

Ageing Aircraft Programmes Working Group (AAPWG)

Paper 013

**Continuing Airworthiness Management
its
Contribution to Identifying Evidence of
Ageing in Aircraft**

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1. DISTRIBUTION

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2. EXECUTIVE SUMMARY

The Defence Science and Technology Laboratories (dstl), with the support of the Military Aviation Authority through the Ageing Aircraft Programmes Working Group (AAPWG), have initiated a research and development programme titled “Understanding Ageing Aircraft”. This paper contributes to the dstl programme by seeking to explore continuing airworthiness management activities that might identify the onset of ageing.

The UK MOD policy for ageing aircraft centres round carrying out an Ageing Aircraft Audit (AAA) 15 years after a type’s in-services date or at the mid-point between the declared ISD and the initial planned Out of Service Date (OSD) whichever is soonest. Repeat audits should be conducted at 10 year intervals thereafter. However, it is recognised that ageing is a progressive process that commences from manufacture and an in-service programme of monitoring ageing would be advantageous. The responsibilities of both a Type Airworthiness Authority (TAA) and a Continuing Airworthiness Management Organisation (CAMO) include data collection and associated analysis, functions which are recognised as essential tools in identifying potential ageing in aircraft.

The concept of an Operator’s CAMO was first introduced as a Joint Aviation Authorities (JAA) requirement; this was later subsumed into EC2042/2003[1] the European Aviation Safety Authority’s regulation for Continuing Airworthiness (CAW). In 2012 the UK MOD published the requirement for Military CAMOs in Regulatory Articles (RA) 4941 to 4956[2]. These regulations are based on the Civilian regulations but tailored for the Military regulatory construct.

The principal CAMO tasks that might be used to identify ageing are the oversight of platform usage and the collection and analysis of maintenance and fault data using the latter to evaluate the effectiveness of the Maintenance Programme. Prior to the introduction of CAMOs these tasks were traditionally undertaken by the TAA who also has data gathering and analysis responsibilities which underpin the Type airworthiness.

The Military CAMO (Mil CAMO) is also responsible for ensuring that each aircraft is subject to an annual Military Airworthiness Review (Mil AR) which includes a physical review of the aircraft. These reviews have proved to be an additional aid to identifying evidence of ageing.

A Mil CAMO can outsource/sub-contract certain tasks but only by using a formal written agreement/subcontract. Such outsourcing requires careful oversight by the CAMO to ensure the work is sufficiently robust to satisfy their responsibilities.

This Paper concludes that the tasks carried out by the Mil CAMO include a number that could make a significant contribution to identifying ageing in individual aircraft.

3. AUTHORSHIP

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5. ABBREVIATIONS

AAA	Ageing Aircraft Audit
AAPWG	Ageing Aircraft Programmes Working Group
AD	Airworthiness Directive
ASIMS	Air Safety Information Management System
CAME	Continuing Airworthiness Management Exposition
CAMO	Continuing Airworthiness Management Organisation
CAW	Continuing Airworthiness
DASOR	Defence Air Safety Occurrence Report
DH	Duty Holder
EASA	European Aviation Safety Agency
EDPC	Environmental Damage Prevention and Control
EWIS	Electrical Wiring Interconnect System
FRACAS	Failure Reporting, Analysis and Corrective Action System
ISD	In Service Date
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
MAA	Military Aviation Authority
MAE	Military Air Environment
MFRI	Mandatory Fault Reporting Instruction
Mil AR	Military Airworthiness Review
MRP	Military Aviation Authority Regulatory Publications
ODH	Operating Duty Holder
OSD	Out of Service Date
PT	Project Team
RA	Regulatory Article

SB	Service Bulletin
SI(T)	Special Instruction (Technical)
SOIU	Statement of Operating Intent and Usage
SPC	Sortie Profile Code
SRM	Structural Repair Manual
SSI	Structurally Significant Item
TAA	Type Airworthiness Authority
TCH	Type Certificate Holder

1 INTRODUCTION

1.1 BACKGROUND

The current MOD policy for ageing aircraft is laid down in the Military Aviation Authority (MAA) Regulatory Articles (RAs), in particular RA 5723[3] which calls for an Ageing Aircraft Audit (AAA) to be carried out 15 years after a type's declared In Service Date (ISD), or at the mid-point between the declared ISD and the initial planned Out of Service Date (OSD) whichever is soonest. Repeat audits should be conducted at 10 year intervals thereafter. The RA lays down conditions for the conduct of the audit which includes a detailed, independent physical examination of the condition of a representative sample of aircraft from the Fleet.

