, legal compliance and operational practices.

Similarly, Hieminga (2017), frames this discussion as a dual construct comprising technical and legal aspects. This perspective is particularly relevant to this thesis, which explores the potential for threats to technical airworthiness even though legal compliance is achieved, as outlined in the problem definition in Chapter 1. For instance, adherence to task certification requirements, correct application of MELs, and component testing using approved facilities may satisfy regulatory obligations, yet risks such as latent faults, or limitations in testing equipment, can persist.

Given that the assurance of airworthiness is intrinsically linked to the quality and integrity of maintenance practices, the following section examines aircraft maintenance as a fundamental pillar in sustaining technical and legal airworthiness.

2.3 Aircraft Maintenance

Aircraft maintenance is a complex task involving a series of interrelated activities carried out by various teams in an organisation. The size and complexity is normally relative to the airline's operation. Under EASA, every Air Operator Certificate (AOC) holder is directly responsible for the continuing airworthiness of its fleet and must carry a CAMO approval. On the other hand, it is not mandatory to hold an Aircraft Maintenance Organisation (AMO) approval because the physical maintenance work may be contracted to third-party organisations.

Kinnison & Siddiqui (2013) present a comprehensive diagram depicting the functions controlling maintenance. Figure 2.1 illustrates various relationships between the different teams involved in aircraft maintenance. Of relevance to this study is the central function of the Maintenance Control Centre (MCC), highlighted in red. The MCC has two-way arrows showing primary interactions with line maintenance, the aircraft in-service, AMOs, and flight operations department.

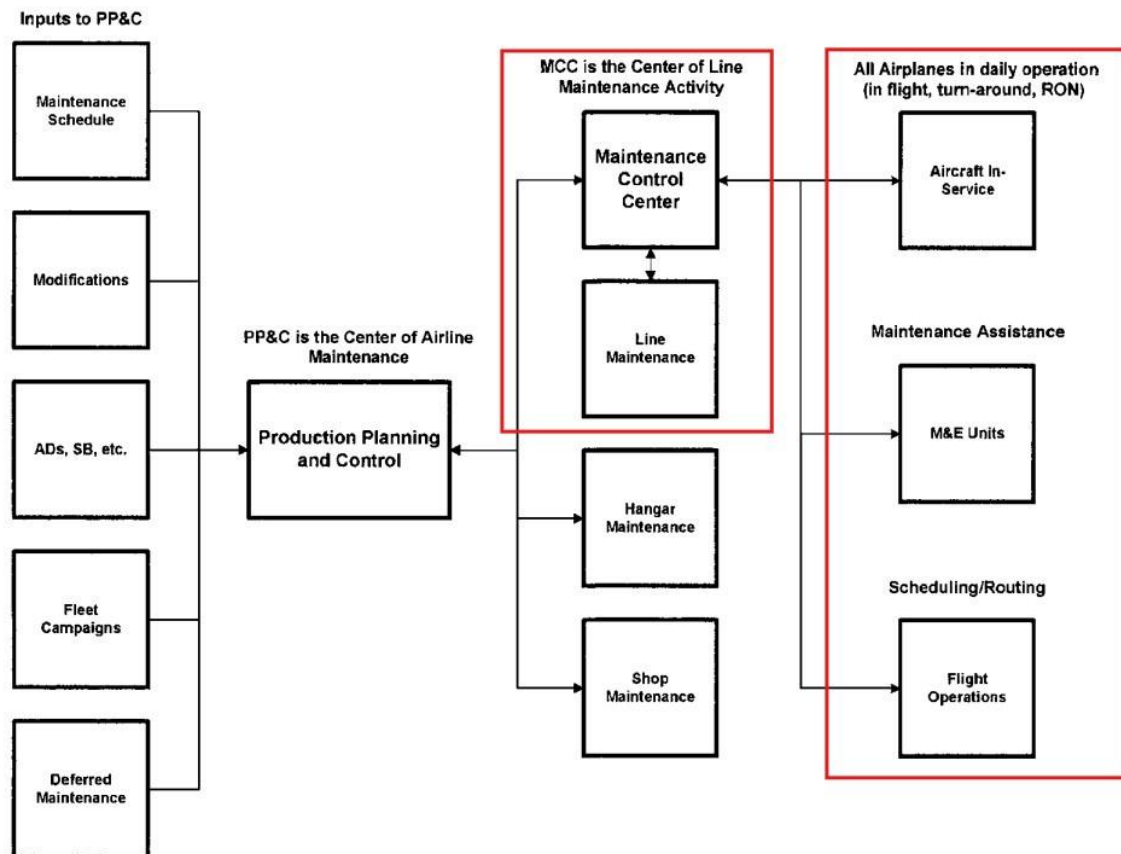


Figure 2.1 Functions controlling maintenance (Kinnison & Siddiqui, 2013)

2.3.1 Line Maintenance

Line maintenance refers to maintenance activities carried out during ground time between operations. These tasks are typically performed on the ramp during turnarounds or night stops. For practical reasons, most line maintenance is performed at home base. However, in certain operational scenarios, defects must be addressed promptly without the possibility of returning the aircraft to its home base; in these instances, rectification is undertaken at the outstation.

Routine maintenance generally consists of planned tasks from the Aircraft Maintenance Programme, Service Bulletins or Airworthiness Directives, while non-routine maintenance usually involves defect rectification and troubleshooting. Defect rectification may be performed on an ad-hoc basis, requiring immediate action, or it may be scheduled for intervention at a later date.

2.3.2 Role of the MCC Engineer

The primary role of an airline's engineering department is to ensure operational aircraft availability, which includes maintaining technical reliability, and on-time readiness. Within the CAMO, the key operational responsibility for day-to-day defect management lies with the MCC Engineer; and hence, the MCC Engineer has a key role in supporting the airline's overall goal.

Kinnison & Siddiqui (2013) argue that "the maintenance control centre is the heart of line maintenance", whilst Aubin (2004) describes maintenance control as "the critical bridge between operations and maintenance functions of the airline." It is the central point of contact for any topic regarding the technical availability of the aircraft, such as extended ground time requirements, technical operational restrictions, or flight cancellations. Additionally, MCC is responsible for coordinating all line maintenance, both at home base and at outstations (Kinnison & Siddiqui, 2013).

Another key function of the MCC Engineer is to ensure that defect rectification which cannot be done on the spot, is deferred, according to official approved documentation such as the MEL or CDL (Kinnison & Siddiqui, 2013). If all requirements are met, then aircraft may depart, with the defect rectification being scheduled for a suitable ground time (Kinnison & Siddiqui, 2013). Therefore, the MCC Engineer is key to ensuring the fleet operates efficiently, and reliably.

In addition to supporting AOG situations, one of the key responsibilities of the MCC is the review of defects raised by line technicians across various stations. The review serves multiple purposes: ensuring correctness of data being entered in the technical log, verifying that all necessary spare parts required to rectify open defects are identified and ordered, and maintaining oversight of the fleet-wide defects, including system faults.

Occasionally, identical faults may reappear across different aircraft or flights. In such instances, it is the responsibility of the MCC Engineer to recognise these as systemic issues that warrant further investigation. These recurring anomalies

are referred to as repetitive defects. Figure 2.2 provides an example of such a case, illustrating an extract from the technical logbook.

Created	Type	Info	Reg	Model	STN	Defect No	Status	Defect Text	Last Action	ATA Chapter	ATA Section
06-Oct-25 04:13	PIREP	✓	9H-ZTC	A321-211 P2F TM	NTE	9H-ZTC001083-001	Closed	PIREP, AUTO FLT FAC 2 FAULT APPEARED ON ECAM AS WE...	NOTED BY MAINTENANCE, NO FURTHER MAINTENANCE ACTIO...	22	60
02-Oct-25 04:30	PIREP		9H-ZTC	A321-211 P2F TM	NTE	9H-ZTC001079-001	Closed	AUTO FLT RUD TRIM2 FAULT	C/RESET AND CHECK IAW AMM 22-91-00-710-001 /R44. N...	22	90
06-Oct-25 19:28	MAREP		9H-ZTC	A321-211 P2F TM	NTE	9H-ZTC001083-004	Deferred	PIREP, AUTOFLT RUD TRIM2 FAULT ON ECAM.	NO RESET POSSIBLE FAC 2 TEST SHOWS FAC2/RT ACTR 10...	27	20
02-Oct-25 21:46	PIREP		9H-ZTC	A321-211 P2F TM	LEJ	9H-ZTC001080-001	Closed	PIREP, AUTO FLT RUD TRIM2 FAULT	FAC 2 REPLACED IAW AMM 22-66-34-04 CONF 00 REV44. ...	27	20

Figure 2.2 Extract from technical log showing repetitive defects

(courtesy of Titan Airways Malta)

2.3.3 Faults

What is a fault? Within the context of electronic systems, a fault represents an indication that an anomaly or malfunction has occurred within the system. To illustrate this concept on a commercial airliner, an example is drawn from the Airbus (2025a) A320 Trouble Shooting Manual (TSM).

The fault detection architecture on Airbus A320 is designed such that the Centralised Fault Detection System (CFDS) maintains continuous bidirectional communication with all other aircraft systems. For instance, Figure 2.3 depicts the interaction between a specific sensor, the Air Data Module (ADM) sensor *19FP1*, and multiple systems, beginning with the Air Data Inertial Reference Unit (ADIRU). The ADIRU subsequently influences other subsystems including the EIS, AFS, ECAM and FADEC. The bidirectional arrows in the figure represent the flow of information among these components.

If the air data sensor becomes faulty, the primary impact is on the ADIRU, which serves as the main processing unit. The ADIRU then transmits an internal fault to the CFDS (e.g., *ADIRU1: NO ADM 19FP1 DATA*) and invalidates certain parameters, such as airspeed. Consequently, other systems that depend on ADIRU inputs detect the loss of the airspeed parameter and generate fault messages to the CFDS. These subsequent messages are classified as ‘external’ faults.

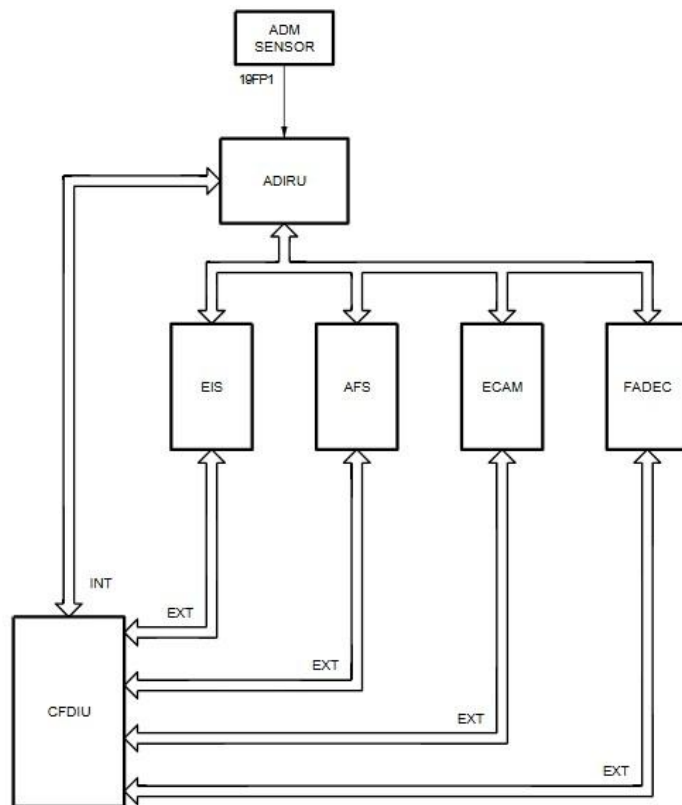


Figure 2.3 Extract from the TSM depicting sensor to fault detection logic relationships (Airbus, 2025a)

All detected faults are recorded within the Centralised Fault Display Interface Unit (CFDIU) and eventually presented in the post-flight report (PFR). This systemic logging process facilitates maintenance personnel in identifying anomalies within specific system sectors and supports in determining the correct troubleshooting procedures. An example of a PFR for an Airbus aircraft is provided in Appendix B.

2.3.4 No Fault Found

Khan et al. (2012) describe “a phenomenon which exists in complex engineered systems, most notably those which are electrical or electronic which is the inability to diagnose faults reported during operation.” In simpler words, this is a situation when a system develops a fault in flight and the engineers cannot reproduce the fault after applying fault isolation procedures on ground.

This phenomenon, commonly referred to as No Fault Found (NFF) is present in many industries including commercial aviation and has been widely examined in literature (Hockley & Phillips, 2012; Khan, Philips, et al., 2014; Mahon, 2009). Aside from Lacey (2023), who examined the relationship between NFF and airworthiness, no studies have been identified that investigate NFF specifically in the context of aircraft repetitive defects. In such cases, the fault may not necessarily originate from the component itself but from the aircraft system, for example due to ageing wiring or certain flight conditions influencing sensor inputs.

Pilots frequently record faults in the technical log during flight; however, subsequent ground tests often confirm normal operation, resulting in entries being closed as “test satisfactory”, or “no fault found”.

Type	Info	Reg	Model	STN	Defect No	Status	Defect Text	Last Action
PIREP		9H-ZTB	A321-211 P2F TM	LEJ	9H-ZTB002498-001	Closed	NAV ILS 2 ECAM	TSM 34-36-00-810-829-A REV45 PERFORMED. MMR 2 OPS ...

Status:	Closed
ATA Chapter:	34 - NAVIGATION
ATA Section:	00 - GENERAL
Text:	<div> TSM 34-36-00-810-829-A REV45 PERFORMED IAW AMM 34-36-00-740-003 REV 45 </div> <div> MMR 2 OPS TEST PERFORMED SATIS. TOOL CHECK PERFORMED </div>

Figure 2.4 Extract from technical log showing test satisfactory

(courtesy of Titan Airways Malta)

Whilst resetting computers may clear a fault, maintenance teams must be cautious about using system resets because “this may only clear the indication, with the failure remaining latent. ...Resets can lead to hidden deteriorating conditions of the system and to unexpected effects” (Airbus, 2022).

Furthermore, understanding why components are classified NFF, despite being removed for reported faults, is essential. Hessburg (2001) explains that bench

checks cannot replicate the full operational context of a component within its system. It is impractical to test every possible interaction and condition, meaning that even a test covering 90% of functions leaves a margin where failures may occur undetected.

Components that pass such tests are returned to the supply chain as serviceable units and may subsequently be reinstalled on the aircraft. However, this practice poses significant challenges when troubleshooting repetitive defects, as it introduces additional complexity and disrupts the logical fault-isolation sequence. When a component is assumed to be serviceable, the troubleshooting process may unintentionally reintroduce a faulty unit.

Appendix C provides a practical example of this issue. A Flight Augmentation Computer previously removed for “repetitive faults” was tested at the workshop and released “Reason confirmed: NO”, with a Part 145 CRS issued in the form of an EASA Form 1. This component was then returned to the spares inventory and supplied to a CAMO for installation as part of defect rectification efforts. Once installed, the repetitive faults on the aircraft not only persisted but worsened. This issue was resolved only after the unit was removed and replaced with another component. A second, comparable case involving a Multi-Mode Receiver, also returned as NFF, further demonstrates the recurrence of this problem.

A unit that fails repeatedly is termed a rogue unit. This differs from low-reliability parts, where multiple physical units of the same type fail across one or more aircraft. A rogue unit refers to a specific serialised component that exhibits recurrent failures (Kinnison & Siddiqui, 2013). These units rotate “between the aircraft and workshop with alarming regularity” (Söderholm, 2007).

Identifying rogue units requires detailed information including the component’s serial number, installation and removal dates, aircraft registration or serial number, flight hours and cycles at removal, hours since overhaul, and the reason for removal, preferably with a fault code (Hessburg, 2001; Khan, Phillips, et al., 2014).

2.4 Communication: Aircraft Flight Crew and CAMO

Communication has been defined as “the process by which information is clearly and accurately exchanged between two or more team members in the prescribed manner and with proper terminology: the ability to clarify or acknowledge the receipt of knowledge.” (Bowers, Jentsch and Salas, 2000 as cited in Lacey, 2023).

This definition highlights communication as a multi-component activity requiring clarity, accuracy, standardised terminology, and mechanisms for verification and message closure. Implicit with this definition is the expectation that participants actively question, confirm and acknowledge information to ensure that the intended meaning is reliably shared rather than assumed.

These principles are directly applicable to exchanges between CAMO personnel and flight crew, where miscommunication can have both operational and safety implications. In commercial aviation, such interaction occurs through both verbal and written channels. Verbal communication typically arises post-flight when defects necessitate immediate reporting to MCC, and some operators mandate a telephone call in addition to a written logbook entry. Written communication extends beyond the logbook to include in-flight data messaging systems (e.g., ACARS on Airbus aircraft) which facilitate real-time operational dialogue.

Since the study by Munro et al. (2008), significant technological developments have transformed communication practices between flight crew and maintenance personnel. Modern aircraft now transmit fault data in real time, reducing reliance of the completeness of technical logbook entries in certain operational contexts. The emergence of electronic tech log has similarly removed earlier constraints such as limited writing space, while enabling the attachment of photographs, such as those showing the ECAM screen, which aid in detailing the documentation. Despite these advances, the findings of Munro et al. (2008) remain highly relevant, particularly for investigations of repetitive system defects, where comprehensive logbook entries continue to be essential due to the complex and challenging nature of the faults.

Munro et al. (2008) highlight that “communication between pilots and mechanics is a critical link in the chain of aviation safety”, arguing that pilots and maintenance engineers hold distinct yet complementary knowledge. Effective information exchange therefore has the potential to strengthen fault diagnosis by integrating operational insights with technical expertise. However, they observe that such communication is often minimal when defects occur, despite the opportunity to facilitate fault resolution. Operational time pressures exacerbate this issue: flight crew typically have limited time on the aircraft prior to departure and even less after arrival, leading to a tendency to complete logbook entries hastily, despite their criticality for troubleshooting.

These findings are echoed by Lacey (2023), who notes that post-flight sorties in the RAF often lack sufficient time and training to enable effective communication, and that the transfer of information from the flight crew to engineers is a critical component of information sharing that can support fault resolution and ultimately reduce NFF outcomes.

In view of these observations, the present study investigates whether pilots and MCC engineers are willing to engage in active communication and collaboration in the context of RSD, and whether they perceive such interaction as an important component of effective fault resolution.

2.5 Terminology Overview

This thesis adopts the term ‘repetitive’ based on its use by EASA in continuing airworthiness regulations (EASA, 2024a) and in the European Plan for Aviation Safety (EASA, 2024b). Nonetheless, terminology across literature remains inconsistent (Arshadi, 2024). Variations appear even within EASA itself; for example, a safety promotion article addressing the same subject is titled “Recurrent Defects” (Franklin, 2020). Such inconsistencies create potential for misunderstanding and may impede effective communication. Consequently, this section examines and compares the terminology employed by regulatory authorities and other relevant sources.

A review of dictionary definitions reveals minimal semantic difference between these terms, which may explain their interchangeable use within the aviation industry.

Table 2.1 Summary of English dictionary meanings (Collins English Dictionary, 2025)

Term	Meaning
<i>recurring</i>	Occurring or appearing again
<i>reoccur</i>	To happen, take place, or come about again
<i>recurrent</i>	Happening or tending to happen again or repeatedly Appearing or occurring again or periodically
<i>repeat</i>	To occur more than once <i>If an event or series of events repeats itself, it happens again</i>
<i>repetitive</i>	Linked to the word “repetition” <i>Repetitive actions are repeated many times</i>

2.5.1 Regulatory Review

An essential component of this review is to establish the current terminology used by worldwide regulators. To achieve this, a search was conducted within regulatory materials for five leading civil aviation authorities, the UK Military Aviation Authority (MAA), and the IATA Operational Safety Audit (IOSA) requirements. The objective was to identify how the terms repeat, repetitive, recurring and recurrent are defined and applied within these sources.

2.5.1.1 EASA

Term used: ***repetitive***

Part-M defines deferred and carried-forward defects but does not provide a definition of repetitive defects. AMC M.A.301(b)3 instructs CAMOs to continuously monitor defects and “highlight any that are repetitive”, while Appendix I to AMC M.A.302 requires the evaluation of repetitive defects within the reliability programme (as part of the Aircraft Maintenance Programme). Likewise, AMC to CAMO.A.125 indicates that when CAMO tasks are subcontracted, procedures should address the handling of defects, including repetitive defects (EASA, 2024a). However, neither Part M nor Part CAMO offer guidance on how such evaluations should be conducted or what these procedures must ensure.

Additionally, Part 145, states within the MOE requirements that line maintenance must include control of defects and repetitive defects (EASA, 2024a).

2.5.1.2 UK CAA

Term used: ***repetitive***

At the time of writing, UK CAA continuing airworthiness requirements (UK CAA, 2025) remain aligned with EASA regulations, and this review identified no divergence between the two.

2.5.1.3 FAA

Term used: ***none***

A review of the CFR Part 91 Subpart E (FAA, 2025a), Part 121 Subpart L (361-380) (FAA, 2025b), Part 43 Subpart C (FAA, 2025d), Part 145 (FAA, 2025c) and the Advisory Circular 145-9A (FAA, 2017) revealed no relevant positions on this topic, nor any use of associated terminology.

2.5.1.4 CASA

Term used: ***repetitive***

The only reference to this subject appears in an Advisory Circular (non-regulatory guidance), which states that the reliability programme should include the “evaluation of repetitive defects” (CASA, 2022). In addition, Part 145 guidance on MOE requirements specifies that line maintenance must incorporate control of defects and repetitive defects (CASA, 2016).

2.5.1.5 TCCA

Term used: ***recurring***

Definitions or guidance: ***A recurring defect is one that is repeated 3 times on a particular aircraft within 15 flight segments***

CAR 706.05 requires operators to establish procedures for detecting defects that recur and identifying them as recurring defects (Canadian Minister of Justice, 2025). Standard 726.05 further mandates a method for highlighting such defects so that they are readily identifiable to flight crews and all involved AMOs. Operators must notify maintenance personnel of recurring defects to prevent “duplication of unsuccessful attempts at rectification”. Moreover, rectification of such defects must “take into account the methodology used in previous repair attempts”. Transport Canada (2025) specifies that: “Defects are recurring defects if a failure mode is repeated three times, on a particular aircraft, within 15 flight segments of a previous repair made in respect to that failure mode”.

Additional guidance is provided in the Maintenance Control Manual (MCM) Guidance Document TP14408, which clarifies that its examples are illustrative only and do not replace regulatory requirements. The MCM must specify the operator’s methods for detecting and reporting recurring defects (Transport Canada, 2018). However, caution is required when interpreting TP14408: one example suggests an aircraft should be grounded upon identification of a recurring defect, a position not supported by the applicable Standard, which requires only that crews and maintenance staff be notified. Grounding is therefore only an example of such a procedure, not a regulatory requirement; the decision remains at the operator's discretion.

This requirement applies not only to Commercial Air Services but also to private operators under CAR 604.129.

2.5.1.6 MAA

Term used: ***repetitive***

Similar to the EASA regulations, the MAA, through RA4816, which provides guidance on MOE requirements, stipulates that line maintenance must include control of defects and repetitive defects (MAA, 2025). However, no corresponding provisions are specified for the CAMO-level management of repetitive defects.

2.5.1.7 IOSA

Term used: ***recurring***

According to MNT 2.7.1, operators must maintain a process for defect management and control that includes *the management of recurring defects*. This process must incorporate documentation, tracking, corrective actions and ensure that rectification activities consider actions performed in previous repair attempts (IATA, 2023).

Notably, an earlier edition of the ISM (edition 6) required operators to inform flight crew of recurring defects. As highlighted by Arshadi (2024), the removal of this requirement introduced a significant gap in safety management. The rationale for this removal is not specified, raising questions about the feedback received and the observations made by IOSA auditors regarding this issue.

2.5.2 Literature

A similar review was conducted to examine usage, definitions and requirements related to these terms in other sources. Kinnison & Siddiqui (2013) use the term '**repeat**', defining it as: "Repeat items occur 3 times within 5 days, or 4 times in 7 days." They further note that such items should be investigated by MCC "on the spot", underscoring the urgency associated with addressing these defects and reinforcing this study's focus. However, beyond this brief definition and

procedural note, the book provides no additional discussion on the topic, a notable omission given its significance.

The term '**repeat**' is also used by Munro et al. (2008) in their paper about logbook communication between pilots and maintenance. It is observed that this term may be primarily predominant in FAA regulated organisations since both above sources are so.

Lacey (2023) makes extensive use of the word '**recurring**' in the narrative context to describe faults that reoccur. These two words are very similar in English (as noted earlier in Table 2.1) and are often used interchangeably by native speakers. Examples from her text include: "the aircrew may be frustrated by a fault recurring" and "systems experience a fault recurring after being fixed" (Lacey, 2023). In all instances, no specific timeframe is mentioned, indicating that the terminology is applied in a generic sense. It is worth adding that the term '**repetitive**' is used in two instances (Lacey, 2023).

In the context of NFF situations, several authors, including Hockley & Phillips (2012) and Khan, Philips, et al. (2014), refer to '**repetitive** defects' or '**repetitive** faults' in their texts. This terminology is relevant to the present study because such units are typically removed from the aircraft during troubleshooting for a fault, which may be either repetitive or first-time occurrence.

On the other hand, still in the same context of NFF, Söderholm (2007) employs the term '**recurring**' in defining a rogue unit as "a unit that experiences a recurring combination of NFF and DOA" (dead on arrival).

Further usage of the term '**repetitive**' defects is found in Coilpillai (2020) where it appears in direct reference to the CAMO's review of technical logbooks for repetitive defects.

Arshadi (2024) consistently uses the term '**repetitive**' defects in the study title and as the focal concept in all interview questions, such as: "How do you define repetitive defects in your organisation?" Thematic analysis of participant responses revealed that many described a repetitive defect as either a

‘recurring’ or ‘repeating’ defect, suggesting that these terms are widely perceived as interchangeable.

Furthermore, Arshadi (2024) highlights the absence of a uniform standard for defining ‘repetitive’ defects. Participants who associated the term with ‘recurring’ defects described these as issues that “reappear persistently despite multiple attempts to fix them”; whereas ‘repeating’ defects were described as “more insidious and difficult to resolve, often requiring extensive investigation to identify the underlying cause”. The discussion also introduced the term ‘intermittent’, referring to failures that only occur under specific flight conditions and are therefore challenging to replicate on the ground.

2.5.3 Others

Airbus employs the term ‘intermittent **repetitive** failure’ in two publications addressing the management of repetitive faults and recommended troubleshooting practices (Airbus, 2025b; Airbus, 2022). The similarity of this terminology to that used by EASA suggests a degree of alignment, or possible influence, between the manufacturer and the regulator.

Ries (2018) reports that American Airlines have implemented technology to assist in managing repetitive faults, explicitly adopting the term ‘**repetitive**’ in the title; however, in the text the terms ‘recurring’ and ‘repeat’ are also used, once more suggesting the concept of interchangeability. This is very much the case of Lufthansa Technik’s AVIATAR product too with the name “Technical **Repetitives** Examination”

Similarly, Kropp & Graesch (2025) use the word ‘**repetitive**’ in the title to their case study explaining how TUI Airlines and Aviatar worked together on enhancing “recurring defects (so-called repetitives)” data management.

However, another software provider VERYON (2017), uses the term ‘**recurring** defects’ in their application description; whilst AIXI (n.d.) called their application ‘**repeat** defect identifier’.

Finally, the Sriwijaya Air B737 accident report explicitly references *repetitive* defects, a term also defined within airline's official technical procedures as three occurrences in 15 sectors (Komite Nasional Keselamatan Transportasi, 2022).

2.5.4 Conclusion

This review highlights a persistent lack of standardisation in terminology across regulatory frameworks and related literature. Although the term *repetitive* appears most frequently, no universal consensus exists. Patterns observed suggest that *repeat* is predominantly associated with FAA-regulated environments, *recurring* with Transport Canada and IATA, and *repetitive* with EASA, UK and Australian regulators. Table 2.2 summarises these variations.

