Recommendations for the future shape of the Ageing Aircraft Structural Audit

Introduction

For UK military aircraft, an aircraft fleet is termed 'ageing', when it has consumed half of the design life in any one of the parameters which are recorded for that type (for example, flying hours, landings, FI, etc.). In practice it has proved difficult to determine the need for the AAA in these terms, and a calendar time-frame has been proposed. However, this does not in any way affect the definition of 'ageing', especially when applied as a trigger for the implementation of structural sampling programmes and the like.

The current Ageing Aircraft Audit process, as laid out in MASAAG Paper 83, was originally proposed in response to the Aloha incident, and fears that there might be undiscovered problems of multiple site damage (MSD) and severe corrosion / disbonding within UK military aircraft fleets. Subsequently, it was shown in a review of the audits that a number of improvements could be made to the audit process to reduce the 'paper trail' produced and to try to ensure that the conclusions and recommendations of the audit were guided towards anticipating and providing for future structural integrity problems. This review also followed changes to Royal Air Force policy on structural integrity management.

The review was discussed at the 47th and 48th MASAAG meetings and proposals for the revision of the AAA process were made. This paper on the Ageing Aircraft Audit (AAA) lays out, in a more formal manner, the proposals for the revised Ageing Aircraft Audit agreed at the 48th MASAAG meeting. These proposals, when endorsed by MASAAG, will be forwarded to STS 1 ASI and ADRP with a recommendation for their adoption into AP100A and JSP318B. Changes agreed at the 50th MASAAG meeting have also been incorporated.

In this paper, the rationale behind particular proposals has been given in italics. It is acknowledged that, in some cases, these proposals will not be appropriate to all types of aircraft, however, the principles should be generally applicable. Thus, where a portion of the audit is not implemented, a reason should be given.

Purpose

The purpose of the Ageing Aircraft Audit is to establish that all of the necessary activities are in place to maintain an aircraft fleet through to its out-of-service date, and further, to establish whether patterns are emerging that point to incipient structural integrity problems. Although many of the activities proposed for the AAA are carried out in the course of structural integrity management, they are often considered in isolation. The Audit is therefore intended to be integrated with other structural integrity activities highlighted by the Structural Integrity (SI) plan, and to build a coherent picture of the state of the aircraft fleet.

The Ageing Aircraft Audit is to be repeated during the life of the aircraft: an additional purpose of the repeat audit, therefore, is to ensure that the necessary activities are in place to plan for life extension.

Where the subject fleet is a derivative of a civil aircraft, if data are available from civil ageing aircraft airworthiness measures, these should be reviewed to determine how far they satisfy these Ageing Aircraft Audit requirements, and to what extent the Services have adopted Service Bulletins, Corrosion Protection and Control Programmes, revised maintenance programmes, supplemental inspection programmes, etc.. Where it is demonstrated that such aircraft are operated in a role essentially similar to the civil role, it is recommended that the civil ageing aircraft measures are adopted. Providing that it can be established that the fleet is compliant with the civil measures, it will be necessary only to address any provisions of the Ageing Aircraft Audit that may not have been covered, including checking that differences in usage do not invalidate

recommended inspection intervals or repair/modification embodiment points. When considering the Ageing Aircraft Audit of a civil derivative aircraft, any modifications should be taken into account and audited, as should the implications of differences in usage and build standard between the baseline civil aircraft and its military derivative.

Frequency

The Ageing Aircraft Audit should be completed no later than 15 years after entry into service. The Audit should be completed at 10 year intervals thereafter; however, an exemption not to repeat the audit could be sought on the grounds that the aircraft would be going out of service within 5 years of the due completion date, provided no life extension were planned.