The adverse effects of age may be described as the cumulative exposure to the threats to Integrity these encompass overload, fatigue, environmental/accidental damage, the loss of configuration control and maintenance/supply errors, and the risk of them interacting increasing with time and usage. Additionally, calendar-based ageing mechanisms such as the effects of environmental ageing and degradation can compromise Integrity.

The effects of ageing are not always comprehensively recognised or addressed by routine activities and whilst the AAA will help identify the risks associated with an ageing fleet the findings are only valid at the time of the Audit and it can be argued that ageing is an on-going process which starts from the day an aircraft is manufactured.

It is imperative that TAAs are able to progressively monitor the fleet for which they are responsible for signs of ageing, to do so feedback is needed on the condition of the individual aircraft that make up the fleet. Aviation regulations both Military and Civil lay the responsibility for the continuing airworthiness of individual aircraft on the Operator of the aircraft. The Operators discharges their responsibilities through their Continuing Airworthiness Management Organisation (CAMO) and the regulations lay down the tasks which must be fulfilled to ensure that Continuing Airworthiness (CAW) is achieved. Amongst these tasks are a number which could be used to identify ageing in the aircraft fleet however, for this to be effective the CAMO needs to be cognisant of ageing and ensure it is considered when analysing trends.

1.2 OBJECTIVES

This paper seeks to highlight the existing CAMO tasks that may provide an indication of ageing in the individual aircraft for which it is responsible. Though aimed at the Military aviation

community, where appropriate, reference is made to the civil regulations not least because the role of the CAMO was originally established in commercial air transport regulations.

2 CAMO REGULATION AND POLICY

2.1 THE CIVILIAN AVIATION APPROACH.

2.1.1 CIVIL REGULATIONS

The Operators responsibilities for the CAW of the aircraft listed on their Air Operators Certificate (AOC) were first defined in Sub-part M to Joint Aviation Requirements (JAR) Ops 1, published by the Joint Aviation Authorities (JAA). On the formation of the European Aviation Safety Agency (EASA) in 2003 these requirements migrated to Annex 1 (Part M) of Commission Regulation (EC) EC2042/2003 [1] which, at Subpart G introduces the concept of a CAMO and at Subpart I provides the regulations for issuing and maintaining an aircraft's Airworthiness Review Certificate (ARC). These regulations have been subject to minor changes since introduction but the basic requirements remain unchanged

A Part M subpart G approval does not prevent an Operator from subcontracting certain CAW tasks to competent persons or organisations; however, the Operator remains accountable though his CAMO for the satisfactory completion of the subcontracted tasks.

2.2 THE MOD UK POLICY

2.2.1 DEVELOPMENT

Initially an interim Part M was published as Part 2 to Def Stan 05-130 [4] but only one approval was granted before the regulation was suspended. The Nimrod Review [5] published in 2009 outlined the responsibilities Duty Holder and the introduction of Military CAMOs, (Page 510). Subsequently, in May 2012, RA 4941 to RA 4956 [6] were issued which covered the requirements and role of a CAMO. These RAs covered only Part M Subpart G, the requirement for a CAMO. RA 4970 – RA 4974 [7] (published Jun 2013) covered Part M Sub Part I - Airworthiness Reviews. Airworthiness Reviews are carried out annually and provide an additional level of scrutiny of the condition of individual aircraft.

2.2.2 CURRENT POLICY

The extant regulations for the CAMO remain as RAs RA 4941 – RA 4956 [6] however these RAs underwent a rewrite resulting in the release of Issue 2 in September 2015. The inclusion of the TAA in the Military airworthiness model is a major difference compared with the civil model, Issue 2 of the CAMO regulations provides clarity of the relationship between the TAA and the CAMO and the division of responsibilities particularly in the gathering and analysis of data.

Two further RAs have an impact on the CAMO. RA 1016 [8] is a top level regulation that lays down the Continuing Airworthiness Responsibilities placed on Aviation Duty Holders (DH) and Accountable Managers Continuing Airworthiness (AM(CAW)). It requires that a DH ensures that the tasks associated with CAW of the Military registered Air Systems in their area of responsibility are managed by a CAMO which is approved iaw RA 4941 [9].