Table 2.2 Summary of terminology used by various regulators

Regulator	Terminology	Rule
EASA	repetitive	/
UK CAA	repetitive	/
UK MAA	repetitive	/
CASA	repetitive	/
TCCA	recurring	3 occurrences in 15 flight sectors
IOSA*	recurring	/
FAA	/	/

**IOSA is not a regulator, but it is deemed relevant to include in this comparison due to its influence and strong presence in commercial airlines*

Only two sources provide explicit quantitative criteria for defining such defects: Transport Canada (2025) and Kinnison & Siddiqui (2013). TCCA defines a recurring defect as one that occurs 3 times in 15 sectors on the same aircraft, whereas Kinnison & Siddiqui (2013) specify a repeat item as occurring 3 times within 5 days, or 4 times in 7 days. These definitions rely on different metrics, sectors versus days, therefore their practical implications may align only under certain fleet utilisation conditions.

Overall, the literature indicates that these terms are used interchangeably within the aviation industry, reflecting their overlap in general English usage and the absence of clear definitions. This underscores the need for explicit, context-

specific definitions in aviation discourse to support precise and effective communication. Moreover, achieving consistency requires not only harmonising the terminology itself, but also establishing aligned definitions to ensure that interpretation and implementation are achieved in a uniform manner.

2.6 Accident/Incident Review

This section examines three significant events comprising two catastrophic accidents and one serious incident, in which ineffective management of repetitive system defects played a contributory role. The purpose is not to provide a comprehensive critique of the official reports, but rather to extract insights directly relevant to the present study.

Moreover, in an article discussing intermittent repetitive failure, Airbus describes an event in which a latent fault in the Elevator Aileron Computer (ELAC) 1, combined with an in-flight failure of ELAC 2, caused the aircraft to revert to alternate law. This reversion removed all flight control computer protections, requiring the flight crew to operate the aircraft in alternate law (Airbus, 2022), a mode that is known to be operationally demanding and associated with increased risk. To obtain further information, correspondence with Airbus in December 2025 sought access to the official incident report issued by the relevant air accident investigation authority. Airbus stated, however, that no public report exists; the case was reported directly to Airbus, and the details remain confidential. Nevertheless, this incident illustrates how an intermittently occurring latent failure, when combined with a secondary system failure, can escalate into a highly serious operational scenario.

2.6.1 B737-500, PK-CLC Accident

The accident involving PK-CLC in January 2021 illustrates how technical, organisational, and human factors can converge to produce a catastrophic outcome (Komite Nasional Keselamatan Transportasi, 2022). During the flight, thrust levers asymmetry developed, resulting in higher thrust on the right-hand engine than on the left, which ultimately led to a loss of control. For the purposes of the present study, the analysis focuses on the technical and organisational elements, with particular emphasis on the principle that documented procedures are ineffective without robust implementation, monitoring and oversight.

Sriwijaya Air had established processes for the identification and management of repetitive defects. However, persistent technical issues affecting the same system continued to occur and contributed significantly to this accident. This discrepancy between formal procedures and operational outcomes highlights a critical weakness in defect management practice and raises questions regarding the effectiveness of oversight mechanisms, data utilisation and organisational follow-through despite the existence of documented processes.

A significant shortcoming was evident within the MCC, which failed to produce adequate guidance to line maintenance engineers and did not require comprehensive troubleshooting once defects became repetitive. Instead, MCC repeatedly accepted superficial corrective actions, such as BITE checks and connector cleaning as terminating measures, despite the reoccurrence of the defects. This approach represented a clear deviation from the Boeing TSM instructions, which provides structured step-by-step instructions, designed to support fault isolation and root cause identification by leveraging system knowledge from the design approval holder. The failure to adhere to these procedures suggests not only procedural noncompliance but also a lack of effective technical leadership within the MCC.

The situation was further compounded by the inability of the Reliability Program to escalate the long-term nature of the defect. Even in the absence of immediate corrective action by the MCC, reliability monitoring should have identified the repeated occurrences, 65 reports over an eight-year period, as indicative of systemic risk and mandated corrective actions.

Multiple defensive barriers failed within the Engineering function concurrently. While procedures existed and personnel were available, their effectiveness depended on appropriate application and oversight. The repeated occurrence of connector cleaning as a corrective action may reflect operational time constraints associated with line maintenance; however, the continual approval of such minimal interventions by MCC engineers indicates a breakdown in engineering judgement rather than a potential resource constraint alone. Therefore, this suggests insufficient challenging of repetitive defects.

Further weaknesses included limited accountability for management and oversight, as well as inadequate documentation in technical logs, which often lacked detail on troubleshooting actions. Deficiencies in the Safety Management System (SMS) meant that the issue was not reported by the crew, missing on this being investigated by the safety department. A more effective SMS could have prompted pilot reporting and independent safety review, potentially leading to earlier identification and resolution of the underlying root cause(s).

Collectively, these failures illustrate that the accident was not solely a technical event but the result of systemic weaknesses in defect management, organisational oversight, and safety culture.

2.6.2 A319-111, G-EZAC Serious Incident

The serious incident involving G-EZAC (AAIB, 2009) occurred during a scheduled flight to London and involved a complete loss of the AC Main Bus 1 whilst the aircraft was operating under an MEL deferral. As with most serious incidents, multiple contributory factors were present, including system design limitations and human factors. However, its relevance to this present study lies primarily in the role of problematic electronic components, commonly referred to as rogue units.

In this case, the MEL was correctly applied to defer an inoperative engine generator that had tripped on the previous flight. This generator supplied the No 1 Main AC bus, and the MEL procedure required the APU generator to substitute for the failed engine generator. The aircraft was legally dispatched in this configuration; yet the underlying fault persisted. This links to the question of legal airworthiness versus technical airworthiness explored earlier in this report.

During the incident flight, AC Main Bus 1 was completely lost, leaving the aircraft with significant loss of functionality.

The investigation concluded that a recurrence of the generator control unit (GCU) fault likely caused the de-energisation of AC Main Bus 1. This intermittent fault had manifested during the previous two sectors and was the probably the reason for the MEL deferral. However, switching out the engine

generator and substituting it with the APU generator, did not eliminate the faulty component, still active in the system. So when the intermittent fault manifested again, it likely caused the de-energisation of the AC Bus 1.

With the failure of a central unit in the system, the complete bus was lost. Consequently, the aircraft had to be flown manually, all radios become inoperative, and the Captain's main displays blanked. For reasons beyond the scope of this study, the crew were unable to restore functionality by switching to essential bus.

Additional concerns include the use of system resets, which must be approached cautiously. The GCU had been reset two sectors preceding the incident, which should have signalled a persistent fault and prompted a more rigorous assessment before authorising dispatch under MEL for a tripped engine generator.

This incident underscores how a single rogue unit, compounded by procedural and design vulnerabilities, can escalate into a major incident. Despite repeated service rejections, the GCU was reintroduced into the operational fleet, revealing a critical gap in mechanisms to identify and prevent reinstallation of defective components.

2.6.3 B737-800, Flight TK1951 Accident

The accident involving Turkish Airlines flight TK1951 in 2009 concerned a B737-800 on final approach into Amsterdam airport (The Dutch Safety Board, 2010). The event exemplifies an accident arising from a complex combination of technical design vulnerabilities, organisational practices, and human factors, with the technical dimensions being directly relevant to the focus of this research.

The aircraft was equipped with dual autopilot channels, a single autothrottle system, and two radio altimeter units. During the later stages of approach, the autothrottle relied on radio altitude data; however, despite the presence of dual sensors, the system architecture did not provide true redundancy. Under normal conditions, only the left-hand radio altimeter provided input to the autothrottle,

while the right-hand unit functioned solely as passive backup, activated only if the primary system self-detected a fault.

In this accident, the left-hand radio altimeter system produced an erroneous indication of -8 feet while the aircraft was still above approximately 750 feet. As this value lay within the valid output range, the system did not recognise it as a fault. Consequently, the autothrottle transitioned prematurely to 'flare' mode, commanding a substantial reduction in thrust under the false assumption that the aircraft was on the ground. The absence of cross-checking between the two radio altimeter systems represents a critical design vulnerability and reflects underlying assumptions regarding radio altimeter system reliability.

Beyond these design issues, this accident is directly relevant to the present study due to the long-standing nature of radio altimeter anomalies. Faults had been occurring for several years prior the accident, both within Turkish Airlines, and across other operators (The Dutch Safety Board, 2010), yet the issue was not given the urgency and importance it required in view of its potential safety implications. Although the radio altimeter provided a direct input to the autothrottle during critical phases of flight, recurring anomalies were largely treated as routine reliability concerns rather than indicators of a latent safety hazard.

The defect was known to multiple stakeholders over an extended period of time. Boeing had been involved in addressing the issue, and the FAA was also aware of its occurrence. However, the defect did not receive elevated priority due to the 'considered' low number of occurrences. Underreporting, particularly in the pilot community for this case, meant that only a fraction of erroneous radio altitude indications were formally recorded, creating a misleading perception of low risk. As a result, the issue was classified as a technical reliability problem rather than a safety-critical condition and remained a long-term item until the accident occurred.

Finally, there was no information sharing with the operational counterparts; as noted by The Dutch Safety Board (2010), "pilots were not informed of the

problems because the problems within Turkish Airlines were considered to be a technical problem not a threat to safety.”

This case illustrates how deficiencies in repetitive defect reporting, data aggregation, and hazard classification can delay corrective action. It highlights the importance of comprehensive defect reports, including pilot logbook entries for intermittent faults that may self-resolve, as aggregated data is essential for identifying adverse trends and ensuring appropriate action by all concerned parties.

A further issue concerns communication between the CAMO and flight crews regarding ongoing repetitive defect investigations. While it cannot be determined whether increased awareness would have altered the outcome of this accident, the absence of such communication represents a missed opportunity to enhance vigilance. Therefore, this study will examine how CAMOs communicate repetitive defect information to flight crews and assess the effectiveness of these mechanisms in supporting proactive safety management.

2.6.4 Concluding Remarks

These three cases demonstrate how technical defects can escalate when organisational shortcomings are present. Although the technical causal factors differ (procedures existing “only on paper”, rogue units combined with MEL usage, and failure to recognise long-term issues as safety-critical and assign appropriate priorities), there is a central element highlighting the critical importance of effective management of repetitive defects.

2.7 Software Applications

In an increasingly automated aviation environment, commercial airlines rely on a wide range of digital tools to support operational and airworthiness functions. Within CAMOs, core software platforms typically support the full set of traditional airworthiness tasks. However, the availability of fully automated solutions specifically tailored to MCC needs, particularly those aimed at managing short-term repetitive defects, remains uncertain.

Scott et al. (2024) argue that recent advances in natural language processing (NLP) and machine learning provide an effective means of exploiting previously under-utilised defect data. These technologies allow maintainers to interpret large volumes of ‘sleeping’ data, offering benefits such as identifying trends that signal the recurrence of defects, and supporting maintenance leaders in making data-driven decisions (Scott et al., 2024). Furthermore, the application of NLP to enhance ATA coding improves the accuracy and consistency of defect classifications, strengthening the reliability of data available to MCC engineers (Aircraft Commerce, 2019). Enhanced coding structures can subsequently support analysis of repetitive defects (Aircraft Commerce, 2019).

Health monitoring and preventive-maintenance technologies have advanced rapidly, driven by major manufacturers such as Airbus, Boeing and Embraer, as well as independent providers like Lufthansa Technik. Real-time fault monitoring capabilities have significantly enhanced maintenance decision-making by enabling MCC engineers to assess issues and plan rectification actions while the aircraft is still in flight, leading to numerous benefits (Vaissieres, 2022). In principle, such capabilities could also support the automatic detection of repetitive defects as they emerge.

This study focuses specifically on software functionality that supports MCC engineers in identifying repetitive defects, presenting related occurrence data, and displaying previous rectification actions. A brief review of available market offerings was carried out and is presented in Appendix D. Together with the primary research findings, this provides a clearer understanding of the current industry landscape.

3 Methodology

3.1 Introduction

This Chapter outlines the research methodology, including the design, data collection methods and their rationale, and the approach to data analysis. It concludes with a discussion of the ethical considerations regarding this project.

As discussed in previous chapters, the effective handling of repetitive system defects (RSD) is of concern not only for the CAMO, but also for the aircraft flight crew, who are key stakeholders in this process. Consequently, this research will examine perspectives from both elements.

3.2 Research Design

This study examines insights from Maintenance Control Centre (MCC) Engineers, who are at the front-line of defect control and management, and who are the CAMO's primary point of contact with the aircraft flight crew before, during, and after a flight.

This research required MCC Engineers to either currently hold the position or have held it within the past two years. This criterion ensured that participants were familiar with detailed processes within their respective organisations and provided an accurate representation of current practices across various CAMOs.

Participation for aircraft flight crew was open to all individuals employed as commercial air transport (CAT) pilots, with no additional restrictions.

A mixed methods approach was employed in this research consisting of both qualitative and quantitative questions. Two different but complementary methods were used based on the requirements: online questionnaires (also referred to as surveys) and semi-structured interviews.

The questions were developed based on themes identified in the literature and regulatory review. Each question was formulated to elicit information relevant to the research objectives and ensure alignment with the study's aims.

Open-ended questions were primarily employed during the interviews, as they enabled respondents to articulate their views freely. Such questions allow for a collection of diverse information, since participants can elaborate on their responses without being constrained by predetermined options or influenced by formats such as multiple-choice questions.

On the other hand, 'Yes/No' questions were incorporated to facilitate the generation of quantifiable data on issues that can be categorised into distinct binary responses. For others, a numeric rating scale was employed, asking participants to rate items such as task difficulty or task effectiveness. For both question types, this facilitated the graphical representation of responses, enabling readers to comprehend the situation visually and with minimal cognitive effort.

Multiple-choice questions were also employed, particularly in the online questionnaires, where several options were anticipated. This format enabled the researcher to gather data organised by pre-defined categories. For participants, this method offered efficiency, as responses could simply be provided by selecting the relevant options rather than composing answers from scratch. Additionally, open comment fields were included to capture any insights not addressed by the listed choices, ensuring no opportunities for data collection were overlooked.

The CAMO interview and questionnaire were designed in five distinct parts. The first collected basic demographic information. The remaining four sections comprised: Part I Definitions, Part II Process, Part III Communication with aircraft flight crew, and Part IV Software aid. This structure facilitated an organised and systemic approach to the research, as each question was aligned to a specific thematic section (Thomas et al., 2024).

The questionnaire for commercial pilots was divided into two sections: the first collected basic demographic data, whilst the second focused on questions related to the core arguments under investigation.

3.3 Data Collection

3.3.1 CAMO

3.3.1.1 Questionnaire

An anonymous, online questionnaire was designed to reach a broad spectrum of MCC engineers with whom no prior connection existed. This was created and managed using Qualtrics, a platform that supports efficient design, distribution and administration of questionnaires. Combining user-friendly functionality with advanced customisation capabilities, Qualtrics enabled the development of a questionnaire, which was fully tailored with the specific requirements of the study.

The questionnaire consisted of 28 questions, grouped according to the different thematic sections as described in the previous section. It was available online between the 26th of September 2025 and the 15th of October 2025.

A total of 68 responses were recorded in Qualtrics; however, many were incomplete, as several participants discontinued the survey at an early stage. Consequently, 18 fully completed responses were retained for analysis in this study.

3.3.1.2 Interview

Whereas online questionnaires facilitate access to a broader participant pool and allow respondents to complete the survey at their convenience, they limit opportunities for interactive discussion, making it difficult to collect in-depth qualitative data (Dewaele, 2018; Thomas et al., 2024). Therefore, this study made use of face-to-face interviews to supplement the data collected from the questionnaire.

An interview format allows for an open discussion, with question-and-answer format, where the participants feel comfortable at expressing their true thoughts. This allows for a more in-depth discussion, consisting of a better understanding of the question being asked, together with a more on-point answer.

A sample of 10 MCC engineers were eventually interviewed. This sample was selected based on a call for MCC engineers working in different airline CAMOs. Interviews were conducted between the 17th and the 30th of September 2025, online, in Malta and in the UK.

3.3.2 Flight Crew

3.3.2.1 Questionnaire

Similarly to above, an anonymous, online questionnaire was designed to reach a broad spectrum of commercial pilots with whom no prior connection existed. Once more, it was designed and managed in Qualtrics.

The questionnaire was intentionally designed to be brief and straightforward to maximise participation and increase the sample size. To encourage engagement, it was promoted as a “2-minute survey”, emphasising its simplicity and minimal time commitment. No restrictions were imposed on participation, provided the respondents were CAT pilots.

The questionnaire consisted of 11 questions. It was available online between the 10th of September and the 9th of October 2025.

A total of 117 responses were recorded in Qualtrics; however, a number were incomplete, as several participants discontinued the survey. Consequently, 75 fully completed responses were retained for analysis in this study.

Despite the questionnaire being intentionally brief, 36% of pilots did not complete it. Whilst promoting it as a “2-minute survey” was intended to convey its brevity, this message may not have been sufficiently explicit. This limitation might have been mitigated by either displaying a progress bar at the bottom of each page, or by indicating the total number of questions at the outset, thereby providing respondents a clear expectation of length and encouraging completion (Thomas et al., 2024). Nevertheless, despite the incomplete responses, the overall participation rate was strong, and the final sample size is considered robust for the purposes of this study.

3.4 Data Analysis

3.4.1 Questionnaire

After data collection, the questionnaires were closed in Qualtrics, and all data was exported in a format compatible with Microsoft Excel. The dataset was then used to generate charts and figures for analysis.

3.4.2 Interview

All verbal interviews were recorded and transcribed. Online interviews were conducted via Microsoft Teams, while in-person interviews used Otter.ai on an iPad. Each transcript required editing to correct inaccuracies caused by factors such as accents or rapid exchanges between interviewer and interviewee.

Playback of recordings ensured that all transcripts were revised to an appropriate standard of clarity and accuracy (Braun & Clarke, 2013).

This step served as the initial phase of interview data analysis. During transcript editing, preliminary interpretation of the content was possible, and notes were taken to support the development of themes for later analysis (Maxwell, 2013).

There was purposeful consistency between the questionnaire and interview questions. As a result, responses were integrated into the Excel dataset when applicable, particularly for quantitative data.

For the remaining open-ended questions, thematic analysis was conducted, with Microsoft Excel used as a supporting tool to generate data tables and charts.

3.5 Ethical Considerations

This research required ethical approval from the Cranfield University Research Ethics System (CURES).

Before the study commenced, ethical approval was sought from the CURES board. The Letter of Approval, dated 10th of September 2025 and referenced CURES/26486/2025, is provided in Appendix A.

Before each interview, participants were provided with a Consent Form outlining the study's general terms, including anonymity, data processing and storage procedures, and the right to withdraw from the study at any point in time. The form also explained that aggregated data would be published to support the research findings.

At the start of each interview, participants were reminded that the study was fully anonymous, and that they would be identified only by a participant number. This measure aimed to ensure that participants felt comfortable sharing opinions and providing honest feedback (Thomas et al., 2024). The scope and background of the study were then explained in detail, and participants were encouraged to ask questions to clear any uncertainties before proceeding.

Each participant signed the Consent Form before the interview began. At the conclusion of each session, participants were thanked for their contribution in supporting this research, and for sharing their expertise in aircraft maintenance.

For the two online questionnaires, consent was integrated as the initial step. After presenting the research background and scope, participants were provided with the study terms and asked to select either Accept or Decline. Progression to the questionnaire was only possible after selecting 'Accept'. If a participant declined, a thank you message was displayed and the questionnaire terminated.

4 Results and Discussion

4.1 Introduction

This Chapter is presented in three distinct sections. The first part will cover CAMO results and discussion from the questionnaire and interviews, with datasets of 18 and 10 respectively. It is then followed by the findings and discussion from the flight crew questionnaire, with a dataset of 75 participants. Finally, recommendations for an optimal process design for the CAMO's effective management of repetitive system defects (RSD) is presented.

4.2 CAMO

4.2.1 Demographics

The first question sought to determine the regulatory authority under which each respondent operated. This was intended to provide insights into the geographical distribution of participants, as the research was targeted for a global audience.

Although multiple regulatory authorities were represented in the responses, 82% of the MCC engineers worked for a CAMO which had an EASA approval, followed by 18% which had a UK CAA approval.

As illustrated in Figure 4.1, there were also respondents working in CAMOs with other regulatory approvals which included Bahrain CAA, Oman CAA, Pakistan CAA, United Arab Emirates GCAA, and the US FAA albeit in limited numbers. Despite the relatively small sample from these regions, their inclusion adds diversity and enhances the global perspective. It is worth noting that a CAMO may have several approvals.

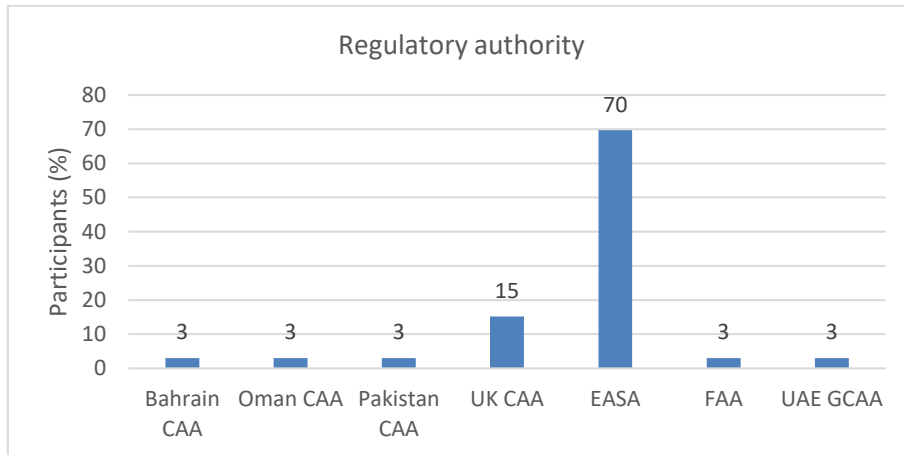


Figure 4.1 Regulatory authority

The subsequent question asked participants to indicate the fleet size managed by their CAMO. As illustrated in Figure 4.2, responses range from small fleets of less than five aircraft to fleets exceeding one hundred aircraft. This variation enhances the robustness of this study by providing a diverse dataset that encompasses a wide spectrum of fleet sizes.

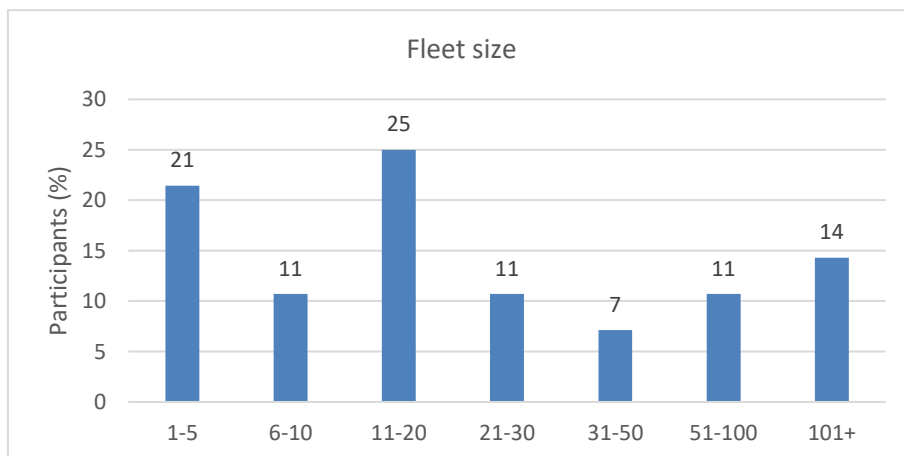


Figure 4.2 Fleet size

As the survey and interviews were open to MCC engineers in commercial air transport, it encompassed not only airline operations but also business and private aviation sectors. Consequently, it was essential to ask participants which type of Air Operator Certificate (AOC) their CAMO was associated to. As illustrated in Figure 4.3, the absolute majority of respondents worked in Commercial AOCs, including airlines operating under the ACMI (aircraft, crew,

maintenance and insurance) model. Consequently, the findings of this study primarily reflect practices within commercial and ACMI airlines operations.

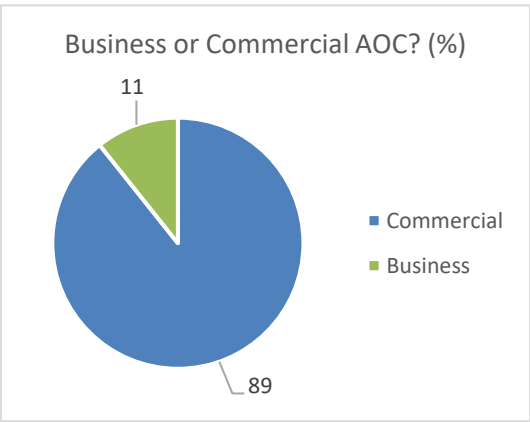


Figure 4.3 Type of AOC

The subsequent set of questions focused on the experience and profile of the participants. By collecting data on years of experience in aviation, years of service working as MCC engineer, and age bracket, the study aimed to establish a comprehensive experience profile of the respondents. As seen in Figure 4.4, respondents exhibit a wide range of aviation experience spanning approximately 40 years. Nearly three quarters of respondents, 72%, reported more than 16 years in the industry, which adds considerable value to the study and strengthens the reliability of its findings.

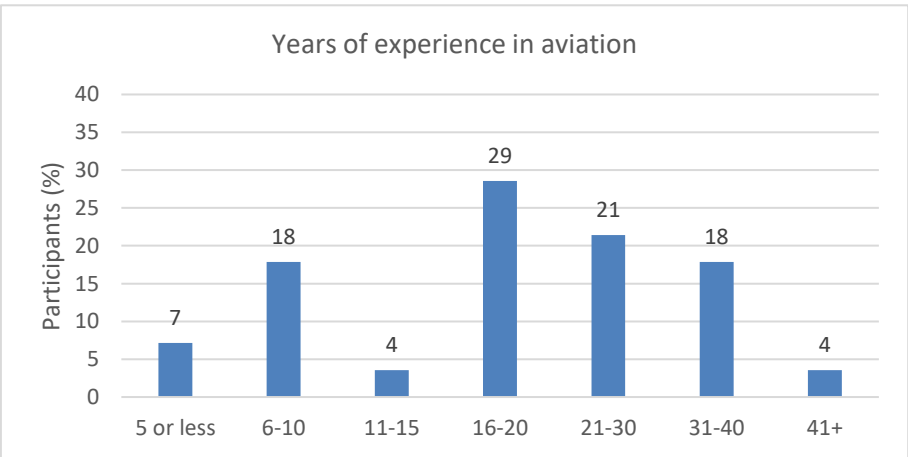


Figure 4.4 Years of experience in aviation

On the other hand, Figure 4.5 below shows that 64% of respondents have spent less than 5 years working as MCC engineers, with 25% having between 6 and 10 years of service in this role.

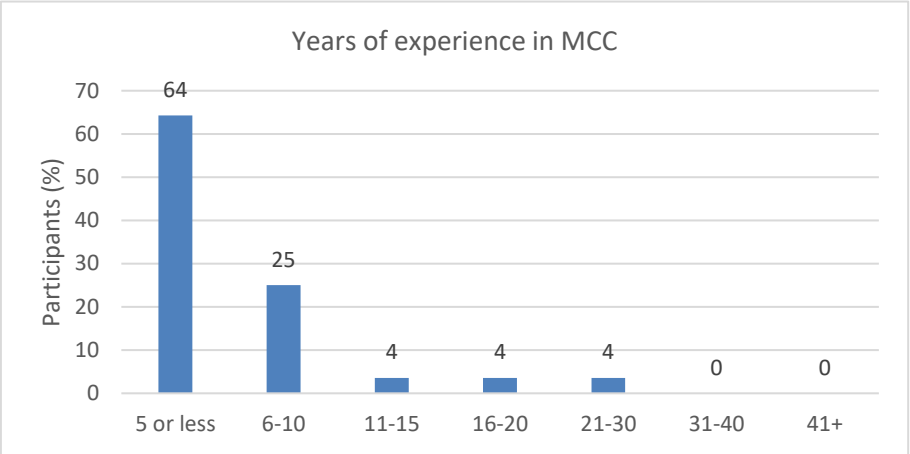


Figure 4.5 Years of experience in MCC

The difference suggests that these engineers have accumulated experience in roles outside of MCC, which is consistent with industry practice where MCC engineers are typically selected from among highly experienced line engineers.

Figure 4.6 illustrates the distribution of age brackets among the 28 participants. The majority are in their forties, indicating that the sample primarily represents mid-career engineers, who possess substantial operational experience while still having significant remaining years of active service. Only 20% of respondents are in their twenties, which aligns with industry norms, as MCC engineers typically require experience (Kinnison & Siddiqui, 2013). This age profile therefore reflects standard practice within the sector.

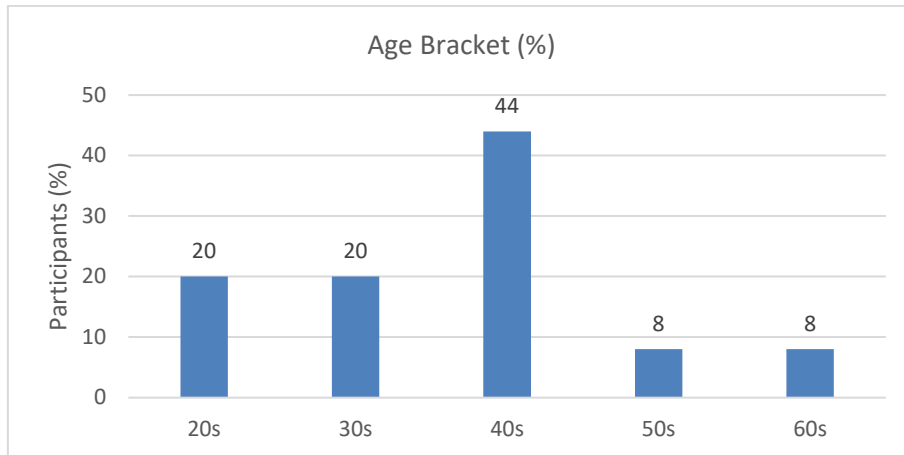


Figure 4.6 Age distribution

4.2.2 Definitions

Given the lack of harmonisation in the usage and understanding of the terms *repeat*, *repetitive*, *recurring* and *recurrent*, as highlighted in the literature review, this theme was selected as the starting point for analysis. To ensure clarity, the research explicitly stated that the study was conducted in the context of system defects, so that all responses would be framed accordingly.

The first question asked respondents whether the four terms above were defined differently within their organisation, implying having distinct meanings; or whether they were used interchangeably, reflecting industry practice identified in the literature review. The purpose of this question was to gather a snapshot of the current industry situation regarding terminology usage and the MCC Engineers' understanding of the terms.

A strong majority of respondents (83%) indicated that these terms were used interchangeably within their organisation, or that only one term was formally defined (Figure 4.7). In contrast, only 18% of the organisations reported defining at least two of the four terms, placing them in the 'different' category.

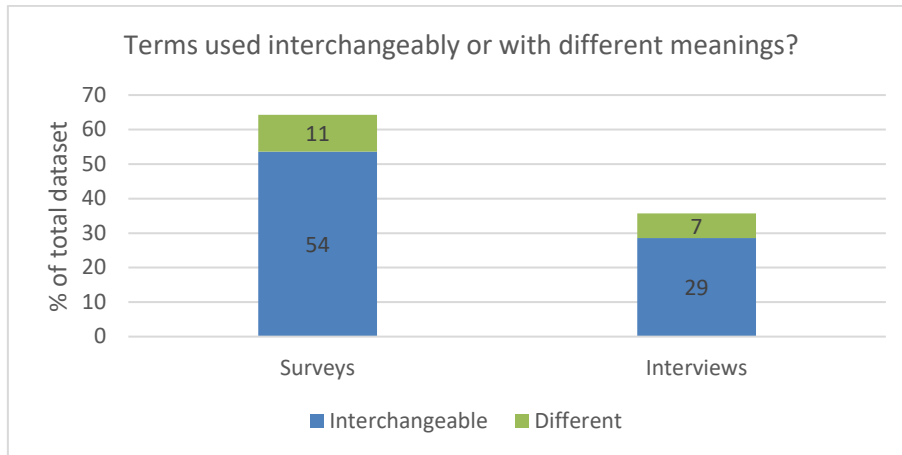


Figure 4.7 A plot showing the distribution of the terms' usage

The second part of this section invited respondents to provide their organisation's interpretation or definition of the terms, particularly where differences existed or if they wished to elaborate. The preliminary analysis revealed inconsistency among CAMOs in the selection and definition of these terms. Evidence of uniformity was limited, highlighting variability in terminology usage across organisations, consistent with the observations in the literature review.

While survey responses showed limited alignment with expectations, this may reflect two factors: either CAMOs lack formalised definitions, or the survey question was subject to misinterpretation. In contrast, interviews required minimal clarification to obtain accurate responses, with the conversational format proving advantageous, a point further illustrated in the next sections of this chapter.

Importantly, several responses were excluded following the review process, as they did not meet the criteria or context of this study. Some were deemed out-of-point because they provided, for example explanations of the terms based on general English language definitions rather than their application within the context of system defects. Others referred to repetitive inspection items for open defects, such as cases involving MEL items with pre-flight inspections, which also fell outside the scope of this research.

Appendix E provides a condensed summary table presenting the relevant responses. In agreement with Arshadi (2024), “there is no uniform standard” and this re-confirms the need for standardised terminology across the industry.

A closer examination of these results reveals that, among the nine responses to this question, there is a consensus that ‘repeat’ refers to an event occurring for a second time, whereas ‘repetitive’ denotes an additional recurrence, typically interpreted as three instances within a specified number of sectors or calendar days. Notably, there is no commonality regarding the time frame (or interval) for investigation. Three responses identify sectors as the interval, while six responses consider calendar days. Table 4.1 contains a summary of these responses.

Table 4.1 Summary of responses

Occurrences		Interval		n
3	in	6	sectors	1
		10		1
		15		1
		7	calendar days	1
		10		3
		14		2

The results clearly indicate that the two terms warranting further consideration are *repeat* and *repetitive* as none of the organisations employ the terms *recurring* or *recurrent* in relation to such system defects.

However, one respondent provided an insightful distinction, suggesting that: “A recurring defect is one that has been rectified but subsequently reappears outside the time frame or criteria that would classify a repetitive defect”. In other words, if a repetitive defect, defined, for example, as 3 occurrences in 14 sectors is identified, investigated and rectified, but subsequently re-emerges after a number of days, weeks, or sectors, it is considered to have reoccurred, and is then described as a ‘recurring defect’.

4.2.3 Process

This section explores processes currently employed by the CAMOs represented, in context of managing repetitive system defects; and seeks to identify and critically analyse the key challenges encountered during their implementation.

To ensure clarity and consistency throughout the remainder of the research, a single representative term from the four was adopted at interview design stage. The term '*repetitive*' defects was used, as it aligned with the terminology used by EASA (2024b) in the European Plan for Aviation Safety.

4.2.3.1 Role of the MCC Engineer

This part of the investigation sought to determine the role of the MCC Engineer in the mission of rectifying repetitive system defects.

This will be examined by means of data from the following questions which were presented to the questionnaire participants:

1. Is there a list of ongoing repetitive system defects in your shift handover?
2. When a new fault is entered in the technical logbook, do you look up a history of it to see if it is new or not?
3. If a defect is repetitive, do you handle this differently to other defects?
What do you do differently?

Building on the questionnaire, interviews provided an opportunity to examine the same topics more comprehensively through open-ended discussion.

Although the predefined survey questions were not posed in their exact form, the core theme they represented was addressed within the conversational element, using this question as a guideline: What is your role as MCC engineer concerning the handling of repetitive system defects?

Finally, the last question of this section was posed exclusively to the interview participants, as it required a detailed discussion to ensure that respondents fully understood the context and its meaning.

4. Do you proactively check component workshop reports *prior* to sending a component to an aircraft for installation?

This question specifically relates to 'No Fault Found' situations, where components are tested (as opposed to repaired or overhauled) and declared NFF, as seen in Chapter 2.

For Question 1, an absolute majority (92%) answered affirmatively when asked if they had a list of ongoing RSD in their shift handover, as illustrated in Figure 4.8 below. This demonstrates a recognised degree of importance.

Furthermore, the interview data revealed that some organisations employed an electronic diary system, commonly referred to as a 'team diary' to fulfil this function. However, some respondents clarified that, although they personally recorded RSD in this diary, this practice was not formally mandated within their teams. Rather, it reflected individual practice. Participants noted that adherence varied amongst their colleagues, with some demonstrating less consistency than others; consequently, this practice was characterised as a personal tendency rather than an enforced requirement.

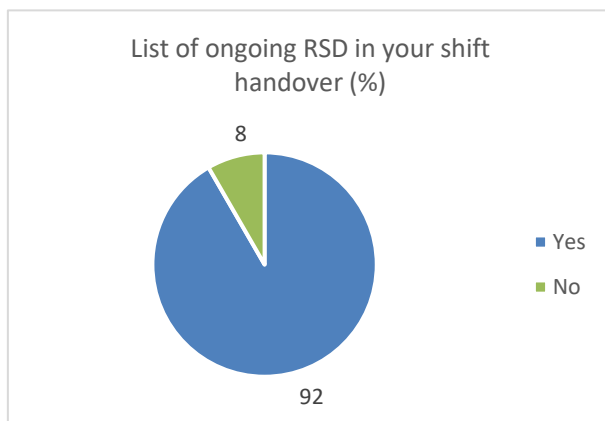


Figure 4.8 List of ongoing RSD in shift handover

For Question 2, when asked whether they conducted a history search to determine if a newly reported fault was novel or repetitive. Once more, an absolute majority (88%) answered affirmatively (Figure 4.9).

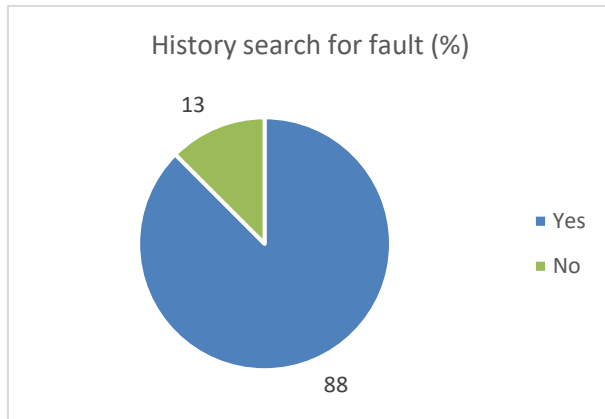


Figure 4.9 Share of respondents who check history for new faults

Interview findings indicated that the CAMO managing the largest fleet enforces the most stringent procedures, requiring a review of the defect history for every reported defect raised and comparison against records from the preceding 14 days. Notably, this review period was previously limited to 7 days but was extended to 14 days based on operational experience. This extended period means that more instances can be captured. This topic is discussed further in Section 4.5.

Interestingly, two of the three respondents who answered negatively clarified that they do perform history checks, but only when prompted by memory. These engineers explained that they work within small teams overseeing relatively small fleets, which allows them to maintain a high level of familiarity with the aircraft. In these organisations, formal responsibility for RSD identification lies with the Reliability Engineer; however, MCC engineers also contribute, relying primarily on memory to prompt a defect history search.

For Question 3, when asked whether they would handle an RSD differently to any other defect, 84% replied 'yes' (Figure 4.10). To gain a deeper insight, respondents were asked to elaborate, and their comments were analysed aiming to identify organisational patterns in the handling of RSDs. The most notable points regarding these responses are presented in Appendix E. Although the level of detail varied, most respondents described performing in-depth troubleshooting activities and reviewing previous history. The most significant insight to emerge from these responses is that an RSD is only

formally closed after 7 days without reoccurrence, which is taken as a confirmation of a successful fix.

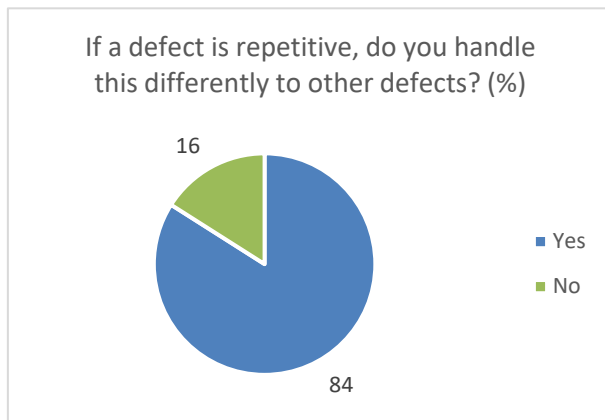


Figure 4.10 Share of respondents who handle an RSD differently

The final question of this section (Question 4) asked MCC engineers whether they proactively review workshop reports of a component prior to its assignment to an aircraft for defect rectification. This question specifically relates to 'No Fault Found' situations, where components are tested (as opposed to repaired or overhauled) and declared NFF, as seen in Chapter 2.

The responses varied, with no clear majority consensus, as illustrated in Figure 4.11. Among the ten interview participants, three indicated that they proactively performed checks, while two stated that they occasionally did so, although this was not a formalised procedure. Additionally, four respondents explained that they initiated a check only if a fault had already been identified on a system component that was recently replaced, noting this as the point at which a detailed review became necessary. Only one participant reported rarely conducting such checks, citing that in business aviation, the maintenance organisation typically sources and installs the part, with CAMO documentation checks occurring retrospectively.

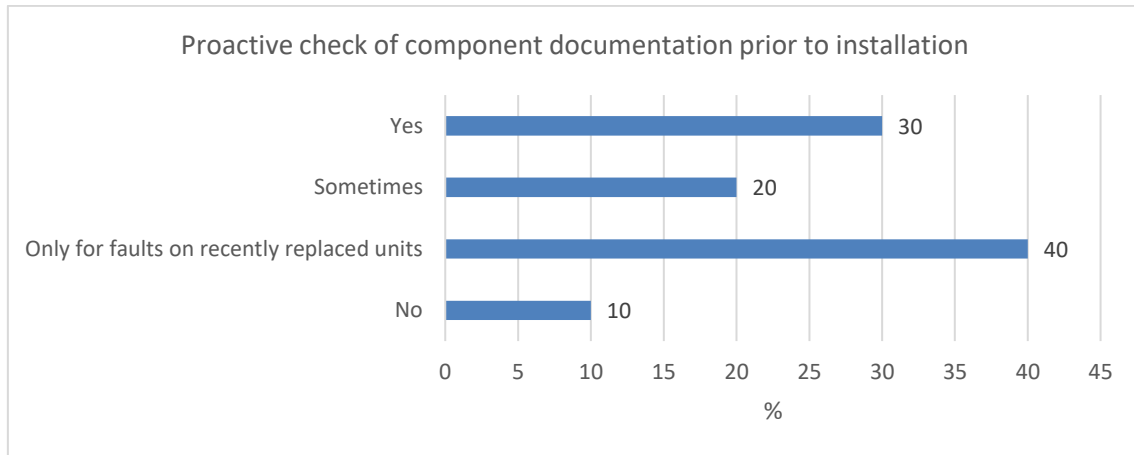


Figure 4.11 Responses for proactive checks of documentation before installation

There was a broad agreement that components returned from workshops with a ‘tested and NFF’ designation may aggravate issues within systems already subject to a repetitive defect investigation. The following excerpts illustrate challenges this poses for CAMOs.

Although the first quotation was provided in response to Question 3 (which examined whether RSD are managed differently from other defects), it was included due to its strong relevance to this theme. Respondent S4 indicated that NFF was a situation of concern: “...the shop report for the previously replaced part. *It can be NFF which is a huge problem*”.

MCCE-05, who has over 30 years of aviation experience and more than 11 years in an MCC role, offered two noteworthy observations: (1) the absence of clear CAMO procedures to address such situations and the element of personal initiative, and (2) the significant reliability concerns raised when workshops return components as ‘NFF’. The relevant response extract is provided in Appendix E.

These insights underscore the importance of performing documentation checks before reinstalling components, as such measures may prevent the reinstallation of potential rogue units on an aircraft experiencing RSD. Failure to do so may create the false impression that a corrective action has been implemented, when in reality the underlying issue remains unresolved. Consequently, the defect may persist, leading to additional (potentially

unnecessary) troubleshooting, resulting in extended aircraft ground times and associated operational penalties.

However, rejecting a component is not always easy or feasible, especially if only one replacement option is made available at time of need. As noted by MCCE-10, "...you have to compromise between keeping the aircraft on ground (AOG) or sending the spare."

This finding highlights a key challenge faced within MCC operations: balancing aircraft serviceability requirements while ensuring component (or system) reliability. This suggests that in the absence of clear guidance (at minimum, internal CAMO procedures), MCC engineers lack formalised protocols to support decision-making when evaluating whether to reject NFF components. This challenge is compounded by the fact that, in some cases, the NFF designation is accurate, and the component is genuinely fault-free.

Overall, these findings point to an area with significant potential for improvement. The lack of regulatory guidance allows organisations to define their own requirements and internal procedures, if any, leading to variability in practice. Given the criticalness of NFF situations, the findings strongly point to the need for more standardised guidance in this domain.

4.2.3.2 Other supporting roles

This question asked respondents whether there are other roles in the CAMO which support the resolution of RSD. The aim was to understand if the complete responsibility is on the MCC engineer, or if there is a shared input, how the other roles contribute to the process. As illustrated in Figure 4.12, there was a 71% response that other roles are part of this process too.

The next question therefore asked which roles support the handling of RSD in a CAMO. The prominent roles were the Technical Services Engineers and the Reliability Engineers. Insights and analysis into this element are presented in Appendix E.

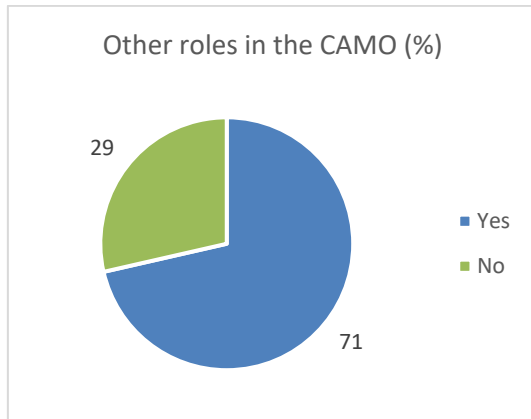


Figure 4.12 Other supporting roles

4.2.3.3 Challenges

The subsequent question aimed to find out what are the challenges that MCC engineers face when they are attempting to resolve RSD. A multiple-choice question was presented to survey respondents, with the opportunity to also add further comments. On the contrary, this topic was presented as an open question in the interviews, providing the opportunity for the respondent to talk freely without being influenced with a pre-defined list. After a response was provided, the multiple-choice list was presented too. This was beneficial because it introduced several elements which most participants did not think of, and therefore it served to provoke more diverse arguments and gather deeper insights.

The responses from the multiple-choice question were collated and plotted in a graph displaying the challenge versus a count of the total number of times a certain challenge was mentioned by the participants (see Figure 4.13).

An analysis of the identified challenges indicates that they can be broadly classified into two categories: (1) technical issues, which pertain to the inherent complexity and difficulty of addressing RSD from an engineering standpoint, and (2) organisational issues which relate to operational, procedural and resource-based factors within the teams.

There was a strong consensus between respondents that the two technical issues presented, no fault found situations and intermittent defects, constitute

the most significant challenges encountered in practice. This is consistent with literature (Khan et al., 2012) and proves that a conclusion “NFF” from troubleshooting is an inherent challenge in commercial aviation.

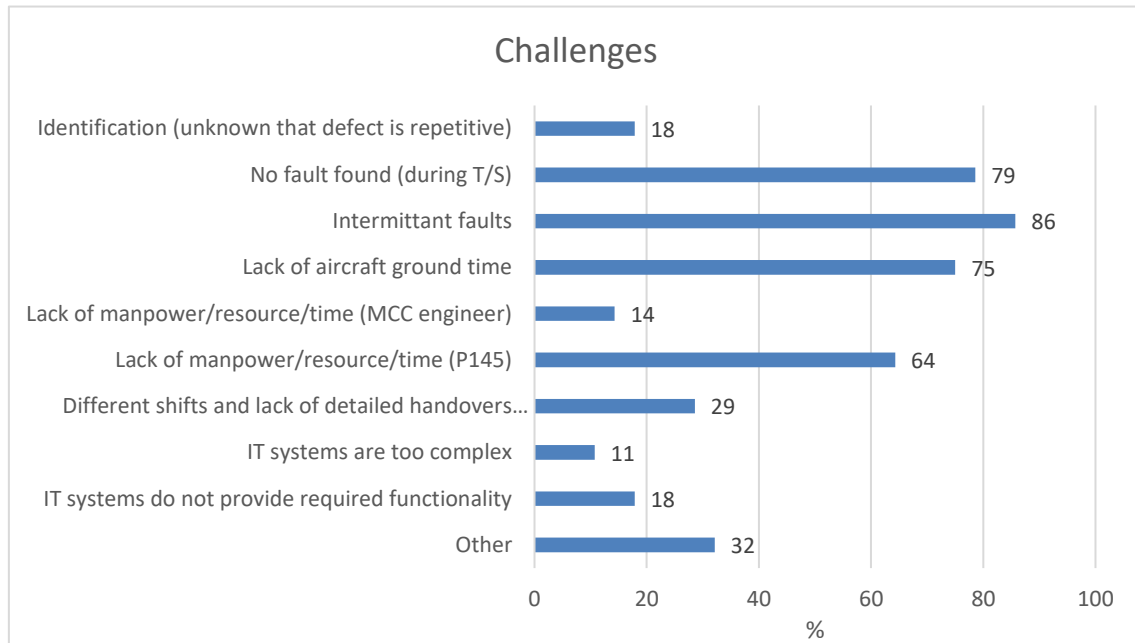


Figure 4.13 Challenges encountered

With regards to organisational challenges, the most prominent issue identified was the lack of aircraft ground time, reported by 75% of participants. This challenge arises from the fact that modern airliners operate on highly demanding flying schedules, leaving minimal time for maintenance activities. Given that RSD often require significant unplanned ground time for effective resolution, securing such time becomes an obstacle for MCC engineers. Consequently, this factor is classified as the most critical non-technical challenge.

Lack of manpower, resource and time in Part 145 AMOs came up as the second most prominent organisational challenge encountered, with 64% of participants concurring that this is a challenge. This topic emerged to be the most prominent from the interview discussions and will be discussed towards the end of this section.

MCCs appear to be well staffed with only 14% of respondents having highlighted that lack of resource or time within their team was a challenge for handling RSD. Having said that, the sample characteristics must be kept in mind, because smaller fleets were more prominent and therefore this cannot be generalised or assumed to be applicable also to MCCs responsible for very large fleets (300+ aircraft).

No significant challenges related to identification of RSD were reported (only 18%). Once more, this outcome may be attributed to adequate staffing within the teams, which minimises time constraints and enables MCC engineers to undertake manual tasks without concern. It is worth noting that respondents replied based on the way they were accustomed to performing identification activities using established practices in their teams. This may lead to a perception that no issues exist in this regard. At this point in the survey, the option of implementing automated identification software had not yet been introduced.

However, in the interviews, a notable concern was raised by one respondent from a CAMO managing the largest fleet, where this team relies on a fully manual process to check for repetitiveness in every defect or fault reported. Unlike other teams that follow scheduled reviews, this CAMO performs a verification for every new defect. This method is highly time consuming, and the respondent emphasised the risk that the accuracy may deteriorate when engineers face time pressure. This creates a potential vulnerability, as RSD may remain undetected under such conditions.

There were no significant complaints regarding the current IT systems being perceived as a challenge. Once more, respondents provided feedback based on their existing experience and tools currently available to them. There was no consideration of potential process improvements or innovations that could enhance efficiency and ease their work, at this point of the survey.

A thematic analysis was performed to gain insights to the most prominent themes emerging from the discussions. The results are presented in Figure 4.14. The dataset is of nine respondents.

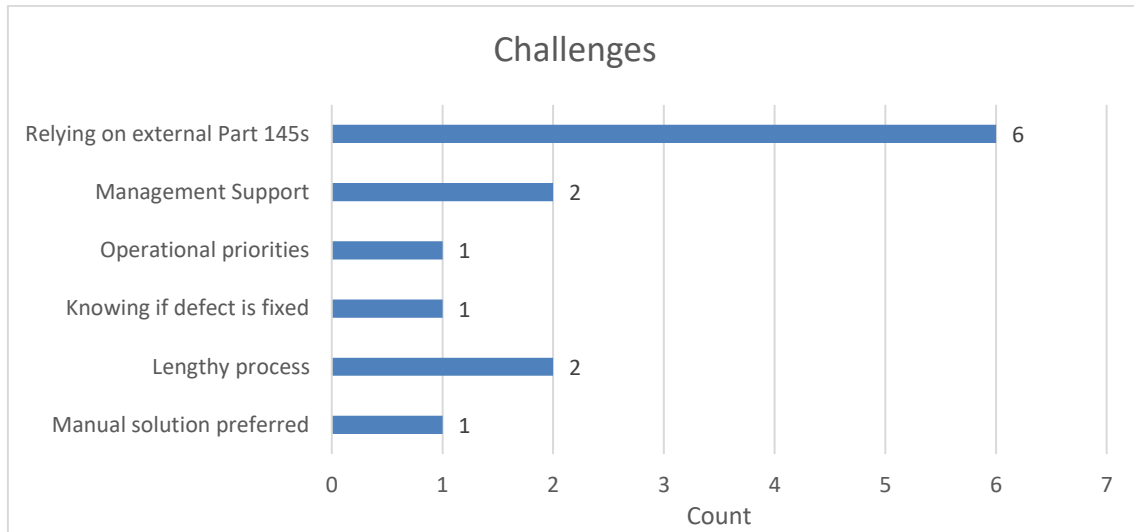


Figure 4.14 Challenges encountered (thematic analysis)

The strongest theme which emerges concerns the dependence of the CAMO on Part 145 organisations in the resolution of such defects. Especially for ACMI or business jet operators, aircraft are often away from home base, and there is complete reliance on the input of contracted maintenance organisations. Geographical region (such as the African continent or certain parts of Asia), language and communication challenges, and availability of the necessary regulatory approvals in the maintenance organisations, are factors hindering the effective rectification of repetitive system defects.

Another element of working with an external maintenance organisation is that it is sometimes difficult to have them follow the troubleshooting steps in the order as advised by the TSM, as often it is easier to go for quick solutions such as LRU replacement, as opposed to wiring checks which are more time consuming.

Other respondents commented that in their teams, a challenge is the lack of company management's understanding of topic, since this process is not one audited by regulators, and it is difficult to emphasise its importance.

The findings from this section broadly align with the work of Arshadi (2024); although, positive differences arise due to use of different datasets. A key point of convergence between the two studies is the recognition that organisational

challenges constitute a significant concern within the industry. Repetitive system defects, by their nature, frequently lead to unplanned ground time, which may result in significant operational disruptions. Furthermore, the previously discussed difficulties encountered when dealing with maintenance organisations, align with the findings of Arshadi (2024), where it was also stressed that inexperience, coupled with lack of workforce may contribute to an increased incidence of RSD. When coupled with the operational pressure to return the aircraft to service, maintenance staff may be compelled to expedite troubleshooting processes. This urgency introduces the risk of bypassing time-consuming troubleshooting steps, in favour of quicker interventions, such as immediate LRU replacements.

A noteworthy distinction between the two studies lies in the absence of technical challenges among those identified by Arshadi (2024). The omission may be attributed to the fact that the respondents in Arshadi's study were not front-line personnel. Consequently, the findings of both studies can be viewed as complementary, offering a more holistic perspective on the challenges faced within the CAMO in this context.

4.2.4 Communication with Flight Crew

This section investigated communication between the CAMO, through the MCC engineer, and the aircraft flight crew. As outlined in the introductory chapter, repetitive defects are typically not recorded in the aircraft technical log; if multiple entries exist, only the most recent defect remains open or deferred. Proactive communication from CAMO to the flight crew ensures that pilots are aware of systems under investigation for RSD, which may enhance their ability to manage a potential emergency effectively. Additionally, pilots may support the RSD investigation by providing in-flight data and observations to Engineering.

This section seeks to determine whether MCC engineers are adequately prepared to address inquiries from crew under time constraints, and to examine their perceptions regarding the proactive communication of RSD information.

The findings from the flight crew, in respect to this topic, are presented in Chapter 4.3.

4.2.4.1 Requests for information

The first question explored whether MCC engineers receive requests from flight crew members regarding repetitive system defects. Pilots may recall previous faults and associate them with specific aircraft, prompting them to contact the MCC for clarification. Typical inquiries may include situations where a fault that was reportedly closed earlier appears to be active again.