RA 1140 [10] requires Operating Duty Holders (ODHs) supported by CAMOs to have a Technical Data Exploitation Strategy in place for the air systems for which they are responsible. It reiterates the CAMO's responsibility for collecting and analysing in-service technical data and stipulates that they should be assisted in this task by the TAA and Design Organisation. The regulation defines content of a Technical Data Exploitation Strategy and provides, at Annex A, a table showing how organisations involved are responsible for data collection, reporting, analysis and exploitation. This table makes no reference to identifying evidence of ageing when analysing data.

Recommendation 1: The table at Annex A to RA 1140[10] which covers Responsibilities for data collection analysis and exploitation should include a statement covering evidence of ageing in the CAMO's responsibilities for data analysis.

3 THE CAW CULTURE

3.1 RESPONSIBILITIES AND THE CULTURE

Figure 1 below serves to illustrate the relationship and responsibilities of the TAA and the Mil CAMO. It also demonstrates how information is fed between the various approved organisations and how they integrate into the CAW culture.

The left of the diagram shows the Design, Manufacture and Certification of a new aircraft type. These functions are carried out by an approved organisation and the process can best be described as the “Type” airworthiness or the “Airworthiness of the Design”. Once the Design is certified and the aircraft produced the responsibility for the CAW of individual aircraft passes to the Operator

The Operator discharges his CAW responsibilities through his Subpart G approved CAMO, this is illustrated on the right of the diagram. To discharge his responsibilities the CAMO will use an approved Part 145 Maintenance Organisation who will employ suitably qualified personnel trained by an approved Part 147 Training Organisation. The personnel employed by the CAMO, including those responsible for carrying out airworthiness reviews will also be trained by a Part 147 approved organisation. The CAMO will manage the Fleet following the processes and procedures laid down its approved Continuing Airworthiness Management Exposition (CAME). The Regulator oversees the organisations and ensures they work within the regulations

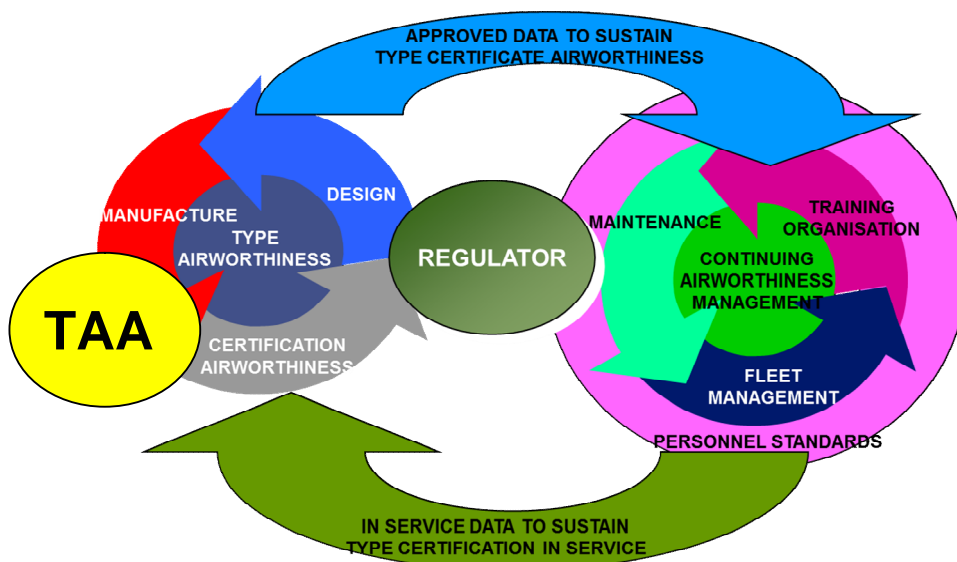


Figure 1. The Airworthiness Culture

During the operation of the aircraft the CAMO will feed back to the TAA the experiences and any problems encountered operating the aircraft and much of this information will be derived from the analysis of data collected, sources of which could include the following:

- Occurrence Reports
- Changes to the Maintenance Programme
- A request for modification or repair information.
- A request to change the operating profiles
- Information gleaned from the CAMO's technical data collection programme.