Figure 4.15 illustrates that, the majority of MCC engineers responded affirmatively, with 86% indicating that they receive requests from flight crew for defect information, including instances where the crew suspects that previously resolved defects have reappeared.

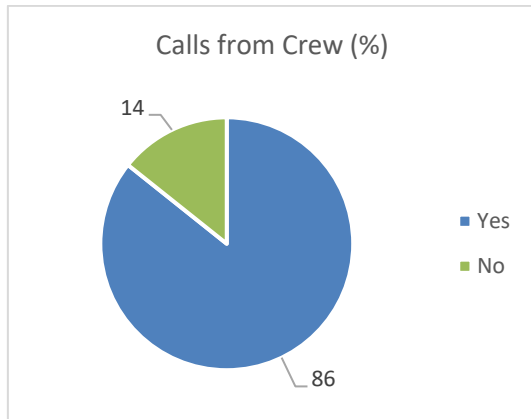


Figure 4.15 Requests from flight crew

Interview responses indicated that such requests are generally infrequent, particularly within organisations operating smaller fleets. This is unsurprising given the low number of aircraft and sectors involved. In contrast, approximately 20% of respondents, primarily those managing larger fleets, reported receiving these calls more often.

This finding reinforces the assumption that pilots initiate these calls, and it demonstrates an interest within the pilot community regarding the technical status of their aircraft. Moreover, this result aligns with the insights presented in Chapter 4.3, which examined with the pilots' perspective on access to technical details and operational status of their aircraft.

4.2.4.2 Ease of providing crew with a defect history

The subsequent question aimed to assess the perceived ease or difficulty for an MCC engineer on shift to provide a pilot with the requested defect history. This closed-ended question utilised a Likert scale, where participants rated their experience on a scale of 1 (extremely difficult) to 10 (extremely easy). Results indicated that 32% of participants rated this as neutral (neither easy nor difficult), while 56% selected scores between 7 and 9, suggesting that the process was generally considered easy (refer to Figure 4.16).

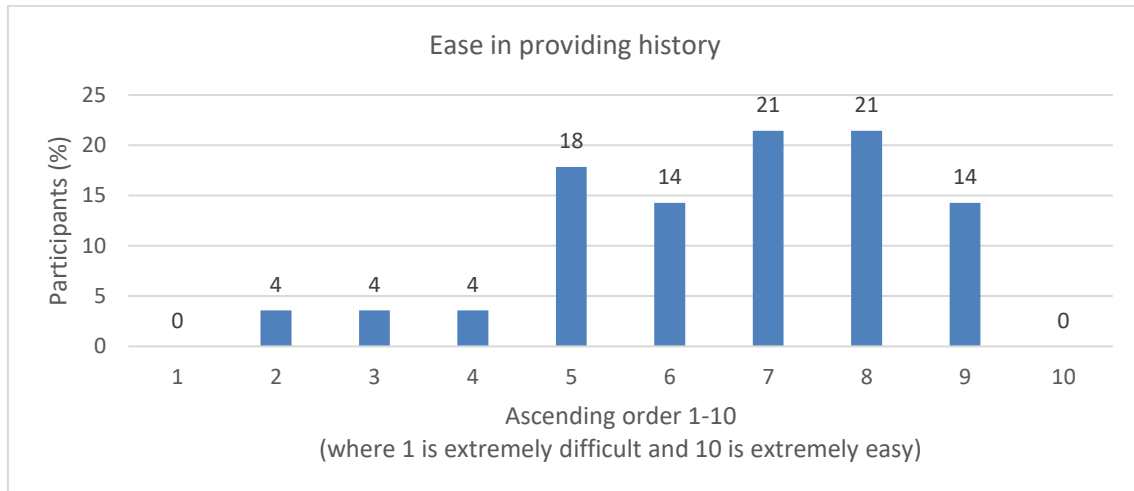


Figure 4.16 Responses regarding ease of providing pilots with a defect history

Insights from the interviews provided further context for these ratings. Several factors appear to influence the perceived ease of providing pilots with a defect history, including the format of the technical log (electronic versus paper), the team structure, and the use of electronic team diaries as mentioned previously.

4.2.4.3 Perception about sharing RSD information proactively

The final question asked respondents whether flight crew should be proactively informed about any RSD on the aircraft they are scheduled to operate. This question was included considering findings from a previous study (Arshadi, 2024), which indicated that the engineering community holds differing views on this issue. The present study specifically aimed to capture the perceptions of CAMO front-line staff and those directly in contact with pilots, as this matter has a direct impact on their operational responsibilities.

The questionnaire presented this question as a closed-ended item with three response options: Yes, Maybe, No. For each option, respondents were invited to provide a comment specifying the reasons for their choice. In contrast, the interviews adopted a more open-ended format, where participants typically expressed a 'Yes' or 'No' stance and supplemented it with their rationale. The conversational approach enabled participants to elaborate on their responses and articulate their underlying thought process in greater detail. Figure 4.17 presents the overall combined results, indicating that 54% of respondents

believe pilots should be proactively informed of RSD under investigation. Figure 4.18 provides a comparative breakdown, distinguishing between responses from the online survey (closed-ended), where respondents were more cautious in selecting ‘yes’, and those obtained through the open-ended interview discussions.

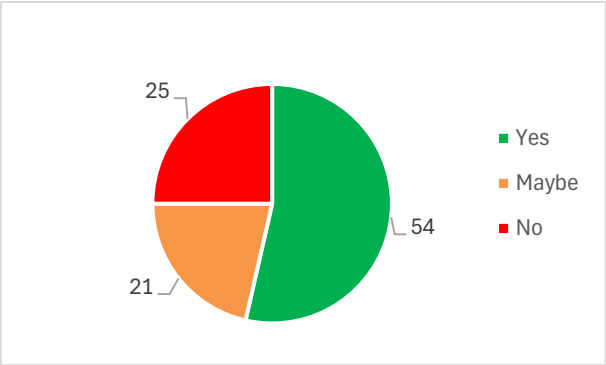


Figure 4.17 MCC engineers’ view on informing pilots of RSD

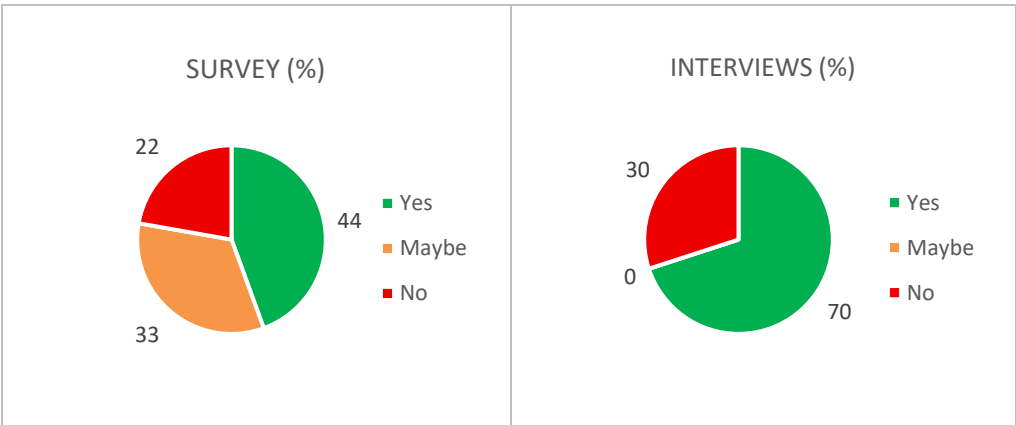


Figure 4.18 Difference between survey and interview responses

A thematic analysis was conducted on the data obtained from the survey comments and the interviews. It became evident that survey comments associated with the ‘Maybe’ and ‘No’ categories were occasionally similar, with differences attributable to phrasing rather than intent. For example:

- No – ‘unless it is a critical system’
- Maybe – ‘only in case of a critical system’.

To address this inconsistency, the thematic analysis focused on consolidating responses and identifying overarching themes. Seven main themes emerged,

as illustrated in Figure 4.19. Two dominant categories, each with equal representation, stand out. The first emphasises that RSD information should be communicated and shared since the crew are well-positioned to support troubleshooting activities by providing observations from flight. There was an emphasis on the idea of crew supporting MCC efforts.

The second prominent theme, ‘Crew situational awareness’ reflects an opposing rationale: that the crew should be informed because it is considered essential for them to be aware of the defect status, enabling preparedness in the event of a system failure during flight, and enhancing the overall situational awareness. Both these two themes were mentioned by 43% of respondents, indicating that they were equally prevalent and collectively represent the most frequently cited reasons for informing the crew about RSD.

Furthermore, 32% of respondents cited that their decision would depend on the severity of the affected system, particularly when it involved a safety-critical component. Conversely, only 11% highlighted transparency and mutual confidence between departments, pointing to the importance of openness and honesty in line with the principles of a robust Safety Management System (SMS).

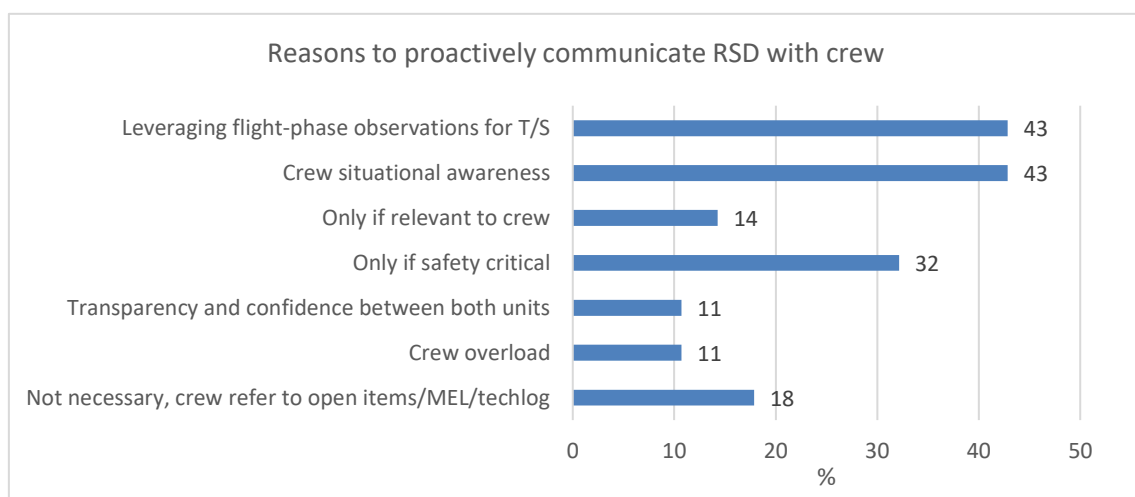


Figure 4.19 Reasons to proactively share RSD information with pilots

To present more insight into the themes’ distribution, Figure 4.20 shows the themes categorised according to whether they were linked to a ‘Yes’ response, and Figure 4.21 shows those for the ‘Maybe and No’ responses.

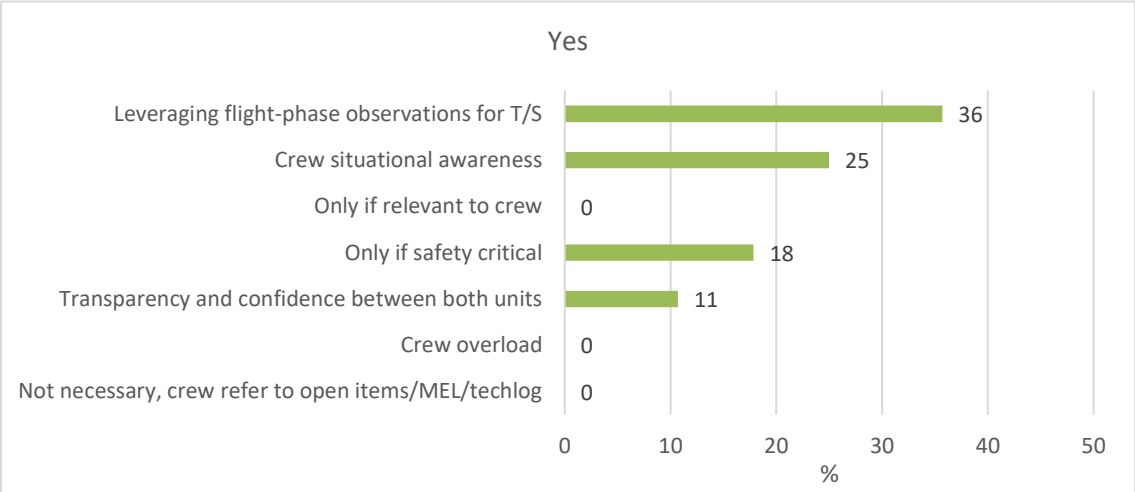


Figure 4.20 Reasons to provide RSD information (Yes responses)

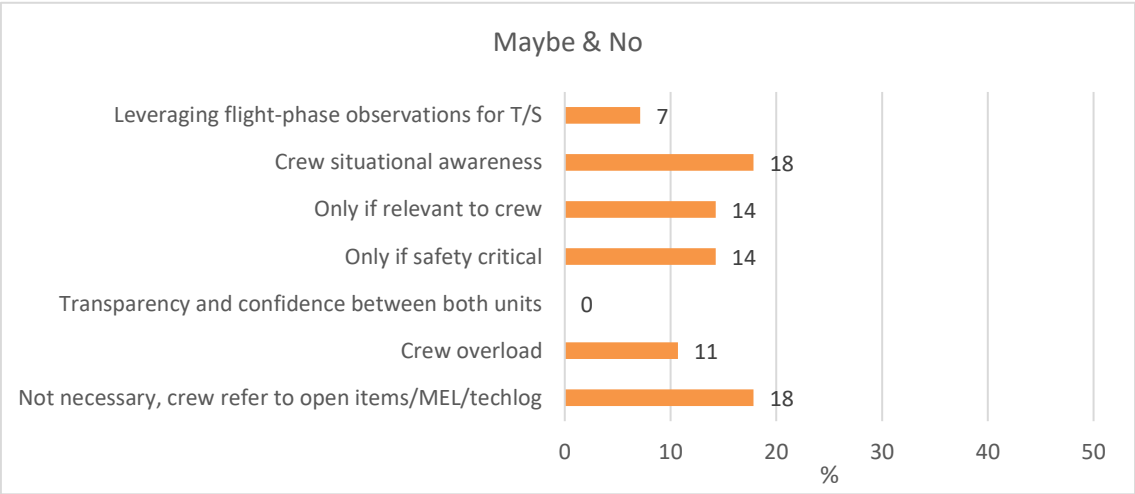


Figure 4.21 Reasons to provide RSD information (Maybe and No responses)

A minority of respondents (11%) suggested that the crew should not be informed to avoid information overload, where excessive details could potentially distract or overwhelm flight crews. Similarly, 18% indicated that pilots should not be informed, citing reasons that crew already have access to open deferred items, the MEL or the technical log in general. This perspective may reflect a limited understanding of the question, particularly considering that RSD are not currently included in the standard technical log format. If this were an

established procedure within their CAMO and standard practice, respondents would likely have answered 'Yes', which was not the case.

These findings can be compared to those reported by Arshadi (2024), who examined the issue of repetitive defects but from broader, higher-level perspective. Both studies converge on the central argument regarding whether repetitive defects should be proactively communicated to flight crews. Consistent with the previous research, the present study confirms that the engineering community remains divided on this matter. A slim majority of respondents favour sharing this information, followed by a smaller proportion who believe it should be done depending on the severity of the defect or system, and a minimal percentage who oppose the concept entirely.

It is noteworthy that the datasets of these two studies were intentionally different. Whereas Arshadi (2024) interviewed management and aviation professionals with high levels of expertise from diverse roles, such as safety managers, maintenance managers and pilots, the present study focused specifically on MCC engineers for reasons previously outlined. Moreover, Arshadi (2024) did not specify the proportion of participants from each role, which could have significantly influenced the findings. Despite these differences, the similarity in overall conclusions suggests a degree of consensus within the industry.

However, notable differences emerged between the two studies. In Arshadi's research, the majority of participants advocated for transparency on issues potentially related to safety, aligning with the principles of a robust SMS. In contrast, this theme did not feature prominently in this study, appearing only as a weak theme (11%). This divergence may be attributed to the distinct composition of the dataset: management roles tend to emphasise safety as an overarching principle, whereas MCC engineers focused more on practical considerations. Interestingly, MCC engineers viewed pilots as potential contributors to the troubleshooting process, a perspective absent from Arshadi's study. This represents a significant difference in findings.

4.2.5 Software Aid

The final section of this study involved presenting all participants with a proposed software solution, the description of which outlined the following key elements:

'A repetitive defect analysis software could automatically flag and prompt repetitive defects without user queries. It could provide past rectification actions, and a large variety of statistics for the tail, for the complete fleet, or across fleets, all in the same system.'

4.2.5.1 Current software applications

The initial question sought to determine whether participants currently use any software application in their workplace comparable to the application proposed in this study. Survey participants who answered 'yes' were asked to identify the software and describe its three key features, while interviews explored this conversationally. Comments and observations regarding the software applications employed within the respondents' organisations are presented in Appendix E. Overall, it was concluded that that none of the organisations employ an RSD tool offering the full functionality envisaged in this study.

4.2.5.2 Perceived benefit of RSD tool

Survey participants who indicated that their organisation did not have a software application of this type, along with all interviewees, were asked whether they perceived any benefit in implementing such tool. Figure 4.22 shows that there was a strong agreement regarding its value, with only one respondent expressing preference for manual processes. This result suggests a strong openness among MCC engineers to adopting new tools that enhance day-to-day operational support.

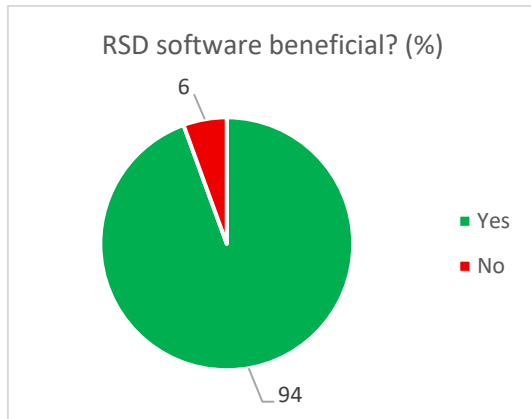


Figure 4.22 Perceived benefit of RSD software

4.2.5.3 Functionality of RSD software

The next question asked all respondents to identify the most critical and useful features of a potential application for managing such defects. In the questionnaire, this was presented as a multiple-choice item. During the interviews, the topic was explored conversationally, after which the same list of features was shown to participants to capture perspectives not previously raised.

As illustrated in Figure 4.23, respondents expressed strong consensus regarding the usefulness of the proposed features. Participants unanimously acknowledged the potential advantages of such automation; an aspect further explored in the following questions. Two comments from the discussion particularly illustrate this view:

- “To take the human element out of it”.
- “To confirm if it is really a repetitive defect or not. Using memory as a trigger for checking may be misleading, and not accurate”.

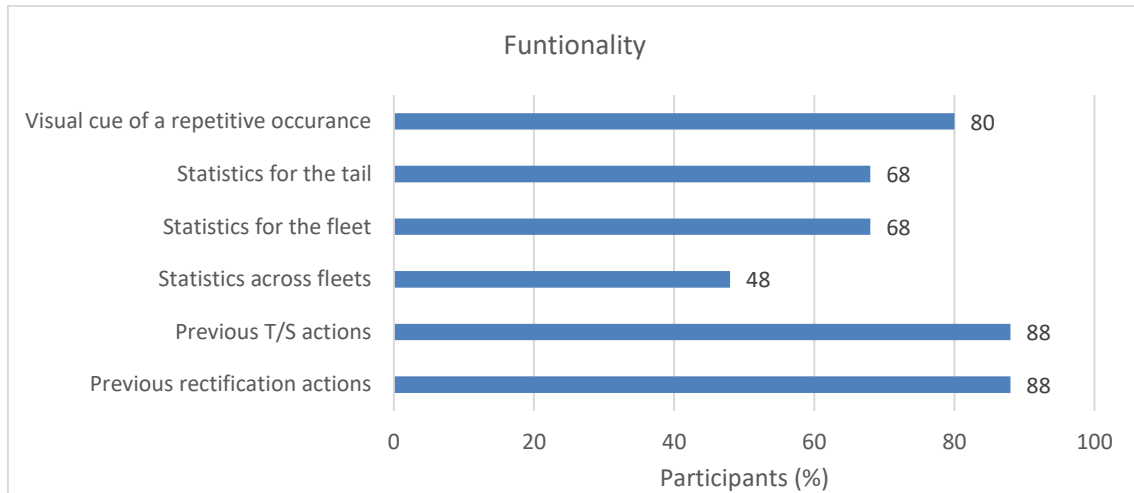


Figure 4.23 RSD software functionality ratings

A strong majority indicated that automated identification of an RSD accompanied by visual cues, previous troubleshooting steps, and historical rectification actions would be highly valuable. This feature was perceived as advantageous because it would allow an MCC Engineer to obtain an immediate overview of the situation directly from the dashboard. It would also reduce reliance on manually maintained electronic diaries, as the application would compile relevant maintenance history, including component changes, directly from existing records.

Notably, only half the sample selected the option for ‘statistics across fleets’. This divergence may reflect a perception that cross-fleet comparisons offer limited operational value at the MCC level, or that respondents interpreted this feature as extending into longer-term reliability analysis rather than supporting the short-term decision-making and therefore viewed it as unnecessary.

The motivation for this option arose from a known limitation in the M&E software ‘OASES’, particularly in situations where an MCC is responsible for managing two or more distinct fleets registered under different AOCs. Because each fleet is treated as a separate entity with its own CAMO responsibilities, OASES does not perform cross-fleet historical integration, resulting in fragmented access to defect and component histories.

However, since the MCC engineer oversees both fleets and all aircraft belong to the same type, it is operationally advantageous to analyse trends and compare data across fleets. The intension behind proposing an “across-fleets” feature was therefore to enable such integrated analysis, supporting more comprehensive and informed decision-making. Furthermore, the proposed software could extend beyond the scope of this thesis, as it would be capable of analysing any category of defect once implemented. For example, recurring cabin issues, such as repeated seat faults on one fleet, could be compared with defects in another fleet equipped with the same seats.

4.2.5.4 Impact to efficiency and safety

In the final question of this research, participants were asked to assess the potential impact of having such software available, specifically in terms of its effectiveness to efficiency in their day-to-day work, and its contribution to overall safety.

When asked to evaluate efficiency (see Figure 4.24), the lowest rating provided was 5, corresponding to ‘moderately effective’. This suggests unanimous agreement among participants, albeit to varying degrees, that an RSD software would enhance efficiency. Notably, 73% of respondents assigned a rating at 8 or higher, reflecting strong confidence in the software’s ability to deliver significant improvements.

This outcome is consistent with findings presented earlier regarding the various processes used across CAMOs, where RSD identification remains largely manual. The results suggest that MCC engineers place significant value on introducing automation to streamline this aspect of their work.

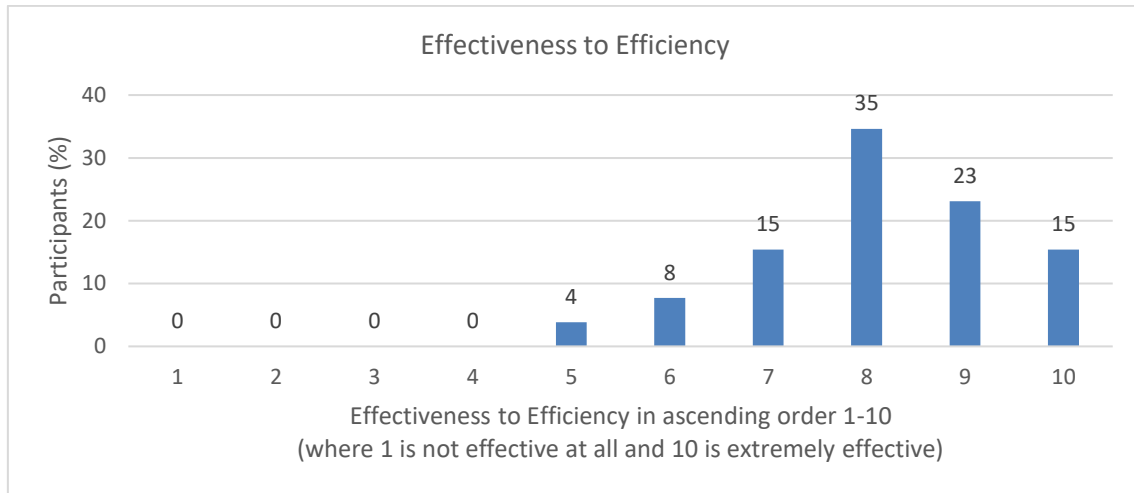


Figure 4.24 Responses for effectiveness to efficiency

Participants were subsequently asked to rate the software's potential contribution in enhancing safety. The results indicate a strong consensus, with 77% assigning scores between 8 and 10, indication the respondents perceive the software as likely to have a positive impact on overall safety.

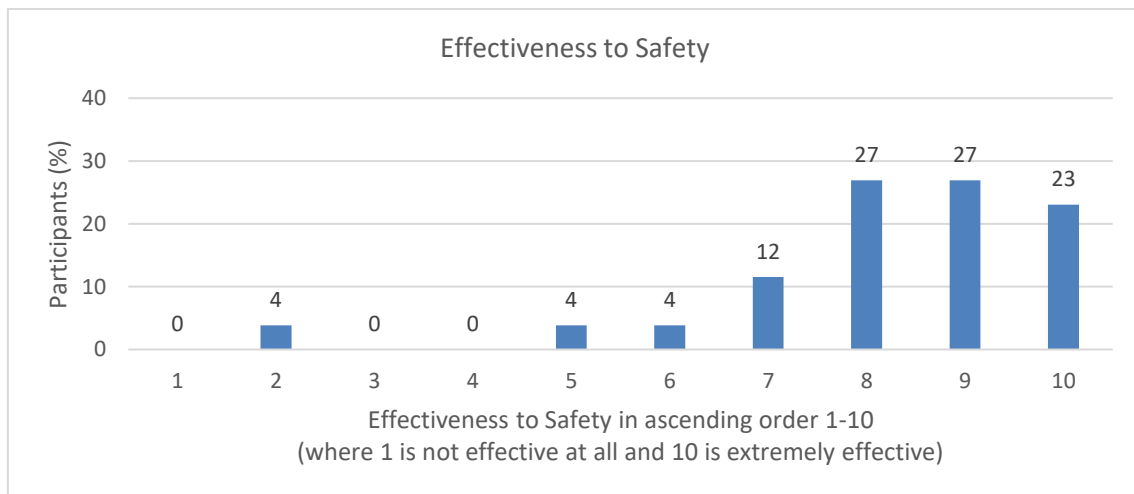


Figure 4.25 Responses for effectiveness to safety

One interpretation of this finding is that introducing automation into a previously manual task may be perceived as enhancing safety by reducing the likelihood of errors. Such errors could include the misidentification of repetitive defects, which may result in inadequate corrective action; delays caused by time spent searching for previous history or troubleshooting procedures; or mistakes arising from divided attention due to competing operational demands.

To conclude, respondents demonstrated clear confidence in the effectiveness of software applications. The clustering of ratings for both efficiency and safety within the upper three levels indicates a substantial degree of trust in such tools. When considered alongside the finding that 94% of respondents viewed a software tool as beneficial, this suggests a favourable outlook for the development and adoption of such an application within the MCC Engineering community. It further implies strong potential for improving job efficiency and contributing to enhanced overall safety.

4.3 Flight Crew

4.3.1 Demographics

The first question sought to determine the regulatory authority under which each respondent operated. This was intended to provide insights into the geographical distribution of participants, as the survey was targeted for a global audience.

Although multiple regulatory authorities were represented in the responses, approximately two thirds reported operating under EASA, followed by the UK CAA at 17%. Refer to Figure 4.26. The survey demonstrated a degree of international reach, with responses from regions such as New Zealand, Brazil, Australia and Canada, albeit in limited numbers. Despite the relatively small sample from these regions, their inclusion adds diversity and enhances the global perspective. Notably, no respondents indicated working under the FAA.

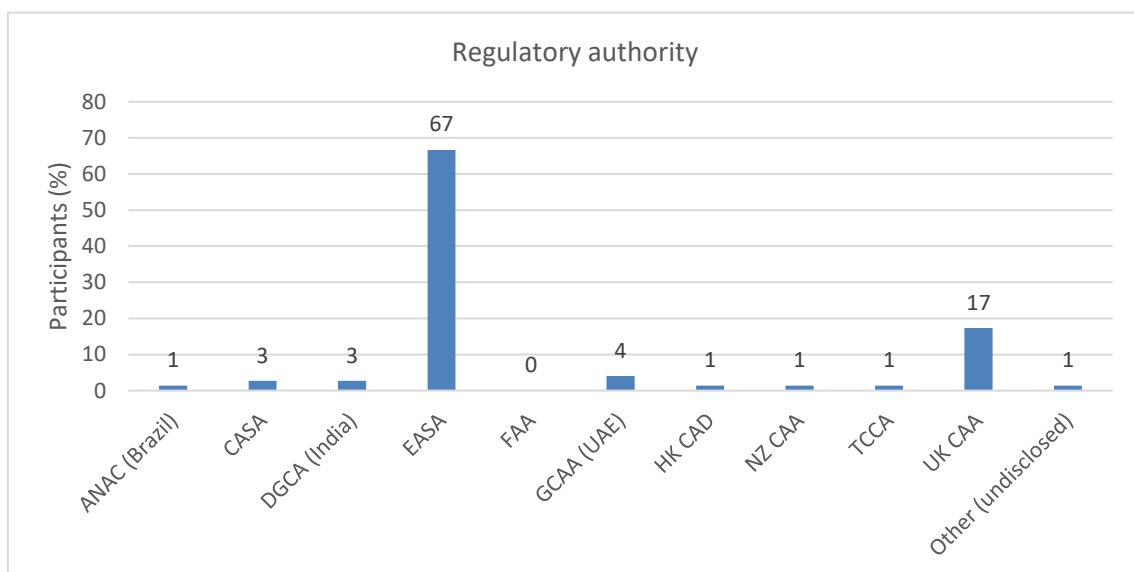


Figure 4.26 Regulatory authority

The next question asked the respondents to indicate their experience in flying commercial aircraft, as this information provides valuable context regarding the dataset and the professional background of the pilots represented. The results reveal a broad range of experience, with 54% of pilots reporting more than 16 years of flight experience. As illustrated in Figure 4.27, the distribution includes

relatively new pilots, with 20% with less than five years' experience, as well as highly experienced pilots, with 12% of respondents having accumulated over thirty years of service.

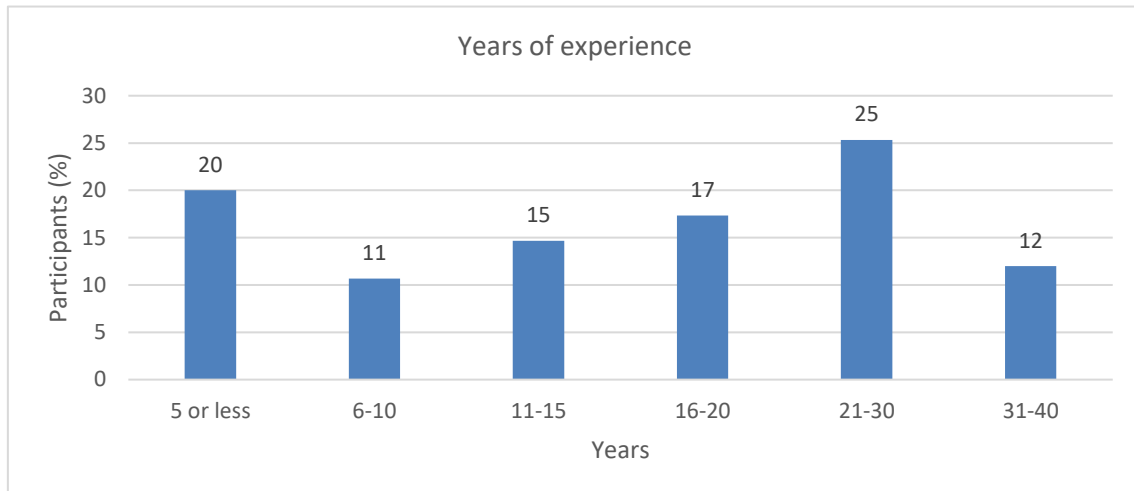


Figure 4.27 Years of experience operating commercial aircraft

The study subsequently examined the distribution between Captains and First Officers. Figure 4.28 shows that nearly two-thirds of respondents were Captains. This strong representation enhances the robustness of the findings, as Captains hold ultimate responsibility for accepting the aircraft prior to departure, a process central to the research topic.

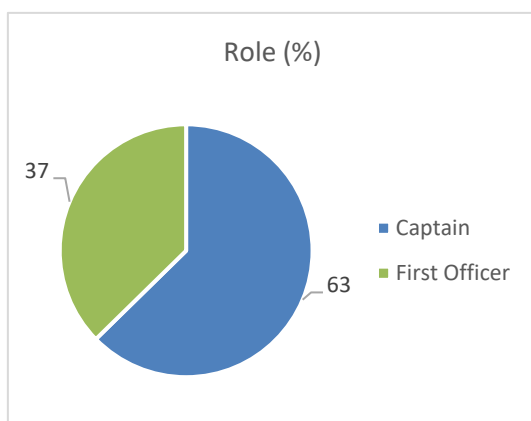


Figure 4.28 Distribution of Captains and First Officers

Finally, half of the respondents were in their forties, and the overall age distribution follows an approximately normal trend shown in Figure 4.29. This suggests that the sample primarily represents mid-career pilots, who possess

substantial operational experience while still having significant remaining years of active service. This is an important factor for the applicability of this study's findings.

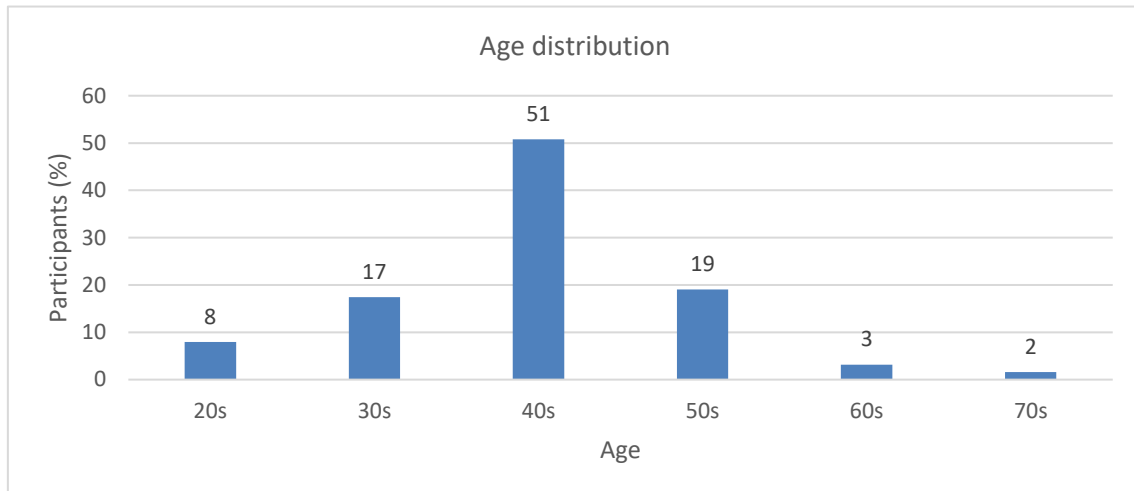


Figure 4.29 Age distribution

4.3.2 Process

4.3.2.1 List of open RSD

The first question of this section asked pilots whether prior to flight, their CAMO presented them with a list of open/identified repetitive system defects, affecting the aircraft they were about to operate.

This closed question presented three response options: 'yes', 'maybe' or 'no'. An explanatory note was included to clarify the meaning of RSD, following initial feedback indicating that the term might not be widely familiar within the pilot community. Incorporating this clarification aimed to ensure consistent understanding among respondents.

Figure 4.30 shows that one third of respondents receive this information prior to flight, however more than half of respondents do not receive such information.

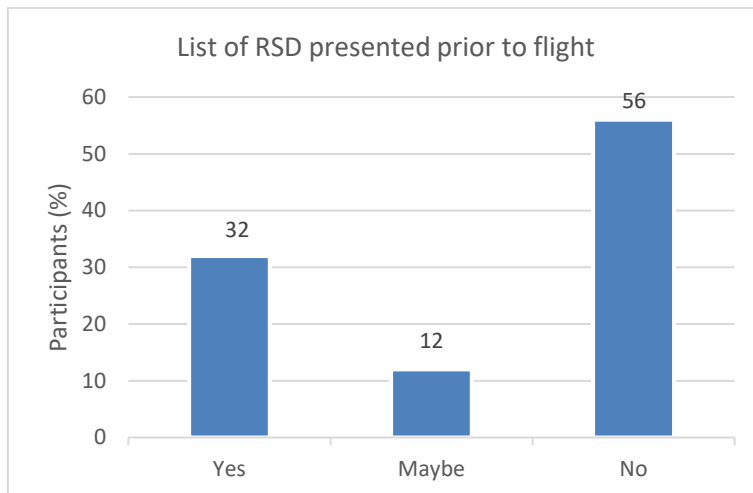


Figure 4.30 List of RSD presented prior to flight

Respondents who answered 'yes' operated for various regulatory authorities as shown in Figure 4.31. This distribution indicates no association with a single authority; rather, selections such as EASA and UK CAA exhibit patterns similar to the overall distribution shown in Figure 4.26. This suggests that the regulatory authority does not influence whether the CAMO communicates this information to pilots.

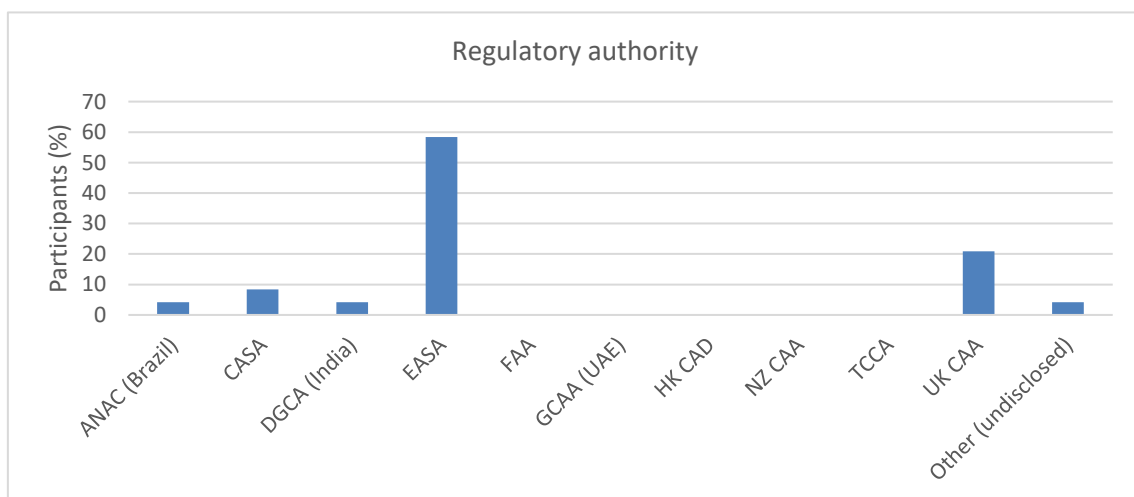


Figure 4.31 Regulatory authority

The next question asked the pilots who responded 'yes' to indicate the method used to communicate this information: the technical logbook, email or flight briefs, or another method. As shown in Figure 4.32, the technical logbook was identified as the primary means of communication by 79% of respondents.

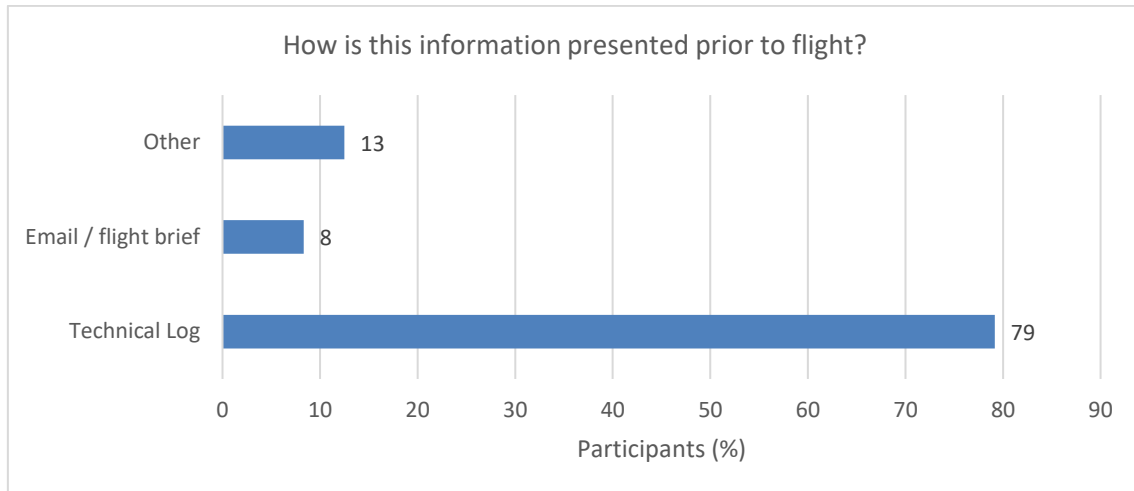


Figure 4.32 Means to share RSD list

4.3.2.2 Access to information

The same participants rated the ease of access to this information on a scale of 1 to 10; where 1 indicated 'extremely difficult', and 10 indicated 'extremely easy'. Apart from two outliers (ratings 1 and 3), responses indicate that this information is generally perceived as accessible, with 63% of pilots assigning the top three ratings.

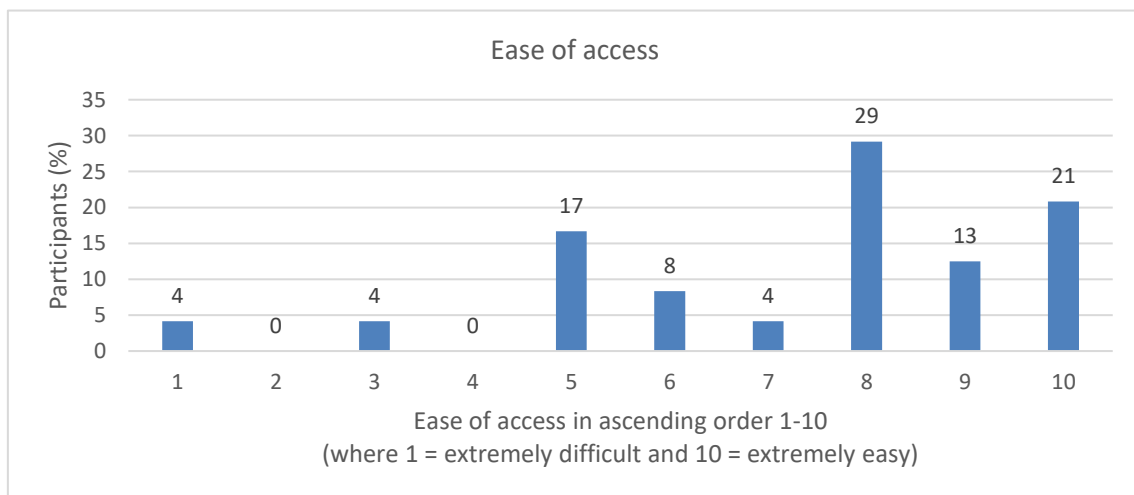


Figure 4.33 Ease of access to RSD list

4.3.3 Pilots' Perspectives

4.3.3.1 Interest in RSD

All respondents were asked whether they would like the CAMO to provide a list of RSD under investigation. The vast majority expressed a preference for receiving this information, with only 5% responding 'no' as illustrated in Figure 4.34.

Figure 4.35 further differentiates responses by rank, showing minimal variation between Captains and First Officers. The only notable difference was a slightly higher proportion of 'maybe' responses among First Officers, offset by marginally fewer 'yes' and 'no' responses compared to Captains.

Overall, these results indicate strong alignment in the cockpit, reflecting a shared interest in greater transparency regarding aircraft status.

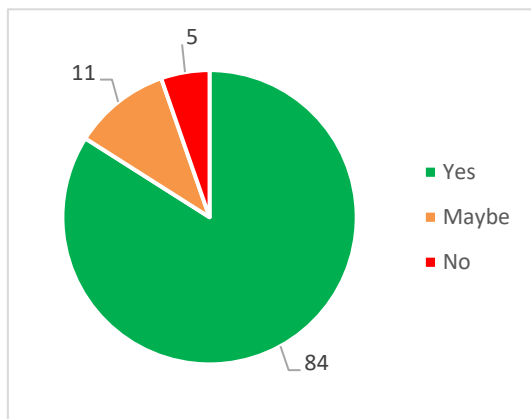


Figure 4.34 Pilots' interest in RSD

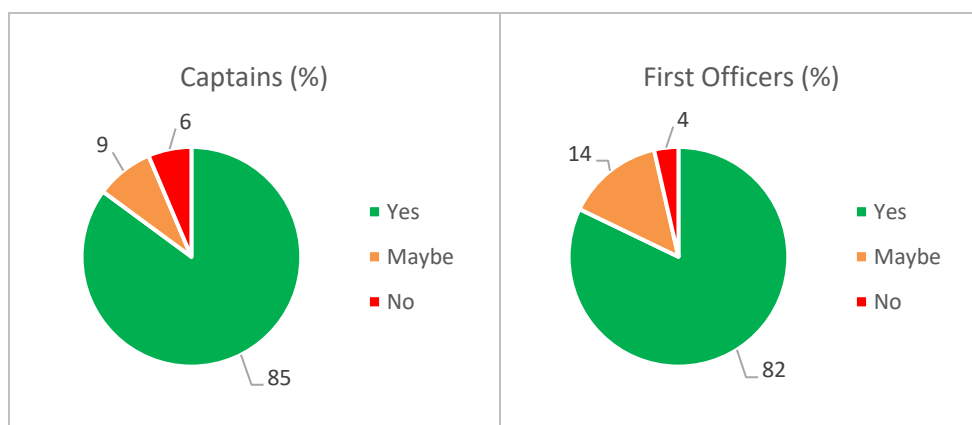


Figure 4.35 Response categorised by Captains and First Officers

4.3.3.2 Perceived importance of RSD communication to flight crew

The second question in this section (Part A) asked pilots to rate the importance of receiving a list of RSD prior to flight on a scale of 1 to 10; where 1 indicated 'not at all important' and 10 indicated 'extremely important'. As illustrated in Figure 4.36, responses were heavily concentrated at the upper end of the scale, with 78% of respondents assigning scores between 7 and 10. This clear predominance of high ratings underscores a strong consensus among pilots regarding the importance of the CAMO communicating the list of open RSD before departure.

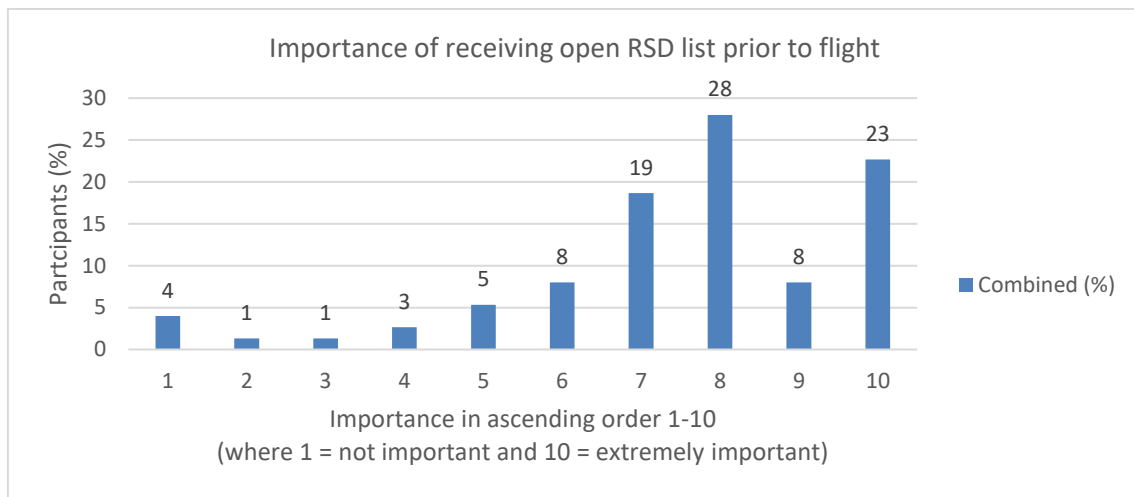


Figure 4.36 Combined responses for the importance of receiving open RSD list

Furthermore, Figure 4.37 shows the results plotted according to the two distinct groups. The Captains' responses were very predominant at the upper end of the scale. Responses on the lower end of the scale were primarily from First Officers; however, these represent a significantly small proportion of the overall dataset.

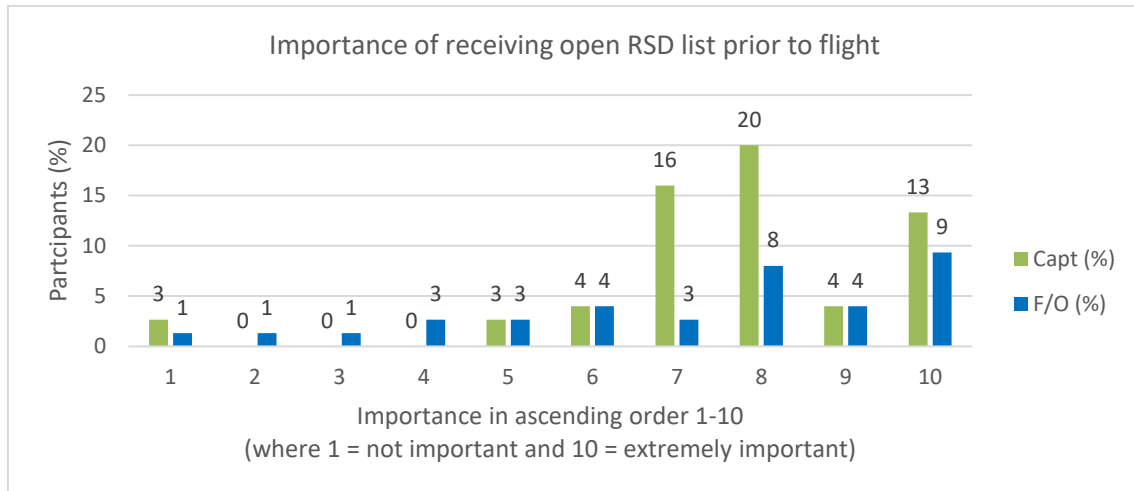


Figure 4.37 Response categorised by Captains and First Officers

For the second part of this question (Part B), respondents were asked to support this response by giving reasons why they scored the way they did. This was a multiple-choice question with the options presented in Figure 4.38 below.

- More than 70% of respondents desired to have oversight of the technical status of the aircraft.
- Furthermore, 61% of respondents indicated that their preference to be informed by the CAMO stems from the belief that RSD may pose a safety risk.
- More than half of the respondents believe that it is important for them, in their role, to be aware of any open RSD under investigation.
- Notably, only 1% of pilots reported having no interest in engineering-related topics. This finding aligns with feedback from the engineering interviews, where MCC engineers observed that pilots are generally willing to engage and assist when possible. Engineering teams view this willingness as an opportunity to strengthen collaboration and enhance defect resolution.

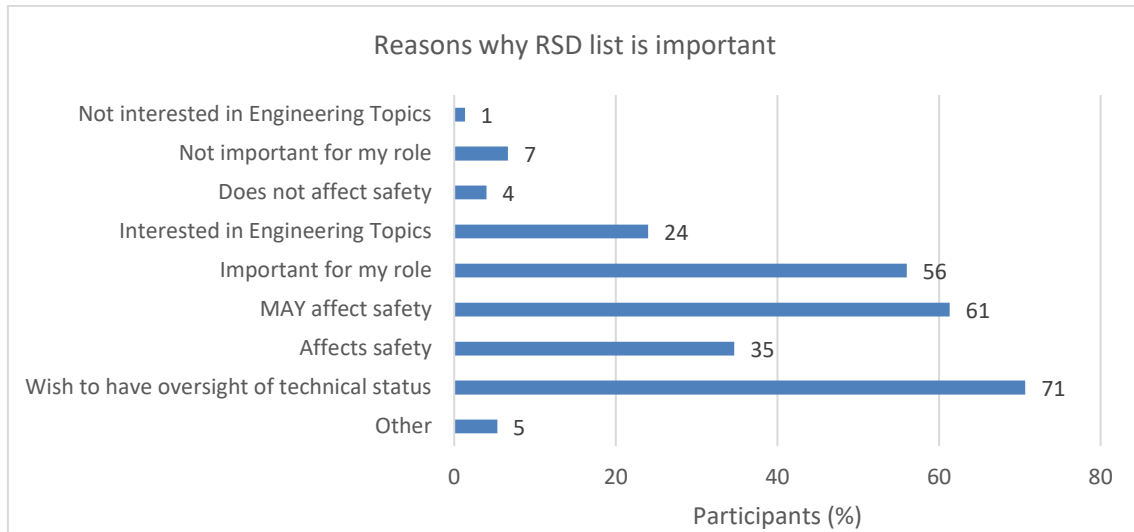


Figure 4.38 Reasons why RSD communication is important

To associate the highest scores with their corresponding reasons and exclude lower-scoring factors, the dataset was filtered to include only responses with scores between 7 and 10. Refer to Figure 4.39.

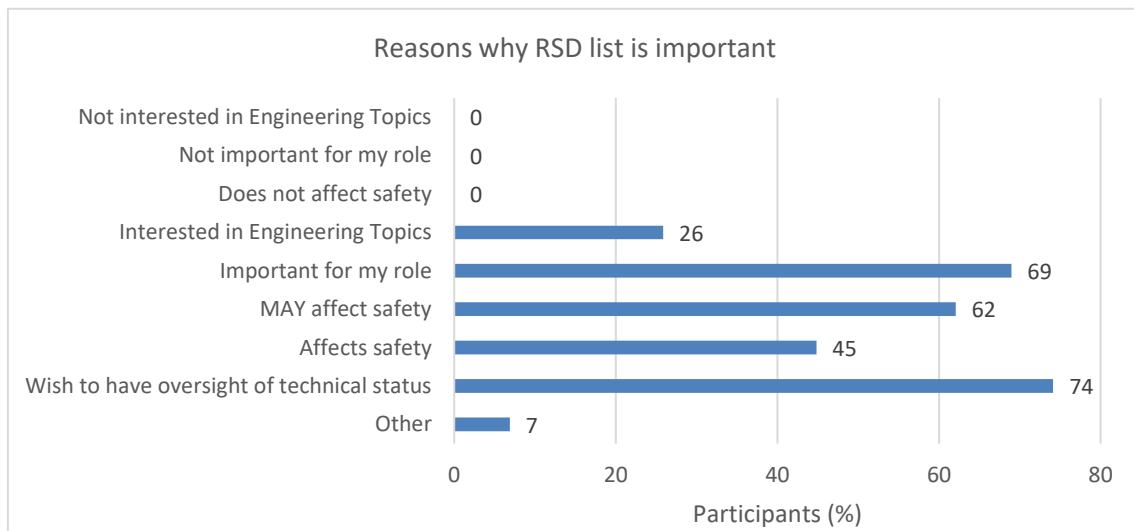


Figure 4.39 Reasons why RSD communication is important (high scores)

The three most frequently cited reasons remain consistent:

1. Desire for oversight of the aircraft's technical status.
2. Perceived importance for the role (Captain or First Officer).
3. Potential impact on safety.

4.3.3.3 Acceptance to operate aircraft

The final question in this section asked pilots whether they would be willing to operate an aircraft with an RSD under investigation, provided a Certificate of Release to Service (CRS) had been issued. This question emphasised that the aircraft had been formally released from maintenance and troubleshooting activities under Part 145 and was deemed operational.

This multiple-choice question included optional open comments, indicated by an asterisk (*) as shown in Figure 4.40.