The TAA will respond to the Operators inputs usually after seeking advice from a Design approved organisation. In addition the TAA may issue:

- Special Instructions (Technical) (SI(T)s),
- Instructions to implement Airworthiness Directives (ADs) issued by the Civil regulator and Service Bulletins (SBs) issued by the Type Designer. Usually AD's and SBs will be covered by a SI (T) but with some civil derivatives this may not be the case..
- Issue modifications to maintain the airworthiness of the design. Such modifications will normally have been raised by the type designer with classification and embodiment approved by the TAA.

4 CAMO/TAA RESPONSIBILITIES

4.1 DATA GATHERING

In managing the CAW of the aircraft for which they are responsible for a CAMO is required to carry out a number of tasks that may contribute to identifying the effects of ageing. It is important that when fulfilling these tasks the CAMO remains aware that they may be the first to identify a trend and that a trend may have ageing implications. It should be noted that whilst the CAMO carries out data gathering and analysis on the in-service fleet the TAA will be monitoring the airworthiness of the Type by gathering and analysing other sources of data. The TAA may also be sub-contracted by the CAMO to gather and analyse data on behalf of the CAMO though the responsibility remains with the CAMO. The following paragraphs cover of the areas where ageing should be considered.

4.1.1 USAGE

The Mil CAM is responsible, on behalf of the DDH for monitoring fleet usage on a day by day basis and being aware of the airworthiness implications of any changes proposed by the Aircraft Operating Authority (AOA). Changes identified in the period between Statement of Operating Intent and Usage (SIOU) reviews should be assessed and if airworthiness implications are apparent the TAA informed. Any of the following changes in usage could have ageing implications:

- Increased utilisation, variations to planned sortie rates typically increased training in the build up to a deployment or longer sortie lengths to meet operational targets.
- Change of usage in terms of fatigue, cycles, landings or similar parameters. e.g. increased landing rates or mass and cycles could place additional or larger stress cycles on landing gear and back-up structure which was not planned at the design stage.
- Variations to extant sortie patterns published in the SOIU. It is not unknown that, to meet a particular task, the interpretation of a Sortie Profile Code (SPC) is not as originally intended. The CAMs close proximity to the Operators may enable him to identify when this occurs and assess the implications.
- Changes to the predicted sortie pattern rates e.g. increased use of a more aggressive SPC. An example may where an SPC with high fatigue implications is predicted to be a

low percentage of the total usage but a change in operational status increases the use of that SPC.

- Changes to the normal operating environment, an example may be operations in prolonged operations in environments with extreme temperatures or sand or dust laden atmosphere. Also changes from land based to embarked operations where ship motion may have an adverse effect on undercarriage life and the marine environment may present an increased corrosion threat.

Whilst the above changes should be identified at the routine reviews of the SOIU detailed in RA5720(4) [11] the CAMO has a unique opportunity to capture changes early and ensure the TAA is made aware.

4.1.2 CONFIGURATION CONTROL

AAAs have shown that a loss of configuration control can have an impact on the ageing of an aircraft this is particularly true in the recording of repairs. The number of repairs, their frequency across the fleet and whether they are repetitive may be indicative of an ageing problem. The CAMO is responsible for the scheduling of repairs and managing their approval even though repairs may be embodied by the Maintenance Organisation. Therefore, all requests for repair schemes must be made to the CAMO who will then seek the necessary information from the TAA. Experience from AAAs has shown that in practice repairs that require a specific repair scheme are normally well managed and recorded. More difficult to control are those repairs carried out using the Structural Repair Manual (SRM) a particular danger area is where blending is carried out to remove corrosion or light damage. In such cases the records must identify the amount of material removed during the rectification process. In addition the CAMO also has responsibility for the scheduling and recording of the following

- Embodiment of modifications.
- Satisfaction of SI(T)s

4.1.3 DATA COLLECTION

The analysis of the data collected can reveal trends in both individual aircraft and in the Fleet as a whole. The CAMO should have access to data from a number of sources, typically:

- Maintenance and fault data captured by maintenance organisations (Forward and Depth)

- Occurrence reports and Air Safety Information Management System (ASIMS)/Defence Air Safety Occurrence Reports (DASORs)
- Occurrence reports from maintenance organisations
- Specific reports such as the reporting of faults on Structurally Significant Items (SSIs).
- Specific aircraft reporting systems such as on-board data recording system in some cases this data may be collected and analysed by the TAA.