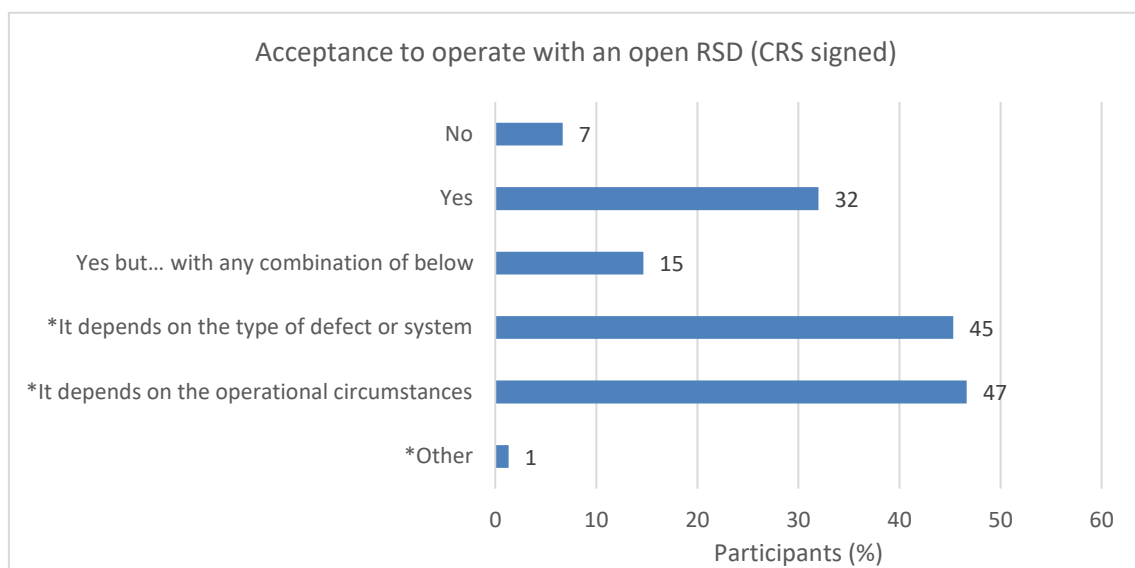


Figure 4.40 Acceptance to operate with an open RSD

A notable finding of this question is that only 7% of pilots responded with an unequivocal 'no', suggesting they were potentially unwilling to operate an aircraft after being informed that RSD were under investigation. This indicates that pilots generally do not perceive such information as a reason to decline a flight. On the other hand, only 32% provided a definitive 'yes'.

The majority of respondents supplemented their response with 'yes, but it depends'; or simply selected 'it depends'. This suggests that pilots seek additional information and reinforces the previously noted high level of interest in being fully informed about the aircraft's technical status. Specifically, pilots appear to value understanding how a fault might affect system functionality and the potential operational consequences should the issue escalate.

To gain insight into the rationale behind the ‘it depends’ responses, a qualitative analysis was performed, and these were analysed to identify recurring themes.

- A total of 17 comments were received to compliment the 34 responses: ‘It depends on the type of defect or system’.
- A total of 10 comments were provided to the 35 responses: ‘It depends on the operational circumstances’.

Regarding the statement ‘it depends on the type of defect or system’, the outlier theme is concerning safety critical systems followed by whether the defect or system effected are operationally significant for the sector ahead. This includes considering factors such as weather conditions, specific routing and destination airport. System redundancy was only mentioned directly on two occasions however this can be understood as part of safety criticality. Refer to Figure 4.41.

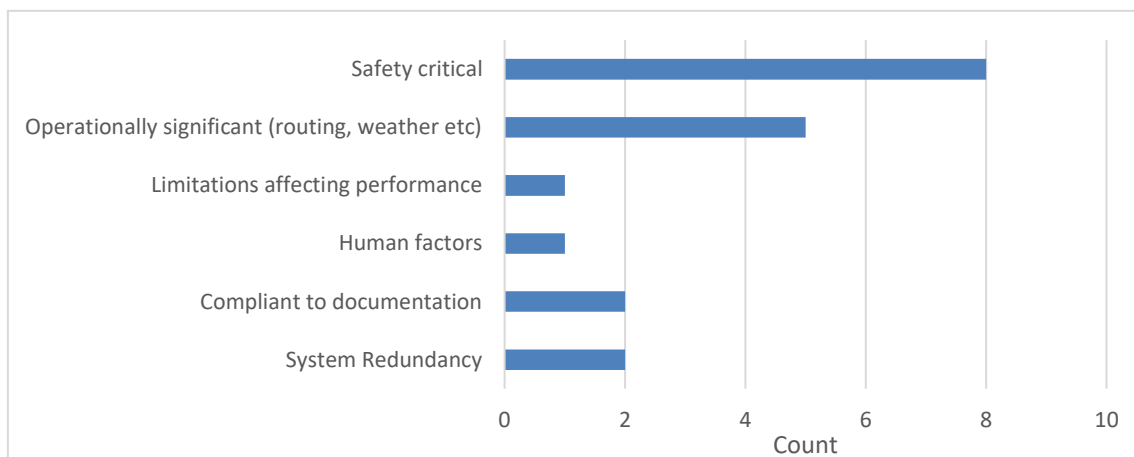


Figure 4.41 Factors that determine pilot decisions (defect or system)

Regarding the statement ‘it depends on the operational circumstances’, comments from a sample of 10 pilots were also analysed thematically and four overarching themes emerged (Figure 4.42).

Operational circumstances such as weather and routing, play a major role in the pilot’s decision whether to accept the aircraft or not. When the system under investigation directly impacts the mission or operational environment, pilots may potentially decline the flight. That means that if the system is essential for safe operations under the given conditions, for example, the weather radar, with

potential for severe weather along the route, the flight may be declined. A similar example applies to the use of TCAS, in a dense airspace.

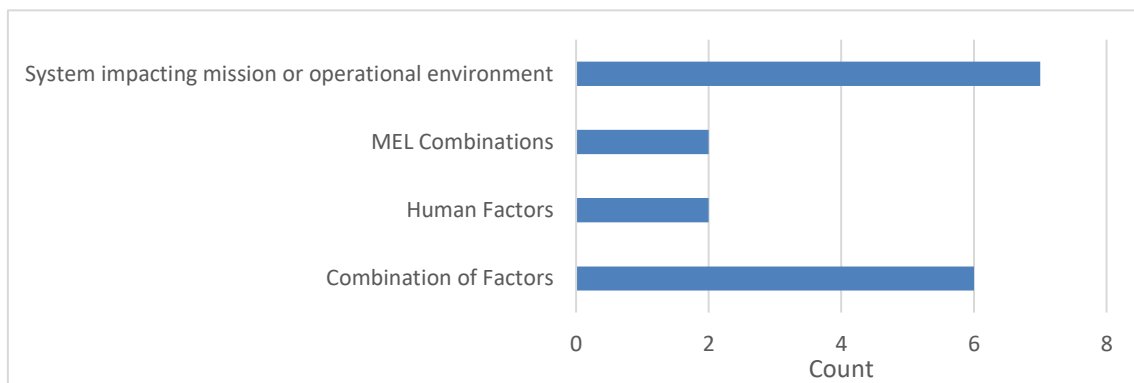


Figure 4.42 Factors that determine pilot decisions (operational circumstances)

Additionally, the findings suggest that most pilots evaluate a combination of situational factors when making such decisions. Weather conditions in combination with human performance considerations are considered and evaluated: for example, a clear day with adequate rest, versus adverse weather following multiple consecutive days of demanding operations.

Pilots' responses indicated that they would tend not to accept the aircraft if there were combinations of factors such as:

- Safety critical systems for example engines, landing gear, brakes, hydraulics; and the element of redundancy in the respective effected system.
- Operational conditions such as adverse weather, destination and diversion airports constraints.
- Human factors including fatigue and alertness.

Therefore, the overall findings suggest for respondents who indicated that their decision 'depends', the choice appears to be shaped by a combination of factors. These include the interplay between system criticality, mission characteristics (route, weather conditions, ETOPS requirements, time of day) and human factors (rostering, start or end of duty days and fatigue).

4.4 Summary of Findings

The below tables provide a concise summary of the findings from the previous two sections, together with the next steps identified for each topic.

Table 4.2 Findings from the CAMO study

	Section	Topic / Question	Finding	Next steps
I	Definitions	Terminology definition or differentiation, and interval/frequency definition	Lack of commonality; differences evident between regulators and CAMOs	Provide recommendations
II	Process	Role of MCC Engineer: 1. List of ongoing RSD in handover 2. History search of a new fault 3. Difference in handling RSD versus other faults 4. Proactive check of component reports	Absolute majority confirmed maintaining list of current RSD, consulting fault history when new events occur, and applying differentiated handling of RSD. No majority consensus on proactive checks of component reports, indicating that such checks are not established as a standard CAMO process.	Valuable supporting information gathered in questions 1-3, whilst question 4 is addressed through the recommendations
		Other CAMO supporting roles	Handling of RSD is predominantly an MCC function	Valuable information
		Challenges encountered in fix for RSD	Expected technical difficulties were confirmed; additional organisational issues emerged, including lack of ground time and high dependence on P145 AMOs for	Provide recommendations for organisational factors influenced by the CAMO

			RSD rectification, compounded by the associated P145 challenges.	
III	Comm. with flight crew	Crew requests for RSD information	86% responded affirmatively, though the activity was reported as infrequent.	Provide recommendations
		History provision to crew	The majority did not perceive this task as challenging, and no significant issues were reported.	Valuable supporting information
		Perception regarding sharing RSD information with the crew before flight	Majority supported informing flight crew, albeit valuable concerns were raised by the minority. Respondents emphasised both the value of in-flight observations to support MCC troubleshooting and the importance of crew situational awareness.	Provide recommendations
IV	Software Aid	Benefits of RSD tool	94% reported perceiving a benefit	Provide recommendations
		Functionality of RSD tool	Strong agreement regarding the tool's features, particularly the presentation of previous troubleshooting and rectification actions.	
		Impact to efficiency and impact to safety	Absolute majority agreed that an RSD tool would be highly effective in improving the efficiency when managing RSD,	

			with a correspondingly strong expected impact on overall safety.	
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Table 4.3 Findings from the flight crew study

	Section	Topic / Question	Finding	Next steps
I	Process	List of open RSD and access to information	A slight majority do not receive a list of open RSD. Respondents who do so receive information via the technical log.	Valuable supporting information
II	Pilots' perspectives	Interest in RSD	Absolute majority indicate preference for pre-flight notification of RSD.	Provide recommendations
		Importance of RSD communication to crew	Strong agreement on the importance of communication, attributed to the desire for greater oversight of the technical status and concerns about potential safety impact.	
		Acceptance to operate aircraft carrying RSD	Outright refusal was limited to 7%; 32% accepted without conditions, whilst the remaining majority indicated conditional agreement dependent on system criticality and the operational circumstances for the upcoming flight.	

4.5 Recommendations

The following recommendations are based on a comprehensive analysis of this study’s consolidated results and findings.

4.5.1 Terminology

This study examined the use of four commonly referenced terms in regulatory and CAMO practice. Consistent with both this study’s findings and those of Arshadi (2024), a single, standardised definition for such terms is recommended, as consistent terminology is fundamental for effective communication.

Table 4.4 Proposed definitions

Context	Safety critical system defects – within a fixed interval (sectors)	
Repeat	2	The second occurrence within 25 monitored sectors
Repetitive	3+	Three or more occurrences within 25 monitored sectors

Context	Other
Recurring	<p>This term is used to indicate a defect that has returned (reoccurred, reappeared), but in a general sense rather than within a defined monitoring period as above, no associated time limit.</p> <p>For example, used in describing a specific damage which reappeared after six months. Meaning, ‘it came back’ and is a ‘recurring’ defect.</p>
Recurrent	<p>This term implies a condition that is ‘always present’*. It refers to known defects, typically non-airworthiness related, that may exist across the fleet because of normal or regular operations and may indicate a possible long-term reliability concern.</p>

For example, certain plastic seat parts are prone to wear and tear from usage, and such defects are commonly recorded across the fleet and can be found at any point in time.

*In aviation, the term 'recurrent' is traditionally associated with 'recurrent training', meaning training that is current and not expired. In this study, the usage of recurrent is proposed as to be derived from this concept, pointing to defects which are commonly found or persistently present.

4.5.2 RSD Identification Interval and Frequency

4.5.2.1 Analysis of Factors Influencing the Interval

A comparative visual matrix was developed to demonstrate the variability in results and the limitations of assessing calendar days or sector counts in isolation. The matrix highlights that these measures are not directly comparable without considering overall fleet utilisation. Appendix F provides the full analysis and illustrates this concept.

This study concludes that a standardised metric is necessary, with sector count identified as the most appropriate common denominator, inherently accounting for utilisation differences.

An interval of 25 sectors is recommended. Where required, CAMOs may convert this into an equivalent number of calendar days for varying fleet utilisations using the tool provided in Appendix G. This conversion is particularly useful for CAMOs conducting manual RSD identification, as it reduces workload and simplifies implementation.

4.5.2.2 Identification Frequency

A timely identification process is essential to ensure that RSDs are detected before escalation into safety or operational issues. For instance, if three occurrences arise within a short span, such as the previous six sectors, delaying the identification exercise, hence detailed analysis, by a week or more may be operationally harmful.

It is therefore recommended that a dedicated software application (see Section 4.5.4) continuously monitors defect entries and provides real-time alerts as soon as a new fault is recorded in the technical log.

For CAMOs that depend on manual identification, it is considered that performing scheduled checks every other day offers an effective balance between timely detection and resource limitations.

4.5.3 Process Design

This section presents the recommended process design for the effective management of repetitive system defects starting with the Identification flow chart in Figure 4.43.

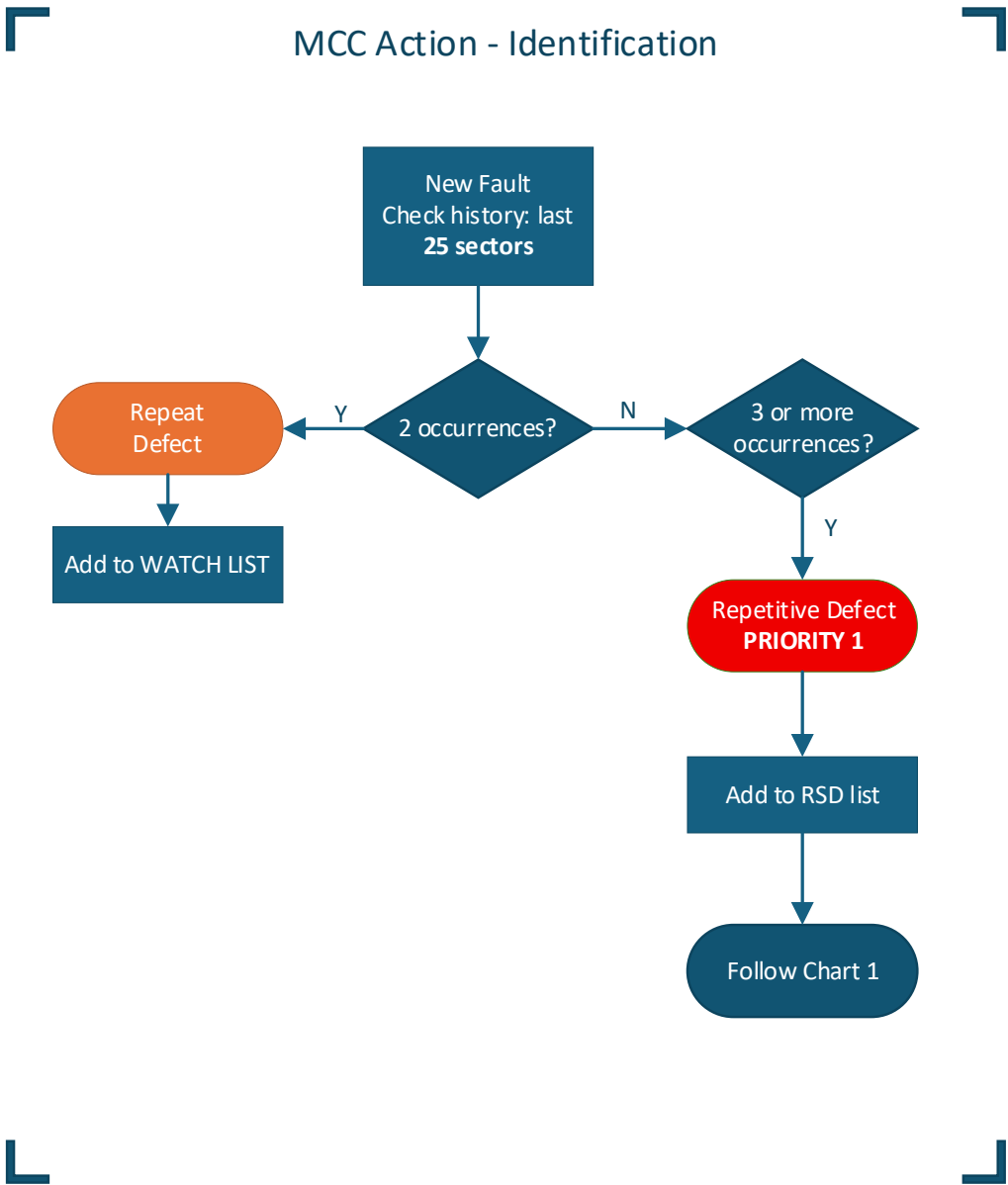


Figure 4.43 Identification flow chart for MCC

Refer to Appendix G for information about the Watch List and the RSD List.

It is further recommended that RSD are managed following the three process charts outlined below:

1. Figure 4.44 illustrates the process flow chart outlining the primary tasks of MCC engineers, together with the relevant supporting roles. Key steps include reviewing detailed defect history, examining component documentation in cases involving NFF components, and liaising with the flight crew.

Following the completion of corrective action, an RSD should continue to be monitored for a further 15 sectors to verify the effectiveness of the fix, before formal closure on the RSD List.

2. Figure 4.45 presents the decision-making aid designed to assist MCC engineers in determining whether flight crew should be notified prior to departure when certain conditions are met.
3. Figure 4.46 shows a high-level overview of the process flow between the line maintenance engineer performing troubleshooting steps, the CAMO Spares Support team, and the specialised component workshop.

Chart 1 – Repetitive System Defect Management

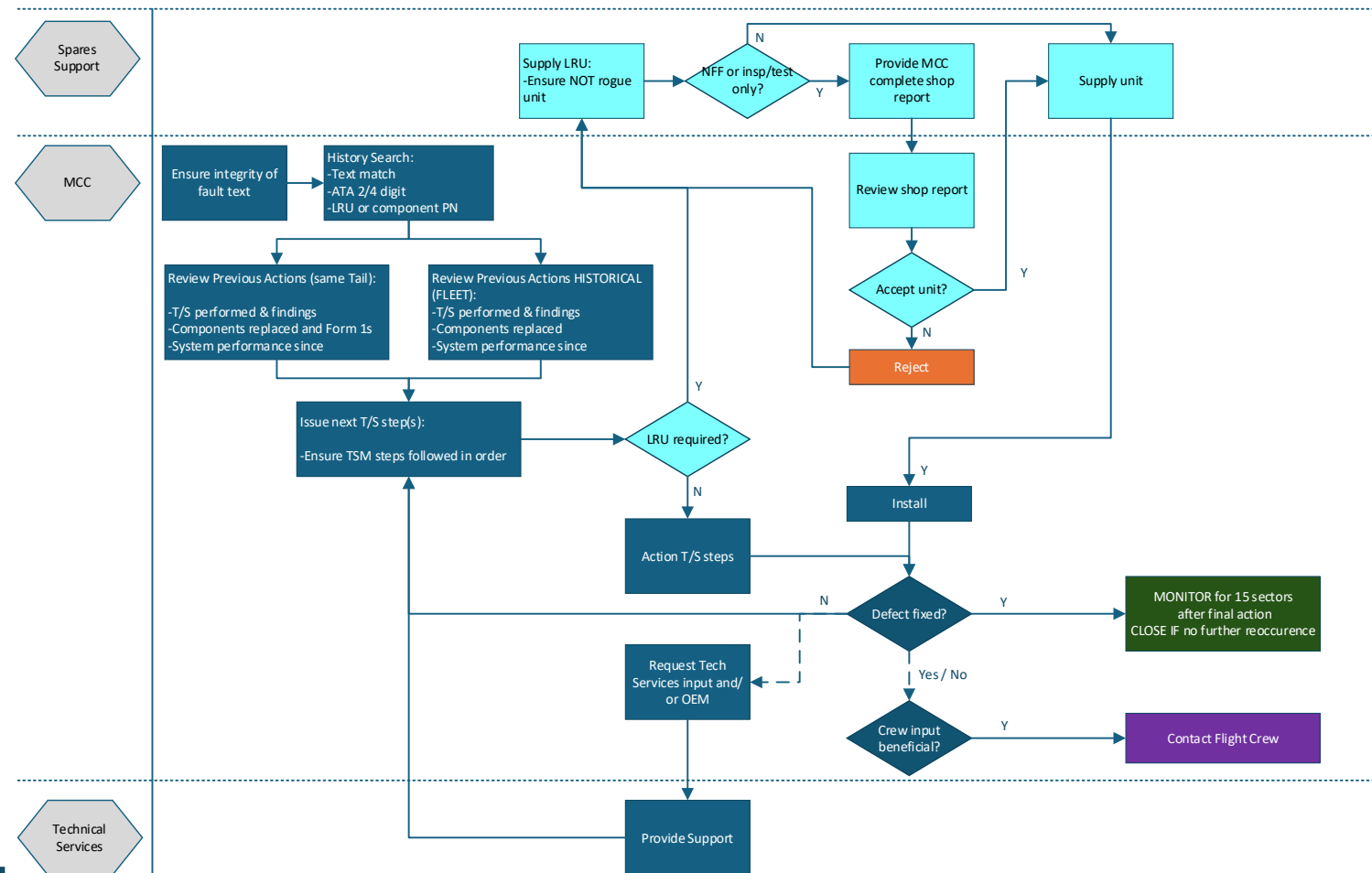


Figure 4.44 Process flow chart for RSD effective management

Chart 2 - Communication MCC to Flight Crew

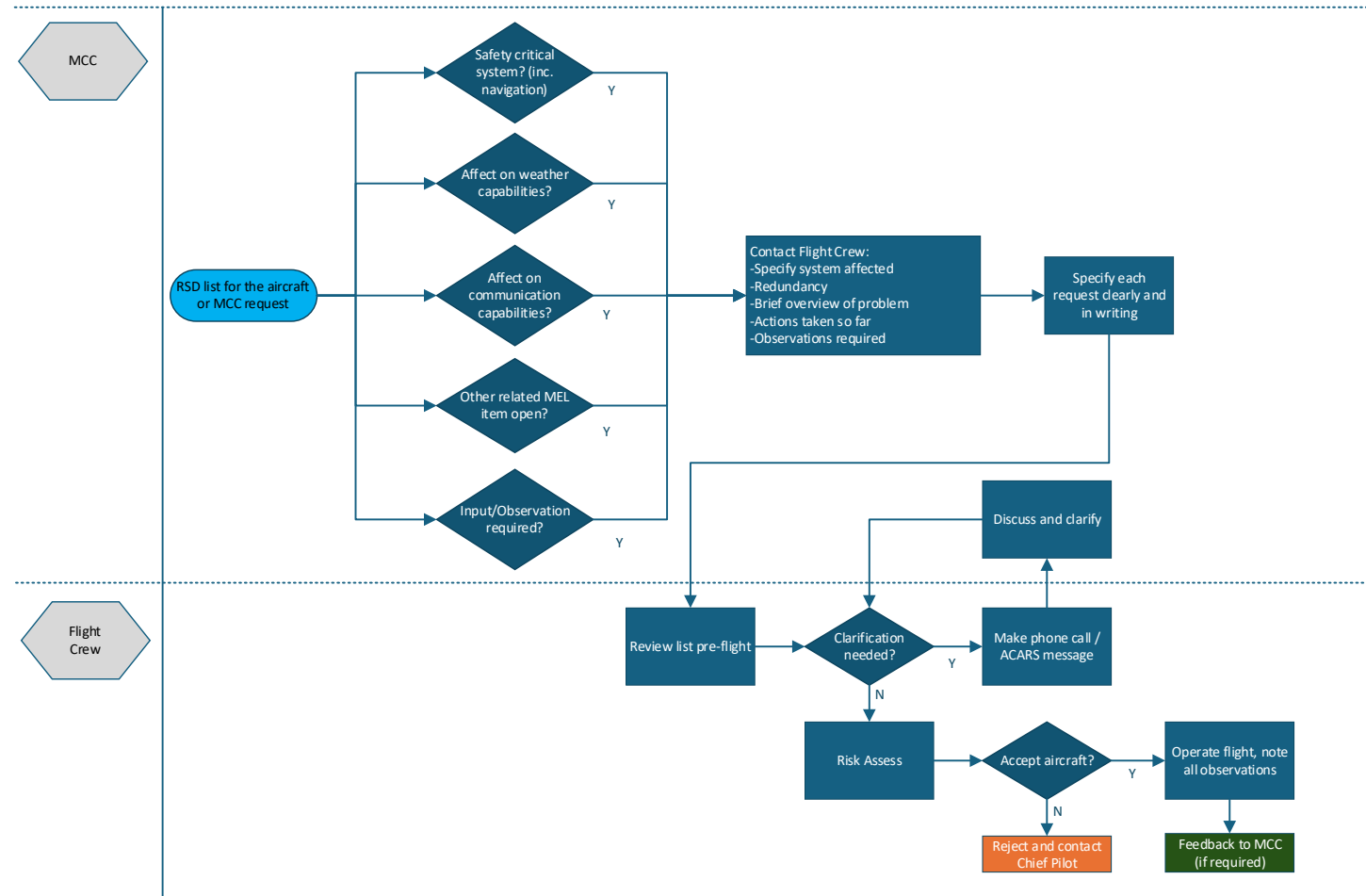


Figure 4.45 Flow chart for communication with flight crew

Chart 3 - Line to Workshop Flow (overview)

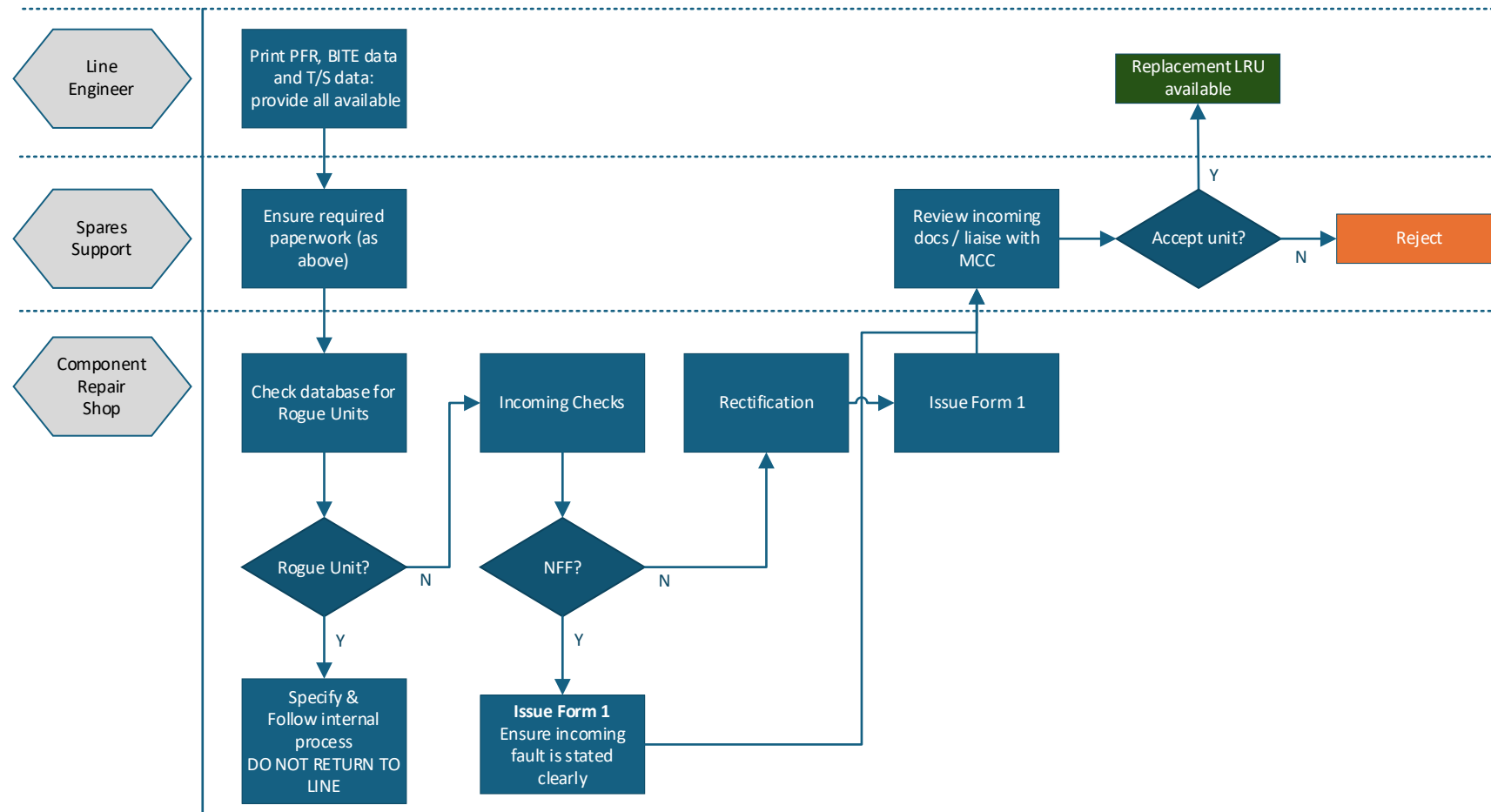


Figure 4.46 Flow chart showing line to workshop flow

4.5.3.1 Roles and responsibilities in the CAMO

Is it recommended that responsibility for this topic remains with the Maintenance Control Centre. The following support structure is proposed:

- **Technical Services:** Provide MCC engineers with specialised system expertise as required including coordination with the Design Approval Holder (DAH) for technical advice.
- **Reliability Engineering:** Assume ownership of issues that extend longer than the timeframes defined by the repetitive defect criteria, ensuring longer-term trend monitoring and analysis.
- **Engineering Management:** From a managerial perspective, CAMO leadership should prioritise mitigating organisational factors that impede effective RSD resolution. Ensuring adequate MCC staffing and advocating for its operational requirements within the wider organisation are essential. This includes upholding necessary ground times, resisting operational pressures, and enabling MCC engineers to perform their duties to the highest standard.
- **Spares Support:** Act as a liaison point between component workshops, MCC and the AMO.
- **Part 145 Organisations:** It is essential that contracted AMOs follow the troubleshooting steps specified by the CAMO, using the DAH documentation (such as the TSM) as the primary reference.

4.5.3.2 Logbook entries

A fundamental prerequisite to this entire process is the requirement that flight crews record all faults in the technical log (Airbus, 2022). Every system reset, whether conducted by the crew or maintenance personnel, must be documented. Failure to record such actions is a potential failure in the timely identification of system issues. This requirement should therefore be clearly reinforced with all personnel to ensure full compliance. Moreover, logbook entries made by the crew need to be detailed to include observations from flight and it is suggested to include such a topic in pilot recurrent training and safety promotion training.

This study recommends setting a standard for logbook entries concerning ECAM fault and warnings (both pilots and maintenance) mandating that the ECAM fault must be identically copied with no deviations allowed. The more accurate logbook entries are, the easier it is to automate the RSD identification process.

4.5.3.3 Component replacements

Based on the findings of this study, it is recommended that component shop reports be subject to comprehensive review prior to acceptance. When components are offered, CAMO personnel should verify the serial number against a maintained list of known rogue units to prevent reintroduction of such units into service. Additional caution is warranted in cases involving NFF components; such items should preferably be rejected, with an alternative component requested. Where no alternative exists and installation is nevertheless required, this decision must be documented.

If faults persist following installation, the component should be replaced with one that is either new or verified fault-confirmed by the workshop, before progressing to further troubleshooting actions. This approach mitigates unnecessary complexity in the troubleshooting process, by ensuring that the integrity of the installed component is not in question.

Finally, all troubleshooting data associated with removed components should be provided to the workshop to support more detailed checks, and to ensure that this information is captured within the component's historical records for future reference.

4.5.3.4 Communication with flight crew

Given the results obtained, it is recommended that MCC notifies flight crew of certain RSD applicable to the aircraft they are scheduled to operate. The decision logic outlining the conditions under which MCC should inform the crew of an open RSD is presented in Figure 4.45. If any of the decisions are answered in the affirmative, the crew should be advised accordingly. This

enables an informed risk assessment and supports a sound operational decision on whether to proceed with the flight.

It is recommended that a dedicated page titled “List of Repetitive System Defects under Investigation” be incorporated into the Technical Log; else an electronic Notice to Crew or an equivalent communication method may be used to fulfil the same function.

It is also strongly recommended that the Chief Pilot be kept regularly informed of ongoing RSD investigations.

4.5.4 Software Solution

In view of this study’s findings, it is strongly recommended that the identification of RSD be performed continuously through dedicated software. Figure 4.47 presents the portion of the process flow that requires automation within an RSD-handling application.

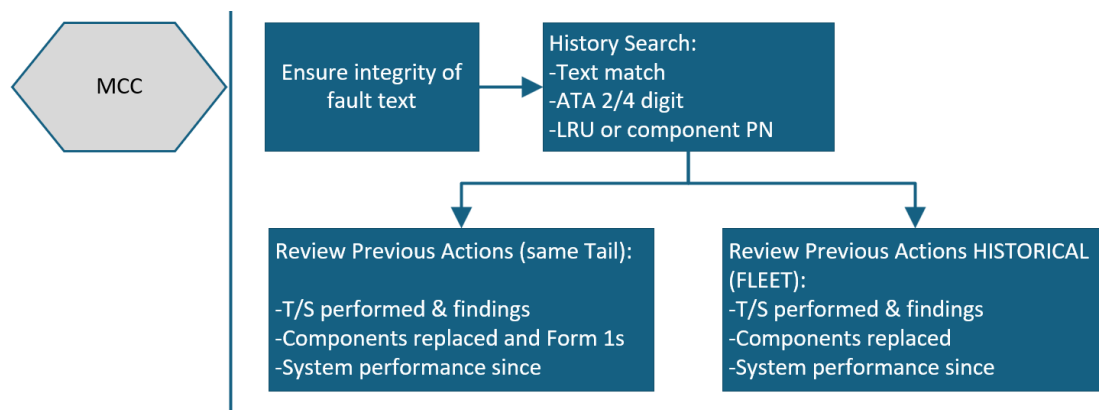


Figure 4.47 Functions requiring automation

The key functional requirements for an automated RSD identification tool include:

1. An automated dashboard that immediately alerts users to newly identified RSDs, accompanied by the relevant aircraft information.
2. Presentation and easy access to aircraft specific defect history.
3. Easy access to fleet-level defect history.

Appendix D provides a market overview of currently available software solutions. While several existing products appear capable of offering aspects of the required functionality, most do not fully meet the scope outlined in this study. It is therefore essential that any future solution integrates the functionalities of existing platforms (such as Aviator and Skywise) with the organisations' maintenance management system (such as AMOS).

For CAMOs utilising an electronic technical logbook, integrating this additional functionality is relatively straightforward. Further technical considerations and implementation details are presented in Appendix G.

4.5.5 National Aviation Authorities

To conclude the recommendations section, below are the suggested measures for National Aviation Authorities (NAAs).

Standardise terminology:

- It is suggested that NAAs adopt clearly defined and consistently applied terminology. While harmonisation across authorities is preferable, particularly for organisations holding multiple approvals, each NAA should, as a minimum, formally define the terminology it requires.

Mandate short-term action:

- NAAs should require operators to implement short-term actions in addition to long-term reliability trending, ensuring timely mitigation of emerging repetitive defects.

Issue guidelines:

- NAAs should publish clear guidelines and require CAMOs to document their methodology in the CAME, subject to regulatory oversight and audit.

NAAs may consult the detailed proposals in Section 4.5 and implement the measures more relevant to their operational context.

5 Conclusion

This study evaluated prevailing CAMO practices and regulatory frameworks for managing repetitive system defects (RSD) and established a standardised process to enhance defect tracking, analysis, resolution and continuous oversight.

It was demonstrated that the effective management of RSD is a critical concern both for CAMO and flight crew. To date, no prior studies have examined the perceptions of MCC engineers and pilots regarding the effective management and safety implications of repetitive faults, making this work a meaningful contribution to literature.

The findings highlight the importance of close collaboration between MCC engineers and flight crew in improving the identification and resolution of RSD. MCC engineers viewed pilots as valuable contributors to the troubleshooting process, recognising that information shared with cockpit crew can both expedite technical resolution and support pilots' decision-making in flight. Pilots, in turn, expressed a strong desire to be informed of their aircraft's technical status so that they can assess risk and consider operational and technical factors in real time.

Although regulatory guidance in this area remains severely limited, this study suggests that formal requirements for the management of RSD would provide a necessary foundation for consistent oversight. However, regulation and procedures alone are insufficient: robust compliance and rigorous supervision are indispensable components of effective safety management. This research further recommends the standardisation of terms used when referring to such defects.

Timely identification of RSD is highly critical, and the interval and frequency of identification play a major role. Performing the identification exercise as frequently as possible facilitates prompt recognition and classification of RSD, enabling detailed investigations to commence without delay. To support this, the implementation of automatic monitoring and data availability through dedicated

software applications is strongly recommended, as such tools enhance the efficiency of MCC engineers and contribute to overall safety performance.

Finally, the study emphasises the importance of thorough component reviews prior to installation. Rogue components have the potential to compromise the troubleshooting efforts and increase operational risk; thus, strengthening these procedures forms a vital part in improving the wider management of repetitive system defects.

Several recommendations were proposed, including the development of a process framework to support the effective management of RSD within a CAMO.

5.1 Limitations and Further Work

While this thesis met all intended objectives, several opportunities for refinement and future work remain.

Both components of this study generated a useful range of responses; however, as most participants operated under EASA regulations, replicating the research with respondents governed by other authorities, such as the FAA, would help determine whether the observed views and practices hold across different regulatory environments.

For the CAMO component, a larger and more diverse sample, particularly including CAMOs managing very large fleets, such as major European low-cost carriers or leading North American airlines, would enhance the robustness and generalisability of the findings by providing insight into engineering processes and decision-making at scale.

As with all survey-based research, the lack of direct interaction with respondents introduces potential for misinterpretation. Despite efforts to design clear and unambiguous questions, some questions may have been understood differently than intended. Likewise, thematic analysis inevitably involves researcher interpretation, and although measures were taken to ensure

neutrality and methodological rigour, complete elimination of subjectivity is not possible.

Several items explored respondents' perceptions of operational scenarios in MCC and flight crew contexts. Future work could usefully examine how cultural background and behavioural factors shape communication, judgement, and risk management, particularly in multinational or cross-cultural aviation environments.

Finally, although this study focused on commercial air transport, undertaking a comparable investigation within military aviation organisations would be equally valuable, enabling them to identify relevant similarities, differences, challenges, and transferable insights.

References

- AAIB. (2009). *Aircraft accident report 4/2009: Report on the serious incident to Airbus A319-111, registration G-EZAC near Nantes, France on 15 September 2006*. <https://www.gov.uk/aaib-reports/4-2009-g-ezac-15-september-2006>
- Airbus. (2022, December 15). *Intermittent repetitive failure*. <https://www.aircraft.airbus.com/en/newsroom/news/2022-12-intermittent-repetitive-failure>
- Airbus. (2025a). *A320 family Trouble Shooting Manual TSM* (revision 45).
- Airbus. (2025b). *Maintenance briefing note: Best practices when using the troubleshooting manual (TSM)* (Number 3).
- Aircraft Commerce. (2019). Eliminating the problem of repetitive aircraft technical defects. *Aircraft Commerce*, 125, 16–21.
- AIXI. (n.d.). *Repeat defect identifier*. Retrieved December 20, 2025, from <https://aviation.aixi.co/repeat-defect-identifier/>
- Arshadi, M. (2024). *Effective management of repetitive defects in aircraft systems: A multi-stakeholder approach to enhance airworthiness and flight safety* [Unpublished Masters thesis]. Cranfield University.
- Aubin, B. R. (2004). *Aircraft maintenance: the art and science of keeping aircraft safe*. SAE International. <https://app.knovel.com/hotlink/toc/id:kpAMTASKA1/aircraft-maintenance-the>
- Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. Sage. https://books.google.co.uk/books?id=EV_Q06CUsXsC&pg=PR3&source=gb_s_selected_pages&cad=1#v=onepage&q&f=false
- Canadian Minister of Justice. (2025). *Canadian Aviation Regulations SOR/96-433*. <https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433>

- CASA. (2016). *Acceptable Means of Compliance (AMC) and Guidance Material (GM): CASR Part 145 Approved Maintenance Organisation requirements*. <https://www.casa.gov.au/>
- CASA. (2022). *AC 42-03 - Reliability programs*. <https://www.casa.gov.au>
- Coilpillai, R. (2020). *Assessing advantages and disadvantages of implementing electronic task cards and electronic tech-logs* [Masters thesis, Cranfield University]. Masters Thesis Archive. <https://mta.cranfield.ac.uk/handle/1826.1/17531>
- Collins English Dictionary. (2025). *Definitions, examples, pronunciations & synonyms*. <https://www.collinsdictionary.com/dictionary/english>
- Dewaele, J.-M. (2018). Online Questionnaires. In A. Phakiti, P. De Costa, L. Plonsky, & S. Starfield (Eds.), *The Palgrave Handbook of Applied Linguistics Research Methodology* (pp. 269–286). Palgrave Macmillan UK. https://doi.org/10.1057/978-1-137-59900-1_13
- Franklin, J. (2020, December 2). *Recurrent defects*. EASA. <https://www.easa.europa.eu/community/topics/recurrent-defects>
- EASA. (2024a). *Easy access rules for continuing airworthiness (Regulation EU No 1321/2014)*. <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-continuing-airworthiness>
- EASA. (2024b). *European Plan for Aviation Safety: Safety risk portfolios 2025 Edition*. <https://www.easa.europa.eu/en/document-library/general-publications/european-plan-aviation-safety-epas-2025>
- EASA. (2025). *Easy access rules for air operations (Regulation EU No 965/2012)*. <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-air-operations-regulation-eu-no-9652012>
- Embraer. (2023, June 21). *Embraer launches the next generation of AHEAD tool for commercial aviation*. <https://www.embraer.com/media->

center/en/?mediatype=NEWS&detail=14123-Embraer-launches-the-next-generation-of-AHEAD-tool-for-Commercial-Aviation

FAA. (2017). *Advisory Circular 145-9A: Guide for developing and evaluating repair station and quality control manuals*.
https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1032006

FAA. (2025a, December 9). *14 CFR Part 91 Subpart E Maintenance, Preventive Maintenance, and Alterations*. <https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-91/subpart-E>

FAA. (2025b, December 9). *14 CFR Part 121 Operating Requirements: Domestic, Flag, and Supplemental Operations*.
<https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121>

FAA. (2025c, December 9). *14 CFR Part 145 Repair Stations*.
<https://www.ecfr.gov/current/title-14/chapter-I/subchapter-H/part-145?toc=1>

FAA. (2025d, December 11). *14 CFR Part 43 Maintenance, Preventive Maintenance, Rebuilding, and Alteration*. <https://www.ecfr.gov/current/title-14/chapter-I/subchapter-C/part-43>

Graesch, J. P. (n.d.). *Technical repetitives examination*. AVIATAR. Retrieved December 20, 2025, from <https://www.aviatar.com/en/Technical-Repetitives-Examination>

Hessburg, J. (2001). *Air carrier MRO handbook: maintenance, repair, and overhaul*. McGraw-Hill.

Hieminga, J. T. (2017). *Identification of safety improvements in aviation maintenance using EU-wide incident reports* [Masters thesis, Cranfield University]. Masters Thesis Archive.
<https://mta.cranfield.ac.uk/handle/1826.1/13923>

- Hockley, C., & Phillips, P. (2012). The impact of no fault found on through-life engineering services. *Journal of Quality in Maintenance Engineering*, 18(2), 141–153. <https://doi.org/10.1108/13552511211244184>
- IATA. (2023). *IOSA Standards Manual (ISM)* (16th ed.).
- Khan, S., Phillips, P., Jennions, I., & Hockley, C. (2014). No Fault Found events in maintenance engineering Part 1: Current trends, implications and organisational practices. *Reliability Engineering and System Safety*, 123, 183–195. <https://doi.org/https://doi.org/10.1016/j.ress.2013.11.003>
- Khan, S., Phillips, P., Hockley, C., & Jennions, I. (2012, November 5-6). No Fault Found, Retest OK, Cannot Duplicate or Fault Not Found? Towards a standardised taxonomy. *1st Conference on Through-Life Engineering Services, Cranfield UK*.
- Khan, S., Phillips, P., Hockley, C., & Jennions, I. (2014). No Fault Found events in maintenance engineering Part 2: Root causes, technical developments and future research. *Reliability Engineering and System Safety*, 123, 196–208. <https://doi.org/10.1016/j.ress.2013.10.013>
- Kinnison, H. A., & Siddiqui, T. (2013). *Aviation maintenance management* (2nd ed.). McGraw-Hill.
- Komite Nasional Keselamatan Transportasi. (2022). *Aircraft accident investigation report PT Sriwijaya Air Boeing 737-500; PK-CLC, Kepulauan Seribu District, DKI Jakarta, Republic of Indonesia*. <https://www.baaa-acro.com/sites/default/files/2022-11/PK-CLC.pdf>
- Kropp, N., & Graesch, J. P. (2025). Case study: Transforming repetitive defect detection at TUI Airline with artificial intelligence. *Aircraft IT MRO*, 64. <https://www.aircraftit.com/articles/case-study-transforming-repetitive-defect-detection-at-tui-airline-with-artificial-intelligence/?area=mro>
- Lacey, L. (2023). *Is there a link between No Fault Found and Airworthiness?* [PhD thesis, Cranfield University]. CERES Research Repository. <https://dspace.lib.cranfield.ac.uk/handle/1826/23205>

- MAA. (2025). *Continuing Airworthiness Engineering (CAE) 4000 Series Regulatory Articles*. <https://www.gov.uk/government/collections/4000-series-continuing-airworthiness-engineering-regulations-cae>
- Mahon, L. (2009). *Human factors, safety and reliability assessment and the No Fault Found (NFF) phenomenon in aviation maintenance* [Masters thesis, Cranfield University]. Masters Thesis Archive. <https://mta.cranfield.ac.uk/handle/1826.1/5712>
- Maxwell, J. A. (2013). *Qualitative research design: An interactive approach* (3rd ed.). Sage Publications.
- Munro, P. A., Kanki, B. G., & Jordan, K. (2008). Beyond “inop”: Logbook communication between airline mechanics and pilots. *International Journal of Aviation Psychology*, 18(1), 86–103. <https://doi.org/10.1080/10508410701749563>
- Ries, K. (2018). Case Study: American Airlines addresses repetitive faults with data. *Aircraft IT MRO*. <https://www.aircraftit.com/articles/american-airlines-addresses-repetitive-faults-with-data/>
- Scott, M. J., Kirkpatrick, O., Verhagen, W., Kekoc, V., Teunisse, B., Zhang, J., Fayek, H., & Marzocca, P. (2024, September 9). Application of natural language processing for aircraft defect tracking in maintenance operations. *34th Congress of the International Council of Aeronautical Sciences*. https://www.icas.org/icas_archive/icas2024/data/papers/icas2024_0083_paper.pdf
- Söderholm, P. (2007). A system view of the No Fault Found (NFF) phenomenon. *Reliability Engineering and System Safety*, 92(1), 1–14. <https://doi.org/10.1016/j.ress.2005.11.004>
- Swiss Aviation Software. (n.d.-a). *AMOS Editions*. Retrieved December 20, 2025, from <https://www.swiss-as.com/amos-mro/amoseditions>

Swiss Aviation Software. (n.d.-b). *Maintenance Control*. Retrieved December 20, 2025, from <https://www.swiss-as.com/amos-mro/modules/maintenance-control>

The Dutch Safety Board. (2010). *Crashed during approach, Boeing 737-800, near Amsterdam Schiphol Airport, 25 February 2009*. <https://onderzoeksraad.nl/en/onderzoek/turkish-airlines-crashed-during-approach-boeing-737-800-amsterdam/>

Thomas, S. L., Pitt, H., McCarthy, S., Arnot, G., & Hennessy, M. (2024). Methodological and practical guidance for designing and conducting online qualitative surveys in public health. *Health Promotion International*, 39(3). <https://doi.org/10.1093/heapro/daae061>

Transport Canada. (2025, October 15). *Standard 726 - Air Operator Maintenance - Canadian Aviation Regulations (CARs)*. Government of Canada. https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433/standards/standard-726-air-operator-maintenance-canadian-aviation-regulations-cars#726_05

Transport Canada. (2018, January 13). *Transport Canada Civil Aviation Guidelines: Maintenance Control Manuals - TP 14408*. Government of Canada. <https://tc.canada.ca/en/aviation/publications/transport-canada-civil-aviation-guidelines-maintenance-control-manuals-tp-14408>

UK CAA. (2025). *Continuing Airworthiness: UK regulation (EU) No. 1321/2014*. https://regulatorylibrary.caa.co.uk/1321-2014/Content/CAW%201321-2014_1.htm

Vaissieres, S. (2022, July). In-flight health monitoring for on-time dispatch. *Airbus FAST Technical Articles*. <https://www.aircraft.airbus.com/sites/g/files/jlcbta126/files/2022-07/FAST-Health-Monitoring-layout.pdf>

VERYON. (2017, April 12). *Effectively managing chronic faults/unplanned maintenance to reduce costs and frequency*.

<https://veryon.com/blog/effectively-managing-chronic-faults-to-reduce-maintenance-costs-and-frequency>

Appendices

Appendix A Ethical Approval Letter



10 September 2025

Dear Ms Scicluna ,

Reference: CURES/26486/2025

Project ID: 29872

Title: Evaluating and Developing an Optimal Process for Managing Repetitive System Defects within a CAMO Environment

Thank you for your application to the Cranfield University Research Ethics System (CURES).

We are pleased to inform you your CURES application, reference CURES/26486/2025 has been reviewed. You may now proceed with the research activities you have sought approval for.

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

Appendix B A321 Post-Flight Report

(Courtesy of Titan Airways Malta)

Export Date : 08 Oct 2025 10:02
Report Date : 07 Oct 2025 21:53
Title : PFR Details
Flight Number : TM43A
A/C ID : 9H-ZTC
From : NTE
To : LEJ

P.	Event date	Flight phase	Type	Message	ATA	Source	Class	Identifiers
M MMEL	07 Oct 2025 21:16	06 - CRUISE	WARN	AUTO FLT RUD TRIM2 FAULT	2200	-	-	-
M MMEL	07 Oct 2025 20:02	02 - ENG START	WARN	AUTO FLT RUD TRIM2 FAULT	2200	-	-	-
N	07 Oct 2025 21:16	06 - CRUISE	FAULT	AFS:FAC2	226634	AFS	-	-
N	07 Oct 2025 21:16	06 - CRUISE	FAULT	AFS:FAC2/P-B SW 12CC2	226634	AFS	-	-
M MMEL	07 Oct 2025 21:16	06 - CRUISE	WARN	AUTO FLT RUD TRV LIM 2	2200	-	-	-
L MMEL	07 Oct 2025 21:16	06 - CRUISE	WARN	AUTO FLT FAC 2 FAULT	2200	-	-	-
M MMEL	07 Oct 2025 21:16	06 - CRUISE	WARN	AUTO FLT YAW DAMPER 2	2200	-	-	-

Appendix C EASA Form 1 Component NFF cases

(Courtesy of Titan Airways Malta)

Flight Augmentation Computer example consisting of a Shop Finding Report and the respective EASA Form 1.



SHOP FINDING REPORT

(Rapport Intervention Technique)

CUSTOMER REPAIR ORDER (N° de commande client): R449070						
INTERNAL REPAIR ORDER (N° de dossier interne): 210138395						
	RECEIVED UNIT (Equipement reçu)			DELIVERED UNIT (Equipement livré)		
PART NUMBER (Référence):	B397BAM0624			B397BAM0624		
SERIAL NUMBER (Numéro de série):	Q00140009312			Q00140009312		
DESIGNATION (Description):	FAC - FLIGHT AUGMENTATION COMPUTER			FAC - FLIGHT AUGMENTATION COMPUTER		
MFG DATE (Date fab.):	01 JUL 2004			01 JUL 2004		
TIMES & CYCLES: (Heures & Cycles)	TSN	TSO	TSI	CSN	CSO	CSI
	UNK	UNK	0 H	UNK	UNK	0 C
DATE OF RECEPTION: 12 JAN 2024 (Date de réception)				DATE OF REMOVAL: (Date de dépose)		
REASON FOR REMOVAL (Raison de dépose): REPETITIVE FAULTS						
Reason confirmed (Motif confirmé): ☐ YES (oui) ☒ NO (non) ☐ OTHER FAILURE (autre panne)						
WORK REQUESTED (Travaux demandés): RP REPAIR				WORK PERFORMED (Travaux réalisés): PB BENCH TEST		
MAINTENANCE DOC (Doc. de référence): CMM 22-66-32A Rev 31 dated 22 NOV 2019						
AMENDMENT RECEPTION : (Amendement arrivée) A B C D E F G				AMENDMENT DEPARTURE : (Amendement départ) A B C D E F G		
MODIFICATION RECEPTION : (Modification arrivée)				MODIFICATION DEPARTURE : (Modification départ)		
REMARKS (Remarques):						
WARRANTY REQUESTED (Garantie demandée): ☐ YES (Oui) ☒ NO (Non) ☐ Manufacturer (OEM) ☐ Repairer (Réparateur) ☐ Stock						
WARRANTY DECISION (Décision garantie) : ☐ Accepted (Acceptée) ☐ Rejected (Rejetée) ☐ Shared (Partagée)						
WARRANTY ANALYSIS:						

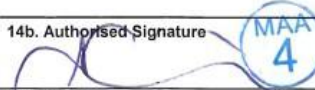
1. Approving competent Authority / Country Autorité compétente / Pays DIRECTION GENERALE DE L'AVIATION CIVILE FRANCE		2. AUTHORISED RELEASE CERTIFICATE Certificat libératoire autorisé EASA FORM 1 Formulaire 1 de l'EASA				3. Form Tracking Number N° de repère du Formulaire 0210138395-T	
4. Organisation Name and Address : Nom et adresse de l'organisme 19 Rue Issartier CS 50 008 33693 MERIGNAC CEDEX - FRANCE Téléphone 33 (0) 5 56 55 40 00 - Fax 33 (0) 5 56 55 42 26		 Sabena technics BOD				5. Work Order/Contract/Invoice Bon de commande/Contrat/Facture R449070-100000910763	
6. Item / Item	7. Description / Description	8. Part No / N° de la pièce	9. Qty / Qté	10. Serial No. / N° série	11. Status/Work Etat/Travaux		
001	FAC - FLIGHT AUGMENTATION COMPUTER	B397BAM0624	1	Q00140009312	INSPECTED/TESTED		
12. Remarks / Remarques TESTED IAW DOC. TYPE : CMM REF.DOC : 22-66-32A REVISION : 31 DATE DOC. : 22-NOV-19 MOD./AMDT. ON ARRIVAL : / A B C D E F G MOD./AMDT. ON DEPARTURE : / A B C D E F G				TSN/CSN UNK / UNK TSO/CSO UNK / UNK TSI/CSI 0 H / 0 C		This civil aeronautical product has been maintained in accordance with TCCA certificate N° 897-41	
13a. Certifies that the items identified above were manufactured in conformity to : Certifie que les éléments identifiés ci-dessus ont été fabriqués conformément aux : ☐ approved design data and are in condition for safe operation. données de conception approuvées et sont en état de fonctionner en toute sécurité. ☐ non-approved design data specified in block 12. données de conception non approuvées identifiées en case 12.				14a. ☒ Part 145.A.50 Release to service Approbation pour remise en service selon partie 145.A.50 ☒ Other regulation specified in block 12 Autre réglementation précisée en case 12 Certifies that unless otherwise specified in block 12, the work identified in block 11 and described in block 12, was accomplished in accordance with PART 145 and in respect to that work the items are considered ready for release to service. Certifie que, sauf indication contraire précisée en case 12, les travaux identifiés en case 11 et décrits en case 12 ont été réalisés conformément à la partie 145 et qu'en regard de ces travaux, la (les) pièce(s) est (sont) considérées prêtes à la remise en service.			
13b. Authorised Signature Signature autorisée		13c. Approval / Authorisation number Numéro d'agrément / d'autorisation		14b. Authorised Signature Signature autorisée 		14c. Certificate / Approval ref. No. N° du certificat / Agrément FR.145.0001	
13d. Name / Nom		13e. Date (dd mmm yyyy) / Date (jj mmm aaaa)		14d. Name / Nom RICHARD		14e. Date (dd mmm yyyy) / Date (jj mmm aaaa) 29 JAN 2024	
<p>USER/INSTALLER RESPONSIBILITIES / Reponsabilités de l'utilisateur/installateur This certificate does not automatically constitute authority to install the item(s). Ce document ne constitue pas forcément l'autorisation d'installer l'(es) item(s). Where the user/installer performs work in accordance with regulations of an airworthiness authority different than the airworthiness authority specified in block 1, it is essential that the user/installer ensures that his/her airworthiness authority accepts items from the airworthiness authority specified in block 1. Quand l'utilisateur/installateur travaille selon les réglementations d'une autorité de navigabilité différente de l'autorité de navigabilité mentionnée dans la case 1, il est essentiel que l'utilisateur/installateur s'assure que son autorité de navigabilité accepte les items libérés par l'autorité de navigabilité mentionnée dans la case 1. Statements in blocks 13a and 14a do not constitute installation certification. In all cases aircraft maintenance records must contain an installation certification issued in accordance with the national regulations by the user/installer before the aircraft may be flown. Les indications portées en cases 13a et 14a ne constituent pas une certification de montage. Dans tous les cas le dossier d'entretien de l'aéronef doit contenir une certification d'installation délivrée conformément aux règlements nationaux par l'utilisateur/installateur avant que l'aéronef puisse voler.</p>							

Multi-mode receiver example consisting of a Shop Finding Report and the respective EASA Form 1.