4.1.4 MAINTENANCE AND FAULT DATA

Maintenance Data is perhaps the most useful data in detecting trends that might indicate the onset of ageing in a system or structure. It can take many forms but is normally based on an information technology system and at its simplest logs faults and the corrective actions taken. The primary reason for a CAMO gathering and analysing maintenance data is to assess the effectiveness of the maintenance programme/schedule thereby allowing changes to be made that will manage risks and enhance reliability. However, collection and analysis of maintenance data is also one of the most effective tools in identifying the onset of ageing.

Auditors carrying out AAAs have reported that generally maintenance data collection and analysis is not being carried out effectively and there is a reluctance to use the data to identify problem areas. The exception is where output based contracts are in place and it is in the interests of the Contractor to understand what are his cost drivers. In these cases effective data gathering, trending and analysis often leading to changes to increase reliability were witnessed.

4.1.5 PRESENTATION OF DATA

To be effective data must be collected from the source, which is likely to an electronic recording system, and though many of these systems will have in-built report formats to present the data for analysis, the following might be considered a minimum.

- Top ten failure rates by component – this will highlight to the CAMO areas where efforts should be focused and where the evidence on ageing may be apparent.
- Comparison of failure rates by systems – analysis of systems failure may indicate a deterioration of components or interconnecting components.
- Environmental Damage – environmental damage has proved to be a major factor in the ageing of aircraft structure and components such that careful monitoring of arisings of corrosion and surface finish deterioration is vital.

- Electrical Wiring Interconnect System (EWIS) – physical surveys carried out during AAAs have revealed a large number of areas of EWIS deterioration. The most common include mechanical damage, contamination by fluids, incorrect routing and clipping and a lack of safe separation from adjacent structure and equipment.
- Damage from wear – arisings of wear may be considered a normal function of usage however, careful consideration should be given as to whether the rate is rising and what the long term effect might be.

The above are only a guide and there will be peculiarities in individual Fleets where a specific parameter may require monitoring.

4.1.6 USE OF RESULTS

The analysis of the data should provide trends that indicate both the failure mode and the root cause. It may be that the cause can easily be attributed to a failure due to inadequate maintenance, corrosion or ageing but at this stage the information derived should be passed to the TAA for further investigation. The TAA may have access to other forms of data such as the results of defect investigations (MOD Form 761), reconditioning/overhaul strip reports and sampling programmes. Throughout the CAMO and the TAA need to be cognisant that ageing may be a factor when examining the results of analysed data.

4.1.7 SUB-CONTRACTING OF TASKS

In the Commercial Airline business sub-contracting of CAMO task is not uncommon and there are stringent regulations¹ that require the operator to have sufficient qualified personnel who are trained and competent to ensure the sub-contracted tasks are correctly carried out. The MAA regulation for CAMO tasks performed by other organisations is at RA 4956 [12]. Both civil and military regulations require a documented agreement between the CAMO and the sub-contracting organisation however, the civil regulation provides more detail on the topics that might be suitable for sub-contracting and describes how oversight of the tasks should be achieved.

In the Military Air Environment (MAE) the CAMOs responsibilities cover some tasks that might have traditionally have been carried out by the TAA's staff in the Project Team. RA 4947 [13] acknowledges that whilst the CAMO must manage the trending and analysis of the Maintenance Programme from a CAW perspective, including reliability and affordability, the TAA will maintain

¹ EC 2042/2003 Part M Appendix II to MA201(h)(1): Sub-contracting of Continuous Airworthiness Management Tasks

specific reliability programmes. RA 4956 [12] also acknowledges that these activities must be coherent. AAAs carried out in the past have shown that the process of data analysis for some platforms has not been as rigorous as it should have been, with many of the tasks remaining with the same organisation albeit with the CAMO having the responsibility. It is essential that any work sub-contracted by the CAMO has robust oversight of the outcome.

4.2 MILITARY AIRWORTHINESS REVIEW

RA 4971 requires that the Mil CAMO shall ensure that a Military Airworthiness Review (Mil AR) is carried out periodically in accordance with RA 4973 [14]. The Mil AR process includes a physical examination of the aircraft, this examination may present a further opportunity to identify deterioration not detected during normal maintenance activities.