 Muirhead Aerospace Limited Contact Name: Customer Services Telephone: Fax:		Tear Down/Inspection Work Order #: RD21731 Date Printed: 12-Apr-25 Page: 1
To: ATTN: REPAIRS AVTRADE LTD GLOBAL HEADQUARTERS SAYERS COMMON WEST SUSSEX BN6 9JQ UK		Ship To: AVTRADE LTD GLOBAL HEADQUARTERS SAYERS COMMON WEST SUSSEX, BN6 9JQ UK
Cust.PO Ref.: R471928 Cust.Code: 200660		Cust.Phone: Cust.Fax: Cust.Email: Station: SOUTH
Part No. In: TLS755-01-0102A Part No. Out: TLS755-01-0102A		Description: MULTI MODE RECEIVER Serial No: 4678434A-04069 Qty: 1 Previous WO No:
Documentation: 34-36-31B (TFI) ATA No: 34-36-31B Location: THALES SHELF Rev. & Date: 17 12-Oct-2023		
Symptoms: <div style="border: 2px solid red; padding: 5px; margin: 5px;"> Tech report REPORTED DEFECT:- Repetitive Fault History. </div> VISUAL INSPECTION: Satisfactory. TEST / INSPECTION RESULTS:- Unit powers up well and passes functional test. FINDINGS / CORRECTIVE ACTIONS:- Units LOC, GLS and GPS functions are in spec. Fault memory cleared. Unit cleaned and full soak tested in accordance to CMM. <div style="border: 2px solid red; padding: 5px; margin: 5px;"> Unit is No Fault Found. </div> Unit assessed serviceable. MODS EMBODIED: Nil MOD PLATE STATUS: 1-9		
Inspection Signature:  Inspect. Print Name: ASKIN EKINGI Stamp: 		

MRO-QUK-0036/01

An AMETEK Aerospace & Defense Company

1. Approving Competent Authority/Country EASA		2. AUTHORISED RELEASE CERTIFICATE EASA FORM 1		3. Form Tracking Number. E-329660	
4. Organisation Name and Address.		MUIRHEAD AEROSPACE LIMITED T/A MUIRHEAD AVIONICS 50 Heron Drive Quadrant House Slough Berkshire, SL3 8XP, United Kingdom Ph: +44(0) 20 8571 3422		5. Work Order/Contract/Invoice Work Order No: RD21731 Customer Order No: R471928	
6. Item	7. Description	8. Part No.	9. Qty.	10. Serial No.	11. Status/Work
1	MULTI MODE RECEIVER	TLS755-01-0102A	1	4678434A-04069	Inspected/Tested
12. Remarks MODS OBSERVED ON IDENT PLATE: 1-9 Manual ID: 34-36-31B (TFI), Revision #: 17, Revision Date: 12/10/2023 Manual ID: 34-36-31A (CMM_IPL), Revision #: 18, Revision Date: 11/10/2023 Repair report attached reference RD21731					
13a. Certifies that the items identified above were manufactured in conformity to: ☐ approved design data and are in a condition for safe operation. ☐ non-approved design data specified in block 12			14a. ☒ Part-145.A.50 Release to Service ☐ Other regulation specified in Block 12 Certifies that unless otherwise specified in block 12, the work identified in block 11and described in block 12, was accomplished in accordance with Part-145 and in respect to that work the items are considered ready for release to service.		
13b. Authorised Signature:		13c. Approval/Authorisation No.		14b. Authorised Signature  MAA 4	
13d. Name		13e. Date (dd mmm yyyy)		14c. Certificate/Approval Ref No. EASA.145.3077	
				14d. Name ASKIN EKINCI	
				14e. Date (dd mmm yyyy) 12 Apr 2025	
USER/INSTALLER RESPONSIBILITIES This certificate does not automatically constitute authority to install the item(s). Where the user/installer performs work in accordance with regulations of an airworthiness authority different than the airworthiness authority specified in block 1, it is essential that the user/installer ensures that his/her airworthiness authority accepts items from the airworthiness authority specified in block 1. Statements in blocks 13a and 14a do not constitute installation certification. In all cases aircraft maintenance records must contain an installation certification issued in accordance with the national regulations by the user/installer before the aircraft may be flown.					

Appendix D Market review of software applications in context of repetitive defect management

The below is a brief market review of available software applications.

AVIATAR (Lufthansa Technik)

Very comprehensive data analysis platform, offering modular products such as live system health/condition-monitoring and digital PFR output. A new module for Reliability suite was launched in 2025 called “Technical Repetitives Examination (TRE)”. A highlight is the individual customisation so that it can be adapted to authority or operator requirements, therefore allowing self-defined criteria for rules declaring repetitive defects. Offering also data integration into M&E applications such as AMOS (Graesch, n.d.).

Traditionally various factors compromise technical logbook data quality. Consequently, this application enhances the free text data from pilot and maintenance reports and enhances the ATA chapter entries based on a combination of artificial intelligence (AI) and engineering knowledge. It also presents results visually (Graesch, n.d.).

AMOS (Swiss Aviation Software)

This is an M&E comprehensive software application offered in tailored packages such as CAMO, airline, airline-MRO and MRO editions, ensuring that organisations can adopt the level of functionality for their operational needs (Swiss Aviation Software, n.d.-a). AMOS offers the core tasks expected for continuing airworthiness management such as maintenance planning and forecasting, component tracking, work order management, authorisation, material, human resources management and more.

Its ‘Maintenance Control’ module, provides the MCC with a tool to control and improve the fleet reliability. It lists standard MCC tasks as functions of this module, but no reference can be found to repetitive defect handling (Swiss Aviation Software, n.d.-b).

AVIATAR and AMOS can be used together to provide a complete picture and range of tools required for an MCC engineer to manage repetitive system defects effectively. However, AMOS does not yet feed maintenance records of previously rectified faults into AVIATAR, so it is missing a level of integration.

OEM Health-Monitoring Platforms:

Skywise Fleet Performance (Airbus)

Skywise Fleet Performance is Airbus’s in-flight health monitoring solution, providing real-time aircraft status through continuous ACMS data streaming. It supports MCC operations by allowing live tracking of faults and displaying a visual history of repetitive occurrences across the previous 15 sectors, linking to the MEL and the TSM. The system also issues automated email notifications when new faults arise, ensuring timely awareness.



Figure D.1 Skywise extract

(courtesy of Titan Airways Malta)

However, Skywise FP operates independently of the CAMO M&E software, meaning past rectification actions and fleet-level statistics cannot be accessed directly, requiring manual cross-referencing. Its main advantage is the ability to present faults before landings and prior to any technical logbook entry by the crew, enabling more proactive MCC planning (Vaissieres, 2022).

Comparison of OEM Platforms including Boeing and Embraer

Boeing AHM, Embraer AHEAD (Embraer, 2023) and Airbus S. Fleet Performance+ all provide real-time aircraft health monitoring and predictive analysis, enabling maintenance teams to identify emerging technical issues before an aircraft lands. While AHM and AHEAD use trend and anomaly detections to indicate potential recurring issues, their repetitive-defect indication is indirect, and embedded within broader predictive-maintenance analytics. In contrast, S. Fleet Performance+ includes explicit AI and NLP based functionality designed to automatically recognise repetitive faults, link them with relevant documentation, and present fault-occurrence histories, offering more targeted support for managing short-term repetitive defects.

Independent suppliers:

VERYON

The module called 'Defect Analysis' analyses defects using AI technology and natural language processing (NLP) algorithms to automatically identify, group and analyse repetitive defects, even after a minimum of two occurrences. It has automation and integration capabilities with logbook updates and mobile access (VERYON, 2017).

AIXI

AIXI (n.d.) provide a product branded 'Repeat Defect Identifier'. This provides functionality to technicians including defect rectification history search, and generates trends based on metrics such as aircraft type and age. It is an aid to MCC engineers which creates visibility on what is causing AOGs and it highlights potential safety threats from untreated repetitive defects.

Appendix E Further Results

E.1 Table of Definitions

ID	Regulator	Years in Aviation	Repeat	Repetitive	Recurring	Recurrent
S2	EASA UK CAA FAA	16-20	Happens after	3 occurrences in 10 sectors	The defect is fixed after mtc then reoccurs	
S6	EASA	40+	Occurred again, after defect originally considered as closed (<i>2nd occurrence</i>)	3 occurrences in 15 sectors	Not heard that term in 26 years	
S10	Bahrain CAA	31-40		3 occurrences in 10 CD		
MCCE-04	EASA	<5	2 occurrences in 6 sectors	3 occurrences in 6 sectors		
MCCE-05	EASA UK CAA	31-40	Repeat is more than once i.e. twice	3 occurrences in 14 CD		
MCCE-06	EASA	21-30	3 occurrences in 7 CD; or 3 times in a row			
MCCE-08	EASA	16-20	3 Interrelated defects or discrepancies in the same ATA chapter (opened for the same aircraft) within 10 days			Items or defects which may occur on a specific aircraft fleet and tail sign (broader as they go beyond MSN)
MCCE-09	EASA	21-30		3 occurrences in 10 CD		
MCCE-10	EASA UK CAA	21-30		3 occurrences in 14 CD		

E.2 Handling of a Repetitive System Defect

The following is a summarised list in response to the question: 'If a defect is repetitive, do you handle this differently to other defects? What do you do differently?'

- Review previous actions performed.
- Check work already performed in order not to repeat same steps.
- Perform more in-depth troubleshooting as opposed to changing components.
- Troubleshooting is to be started even if the fault is not active/present at the time. A work order is to be opened to start troubleshooting.
- Check of history, if any complex troubleshooting is required. Also, a check of workshop report for the previously replaced part. "It can be NFF which is a huge problem."
- Review documentation other than the TSM, such as the Airbus WISE system or Boeing Fleet Team Digest system.
- If it is an MEL item, and it is repeated within 2FC, then use original date as the original expired MEL due date.
- After history review, discussion on team meeting and collaboration with all stakeholders for the next actions. Monitoring of repetitive defects for 7 days after positive action has been taken with no further repeats.

E.3 Handling of Components

Extract from engineer 'MCCE-05' in response to whether he proactively reviews component paperwork before accepting a unit:

"Sometimes, I do ...Yesterday I happened to go and look at the Form 1 details... Found that it was only a tested unit, not repaired or an overhaul. And when I looked at the workshop report, it showed me that when it went into the workshop it had exactly the same fault that we had on the aircraft, and the workshop report was unable to reproduce the fault, and that it's been released... I personally happened to just go out of my way. It was kind of lucky I did that."

Managed to get stores to source another part that they'd actually found a fault with and repaired something ...you've got more confidence that that's good. ...it is really down to the individual MCC engineer on the day to do that extra bit of research. We don't have to, some people do, some people don't, but it is amazing *how many times I have done it, and you do have serious question marks over the part you are about to fit.*"

E.4 Supporting Roles

A thematic analysis was performed to clarify the role of Technical Services Engineers (TSEs) in this process. Responses varied, but a common theme was that approximately half of the participants saw TSEs as providing support to ongoing defect rectification. Additional tasks included taking over DAH communication when available documentation is insufficient to fix a defect, reviewing fleet publications such as ISIs and TFUs, and monitoring issues for potential AMP inclusion or longer-term reliability trends.

The question also explored whether Reliability Engineers contributed to this area. Among those who did, the tasks described related to long-term reliability analysis rather than the short-term identification related to this study. Only two of the 28 respondents indicated that the Reliability Engineers supported short-term repetitive system defect identification, suggesting that this responsibility lies primarily with MCC Engineers.

Interviews also showed that in some CAMOs, Planning Engineers support MCC Engineers by issuing investigation work orders, whilst in others, MCC Engineers issue these directly.

E.5 Software Applications in Use

Participants identified the following software applications currently used within their organisations: Airbus Skywise, AMOS, Aviatar, eMRO.

Despite differences in platforms, respondents constantly described features typical to Aviation Maintenance & Engineering (M&E) software, including:

- Defect and technical log history search

- Part search functionality
- Planned task expiry monitoring
- Parts inventory checks
- Generation of open defects lists.

For Skywise and Aviator, the reported functionalities included digital PFRs, automatic fault logging, fault classification by severity, and integrated links to the TSM. Respondents emphasised that the most relevant capability for managing RSD is the condition monitoring feature, which performs live data analysis to identify recurring faults and warnings, grouped by sector and flight phase. Users expressed broad agreement that this functionality is highly beneficial, however it applies only at the individual aircraft level.

All interview participants confirmed that their software systems operate independently. Engineers must manually move between platforms when conducting RSD investigations, as no integrated or cross-system functionality exists. In particular, Skywise nor Aviator do not contain maintenance records and are not connected to the technical logbook or M&E systems, limiting their ability to interrogate defect history.

Appendix F Analysis of Interval Variability

This appendix demonstrates that calendar-day intervals and sector-count intervals cannot be meaningfully compared in isolation; proper interpretation requires explicit consideration of fleet utilisation.

Four utilisation scenarios were assessed to reflect a typical airline operating mixed short-haul and long-haul fleets, with both high and low-utilisation conditions (Aubin, 2004). The resulting matrix aligns time-based intervals of 5, 7, 10 and 14 days, and sector-based intervals of 6, 10 and 15 sectors, supplemented by additional 20, 25, and 30 sector intervals for improved comparability with time-based data (see Section 4.2.2). Colour coding groups equivalent sector totals and highlights their relative positions across the matrix (Figure F.1).

Decision Matrix		Days					Sectors							
			5	7	10	14	6	10	15	20	25	30		
Fleet Utilisation		Sectors/Day	Total sectors flown in interval					Days for a number of fixed sectors in interval						
Short range	High	4	20	28	40	56	1.5	2.5	3.8	5.0	6.3	7.5		
Short range	Low	2	10	14	20	28	3.0	5.0	7.5	10.0	12.5	15.0		
Long range	High	1.5	7.5	10.5	15	21	4.0	6.7	10.0	13.3	16.7	20.0		
Long range	Low	1	5	7	10	14	6.0	10.0	15.0	20.0	25.0	30.0		
		input field												
Target/sectors		15												
		20												
		25												
		30												

Figure F.1 Decision matrix displaying various fleet utilisations

The first section of the matrix illustrates that for a short-haul fleet averaging 4 sectors per day, a 14-day interval equates to approximately 56 sectors. Identifying 3 occurrences within 56 sectors is therefore fundamentally different from identifying 3 occurrences within only 14 sectors, as might be the case in a low-utilisation long-haul operation.

Similarly, the sector-based portion of the matrix shows how fixed sector counts translate into significantly different elapsed times depending on utilisation. For example, 15 sectors represent fewer than 4 days for a high-utilisation short-haul fleet; yet correspond to 15 days for a low-utilisation long-haul operation.

Interval length also influences whether multiple events meet the threshold for classification as repetitive. Widely spaced occurrences, such as sectors 1, 10 and 24, may constitute a repetitive defect under a 25-sector interval, but not under a 15-sector interval. Increasing the interval therefore yields a more conservative classification.

As anticipated, this study confirmed the absence of an industry-wide consensus on interval selection. Kinnison & Siddiqui (2013) reference a 5-day interval, whereas the most common value observed in this study was 10 days, equating roughly to 20 and 40 sectors respectively for high-utilisation fleets. In contrast, TCCA specifies an interval of 15 sectors.

Based on these findings, a standardised metric is considered necessary. Sector count is recommended as the most appropriate common denominator, as it inherently accommodates utilisation differences across diverse fleet types.

Appendix G Recommended Tools for MCC

G.1 Fleet Utilisation Conversion Matrix

Fleet Utilisation Conversion Matrix

Target (sectors)			25	Sectors	
				25	
Fleet	Utilisation		Sectors/Day	Days (rounded)	
1	Short range	High	3.75		7
2	Short range	Low	2		13
3	Long range	High	1.7		15
4	Long range	Low	1.2		21

input field

Figure G.1 Example of a conversion matrix

Utilisation values under the Sectors/Day column are to be derived from the operational flying figures of the respective operator.

G.2 Repeat Items Watch List

This list records the second occurrence of a fault. Although this stage does not mandate immediate troubleshooting/investigation, it functions as a watch list: faults are monitored so that, should a third occurrence arise, they can be transferred into the RSD list and investigated.

G.3 Repetitive Defects Tracker

Official CAMO list of Repetitive Defects to include as a minimum:

1. Timestamp at identification
2. Aircraft Registration
3. ATA Chapter (ideally accurate up to 4 digits)
4. Exact Defect Description (Warning / fault text)
5. Action Taken (with timestamp including component changes)
6. Live status

7. Repeat Count
8. Notification to Flight Operations
9. Root Cause Analysis Done?
10. Monitoring for 15 sectors post-final fix
11. Final Fix actions
12. Closed (Y/N)

G.4 RSD Handling Software Tool (MCC Support Application)

Purpose

The application supports MCC engineers by automatically identifying RSD and presenting related historical data. Its aim is to improve defect trend visibility, reduce troubleshooting time, and support compliance with repetitive defect rules.

Objective

To detect, classify and present RSD per tail sign and across the fleet, using automated text-based matching of technical logbook entries (PIREP/MAREP).

User Interface Overview

A dashboard-style interface offering:

1. Quick reference panels for tail-specific history and fleet-level occurrences.
2. Clickable links to open individual events.
3. Clear visual alerts when repetitive defect rules are triggered.
4. Clean, large-font notification panels for ease of use in an operational MCC environment.

Workflow and Preconditions

1. MVP Functionality:
 - a. The user manually inputs the fault/warning text string exactly as recorded in the logbook.
 - b. The system performs a history search using text-matching algorithms (initially simple text strong match; expandable to fuzzy matching or NLP-based similarity detection).
2. Full-Product Functionality:
 - a. Each new defect entry is automatically parsed.
 - b. The system launches and automatic search for matching faults without requiring explicit user input.

- c. The interface proactively displays a notification if an RSD condition is met.
3. Preconditions for accurate matching:
 - a. The PIREP/MAREP warning text must be copied word-for-word from the ECAM or post-flight report.
 - b. The allows deterministic matching, supported by enhanced algorithms such as fuzzy matching to accommodate minor variation.

Repetitive Defect Identification Logic

The system applies customisable identification rules (such as 3 events within 25 sectors). Rules may be configured per operator or per system.

When a rule is met:

1. A repetitive defect alert appears prominently on the dashboard.
2. The system displays relevant fault text and clickable links to relevant events.

Dashboard Output Specification

1. Tail-level output. For the searched fault, the dashboard outputs a table as below:
 - a. Engineer verification column (“Accept Y/N”) allows the user to exclude irrelevant matches (such as nonsense entries, mistyped reports or unrelated issues).
 - b. Each event row is clickable (“Click to open event”).

Table G.1 Sample events

Timestamp (newest first) UTC	Event	ATA (4 DIGIT)	Accept? Y/N
16/12/2025 20:54	AUTO FLT FAC 2	22-60	Y
16/12/2025 06:32	AUTO FLT FAC2	22-60	Y
13/12/2025 14:50	AUTO FLT FAC 2	22-60	Y

12/12/2025 03:15	AUTO FL FAC2	22-00	Y
01/10/2025 16:30	AUTO FLT FAC ¹	22-60	N

Event Detail View

Selecting an event opens a detailed view containing:

- List of rectification actions in chronological order
- Component change history associated with the event
- Attachments such as Form 1 and shop reports.

Fleet-Level Analysis

In addition to the tail's history, the system performs a fleet-wide search for the same fault/warning text. Displayed items include:

- Number of occurrences across the fleet
- List of affected tails
- Links to open each event's rectification record
- Statistical graphics:
 - Occurrence frequency
 - Mean time between events (on same tail)

Selecting any fleet events opens the same rectification details page as the tail-level events.

Appendix H Charts Data

H.1 CAMO Demographics

Regulatory authority	Quantity - abs	Quantity - %
Bahrain CAA	1	4
Oman CAA	1	4
Pakistan CAA	1	4
UK CAA	5	18
EASA	23	82
FAA	1	4
UAE GCAA	1	4
Respondents (multiple approvals)	28	

Fleet size	Quantity - abs	Quantity - %
1-5	6	21
6-10	3	11
11-20	7	25
21-30	3	11
31-50	2	7
51-100	3	11
101+	4	14
	28	100

AOC	Quantity - abs	Quantity - %
Commercial	25	89
Business	3	11
	28	100

Age Bracket	Quantity - abs	Quantity - %
20s	5	20
30s	5	20
40s	11	44
50s	2	8
60s	2	8
	25	100
undisclosed	3	

Years of experience in aviation	Quantity - abs	Quantity - %
5 or less	2	7
6-10	5	18
11-15	1	4
16-20	8	29
21-30	6	21
31-40	5	18
41+	1	4
	28	100

Years of experience in MCC	Quantity - abs	Quantity - %
5 or less	18	64
6-10	7	25
11-15	1	4
16-20	1	4
21-30	1	4
31-40	0	0
41+	0	0
	28	100

Definitions

	Survey		Interview	
Meanings	Quantity - abs	Quantity - %	Quantity - abs	Quantity - %
Interchangeable	15	54	8	29
Different	3	11	2	7
	28			

Process

List of ongoing RSD in handover	Quantity - abs	Quantity - %
Yes	22	92
No	2	8
	24	100

Search history for new fault	Quantity - abs	Quantity - %
Yes	21	88
No	3	13
	24	100

If a defect is repetitive, do you handle this differently to other defects?	Quantity - abs	Quantity - %
Yes	21	84
No	4	16
	25	100

Proactive check of component paperwork prior to installation	Quantity - abs	Quantity - %
No	1	10
Only for faults on recently replaced units	4	40
Sometimes	2	20
Yes	3	30
	10	100

Communication with flight crew

Calls from Crew	Quantity - abs	Quantity - %
Yes	24	86
No	4	14
	28	100

How easy is it to give the crew a history?	Quantity - abs	Quantity - %
1	0	0
2	1	4
3	1	4
4	1	4
5	5	18
6	4	14
7	6	21
8	6	21
9	4	14
10	0	0
	28	100

Informing crew about RSD: Combined	Quantity - abs	Quantity - %
Yes	15	54
Maybe	6	21
No	7	25
	28	100

Informing crew about RSD: Survey	Quantity - abs	Quantity - %
Yes	8	44
Maybe	6	33
No	4	22
	18	100

Informing crew about RSD: Interview	Quantity - abs	Quantity - %
Yes	7	70
Maybe	0	0
No	3	30
	10	100

Software Aid

Software beneficial?	Quantity - abs	Quantity - %
Yes	17	94
No	1	6
	18	100

Desired functionality	Quantity - abs	Quantity - %
Previous rectification actions	22	88
Previous T/S actions	22	88
Statistics across fleets	12	48
Statistics for the fleet	17	68
Statistics for the tail	17	68
Visual cue of a repetitive occurrence	20	80
	25	100

Effectiveness to Efficiency	Quantity - abs	Quantity - %
1	0	0
2	0	0
3	0	0
4	0	0
5	1	4
6	2	8
7	4	15
8	9	35

9	6	23
10	4	15
	26	100

Effectiveness to Safety	Quantity - abs	Quantity - %
1	0	0
2	1	4
3	0	0
4	0	0
5	1	4
6	1	4
7	3	12
8	7	27
9	7	27
10	6	23
	26	100

H.2 Flight crew Demographics

Regulatory authority	Quantity - abs	Quantity - %
ANAC (Brazil)	1	1
CASA	2	3
DGCA (India)	2	3
EASA	50	67
FAA	0	0
GCAA (UAE)	3	4
HK CAD	1	1
NZ CAA	1	1
TCCA	1	1
UK CAA	13	17
Other (undisclosed)	1	1
	75	100

Years flying CAT a/c	Quantity - abs	Quantity - %
5 or less	15	20
6-10	8	11
11-15	11	15
16-20	13	17
21-30	19	25
31-40	9	12
	75	100

Role	Quantity - abs	Quantity - %
Captain	47	63
First Officer	28	37
	75	100

Age Bracket	Quantity - abs	Quantity - %
20s	5	8
30s	11	17
40s	32	51
50s	12	19
60s	2	3
70s	1	2
	63	100
undisclosed	12	

Process

List of RSD presented prior to flight	Quantity - abs	Quantity - %
Yes	24	32
Maybe	9	12
No	42	56
	75	100

From the 'yes' replies:

Regulatory authority	Quantity - abs	Quantity - %
ANAC (Brazil)	1	4
CASA	2	8
DGCA (India)	1	4
EASA	14	58
FAA	0	0
GCAA (UAE)	0	0
HK CAD	0	0
NZ CAA	0	0
TCCA	0	0
UK CAA	5	21
Other (undisclosed)	1	4
	24	100

How is this information presented prior flight?		
Means	Quantity - abs	Quantity - %
Technical Log	19	79
Email / flight brief	2	8
Other	3	13
	24	100
Other	Quantity - abs	
Word by colleagues	1	
Tech log and digital flight plan	1	
Not tracked other than by maintenance department reliability monitoring	1	

Ease of access to this information	Quantity - abs	Quantity - %
1	1	4
2	0	0
3	1	4
4	0	0
5	4	17
6	2	8
7	1	4
8	7	29
9	3	13
10	5	21
	24	100

Pilots' Perspectives

Would you like to receive this information?		
Combined	Quantity - abs	Quantity - %
Yes	63	84
Maybe	8	11
No	4	5
	75	100

Capt	Quantity - abs	Quantity - %
Yes	40	85
Maybe	4	9
No	3	6
	47	100

F/O	Quantity - abs	Quantity - %
Yes	23	82
Maybe	4	14
No	1	4
	28	100

	Quantity - abs	Quantity - %	abs	%	abs	%
Importance	Combined	Combined (%)	Capt	Capt (%)	F/O	F/O (%)
1	3	4	2	3	1	1
2	1	1	0	0	1	1
3	1	1	0	0	1	1
4	2	3	0	0	2	3
5	4	5	2	3	2	3
6	6	8	3	4	3	4
7	14	19	12	16	2	3
8	21	28	15	20	6	8
9	6	8	3	4	3	4
10	17	23	10	13	7	9
	75	100	47	62.7	28	37.3

Reasons for wanting RSD list prior to flight		
Reasons	Quantity - abs	% (out of 75 resp)
Not interested in Engineering Topics	1	1
Not important for my role	5	7
Does not affect safety	3	4
Interested in Engineering Topics	18	24
Important for my role	42	56
MAY affect safety	46	61
Affects safety	26	35
Wish to have oversight of technical status	53	71
Other	4	5

Acceptance to operate an a/c with an open RSD	Quantity - abs	% (out of 75 resp)
No	5	7
Yes	24	32
Yes but... with any combination of below	11	15
*It depends on the type of defect or system	34	45
*It depends on the operational circumstances	35	47
*Other	1	1