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5 CONCLUSIONS

Data collection and trend analysis is a vital tool in identifying the early onset of ageing in aircraft structure, systems and propulsion systems. The introduction of CAMOs into the MAE and the resultant requirement to monitor the continuing airworthiness of individual aircraft presents an opportunity to progressively monitor ageing of an aircraft through the analysis of in-service data. The role and functions of a CAMO are laid down in RA 4941 to RA 4956 [6] which follow the EASA regulation as far as is practicable. The construct of the UK's military aviation organisation, particularly the inclusion of the TAA, means that the relationship seen in civil aviation between the CAMO and Designer is not as clearly defined in the military system and some of the tasks which the CAMO is now responsible for may remain with the TAA under a formal agreement/sub-contract arrangement.

There are a number of areas where the tasks for which the CAMO is responsible may identify potential ageing or identify trends caused by ageing. The most important tasks which may relate to ageing are monitoring the usage of the aircraft and the analysis of maintenance data. Changes in usage may centre around an increased use of individual SPCs beyond that originally assumed or a change in operating environment. The analysis of maintenance data is essential to verify the effectiveness of the maintenance programme. However, faults reported during maintenance activities will provide a good indication of how individual aircraft are ageing and, when identified as part of a trend, how the fleet is ageing. Evidence gathered during AAAs has shown that maintenance data recording can be below an acceptable standard, equally the analysis of such data can be variably. AAAs also showed that in one particular output based contract the Contractor used maintenance data analysis to identify cost drivers. He was then able to initiate improvements to increase reliability. In this case the data analysis was thorough. A further aid to assessing the condition of individual aircraft is the physical examination carried out as part of the MIL AR process. This examination can reveal age related deterioration not detected during scheduled maintenance activities.

The introduction of the CAMO into the UK's military regulatory framework has the potential to be a valuable tool in identifying the onset of ageing in a fleet. However, care must be taken to ensure that where tasks are sub-contracted, particularly where they remain with the organisation that has traditionally been responsible, an effective oversight regime is in place.

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6. RECOMMENDATIONS

5.1 RECOMMENDATION

There is just one recommendation made in this Paper which is summarized as follows:

Recommendation 1: The table in RA 1140[10] should include a statement covering evidence of ageing in the CAMO's responsibilities for data analysis.

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7. REFERENCES

- [1] <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:315:0001:0165:EN:PDF>
- [2] RA 4941 to RA 4956 – Continuing Airworthiness Management Organisation (CAMO) regulations
- [3] RA5723 – Ageing Aircraft Audit
- [4] Def Stan 05-130 - Part 2: MAOS Military Regulations Part M: Continuing Airworthiness Management Organisation (Obsolete)
- [5] The Nimrod Review: An independent review into the broader issues surrounding the loss of the RAF Nimrod MR2 Aircraft XV230 in Afghanistan in 2006
- [6] RA 4941 to RA 4956 - Continuing Airworthiness Management Organisation (CAMO) Regulation.
- [7] RA 4970 to RA 4974 – Military Airworthiness Review (AR) Regulation
- [8] RA 1016 - Continuing Airworthiness Responsibilities
- [9] RA 4941 - Application - MRP Part M Sub Part G.
- [10] RA 1140 - Military Air System Technical Data Exploitation.
- [11] RA 5720 – Structural Integrity Management.
- [12] RA 4956 - Military Continuing Airworthiness Management Organization (Mil CAMO) Tasks Performed by Other Organizations - MRP Part M Sub Part G
- [13] RA4947 - Military Continuing Airworthiness Management Organization (Mil CAMO) Responsibilities
- [14] Military Airworthiness Review Process, MRP Part M Sub Part I

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13. Abstract (A brief (approximately 150 words) factual summary of the report) This Paper contributes to the dstl "Understanding Ageing Aircraft" research and development programme. It seeks to provide an understanding of the role of the Continuing Airworthiness Management Organisation, how its responsibilities are met. It further examines the relationship between the CAMO and the Type Airworthiness Authorities Project Team and the tasks being carried out that might help identify the early onset of ageing in both individual aircraft and in the fleet.			
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