> *For UK military aircraft, an aircraft fleet is termed 'ageing', when its leader has reached half of the design life in any one of the parameters which are recorded for that type (for example, flying hours, landings, FI, etc.). In practice it has proved difficult to determine the need for the AAA in these terms, and a calendar time-frame has been proposed. The time-frame selected, although somewhat arbitrary, was based on experience: thirty years is approximately the usual design life for a military aircraft, so fifteen years is sufficient time for the aircraft fleet to be mature. Also, while some of the degradation of structure that occurs during the life of an aircraft is related to usage (for example fatigue), other degradation may be more related to elapsed time (for example, some types of corrosion, other types of environmental degradation (such as that caused by UV), etc.). Furthermore, using a calendar time-frame can be used to embrace aircraft designed to any philosophy, whether safe-life or damage tolerant. However, this does not in any way affect the definition of 'ageing', especially when applied as a trigger for the implementation of structural sampling programmes and the like. This is because it is more appropriate to trigger structural sampling of particular areas of the aircraft in terms of the appropriate usage parameter for that area – for example, undercarriages in terms of landings.*
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> *It is also noted that some civil-derivative aircraft in service in the UK may have comparatively low usage in terms of flight cycles, but usage in terms of flying hours or calendar age on a par with their civilian counterparts. Since the depredations of corrosion, climate and so on are often related more closely to calendar age than usage, this adds weight to the argument that, even for these aircraft, a time-determined audit is more appropriate.*
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> *It was proposed (MASAAG Meeting 48) that the AAA should be repeated/updated, because many of the necessary review activities could be used to scope the work needed for any life extension programme.*
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> *If these proposals for a revised AAA are adopted, new aircraft would be audited as suggested. Current aircraft which have not been audited should be done as soon as practical, with the proviso that an exemption may be sought on the basis of out of service date, and no likely life extension need. It is not the intention that the AAA should be repeated immediately for aircraft which have already been audited according to MASAAG 83; however, it is strongly recommended that the new style audit should be completed within 10 years of the original audit, in accordance with the proposed requirements laid out above.*

Management

The need to do the Audit and subsequent repeats should be reflected in the SI plan, with the completion date shown as a milestone; the audit should be planned to begin well in advance of the completion date. The Audit process should be monitored by a Specialist Working Group,

nominated by the SIWG; it should include, as a minimum, representatives from the IPT, the DA, STS 1 ASI, LSS, DERA, DARA (if appropriate) and users, as necessary. The Specialist Working Group should report progress to the SIWG regularly.

Including the AAA in the SI plan allows the IPT to make suitable long-term financial provision for it. The audit must be started well in advance of the due date; probably, two to three years should be allowed.

The SIWG is the appropriate executive body to monitor progress, and implement recommendations.

Assumptions

It has been assumed that the following measures will have been planned for by the IPT:

1. Fleet structural sampling programme;
2. Teardown inspection(s);
3. Fleet fatigue and usage monitoring programmes, including OLM/ODR exercises.

However, it should be confirmed that this is the case. Results from these measures will need to be considered as part of the Audit. It is important to establish whether recommendations arising from these activities have been implemented.

The aim of the AAA is to get an overall picture of the SI status of the fleet.

The Ageing Aircraft Audit

Static strength related issues

1. A review shall be made of the aircraft static clearance and the Static Type Record. The objective is to establish whether incremental mass growth or mass distribution changes had been adequately taken into account.

Fatigue-related issues

2. Review the fatigue clearance of the aircraft. The objective of this part of the review is to establish whether adequate clearance, in terms of service usage, is available to take the aircraft through to its out-of-service date, including the impact on fatigue life of, for example, weight growth and role changes. This review should consider, but not necessarily be confined to, the following activities.

2.1 Review the clearance as a whole in relation to the design life and the equivalent clearance under the actual usage in terms of each relevant clearance parameter (i.e., FI, flying hours, landings, pressurisations, etc.). Check that these clearances are reflected in the fatigue type record and that it is up to date. This review should also include fatigue modification or refurbishment programmes and their impact on fatigue lives, and inspection intervals, as appropriate.

2.2 Review any fatigue tests (past, in progress and planned) and consider requirements for any further testing that may be required to achieve the OSD. This should be done in the light of the review of the fatigue clearances and the results of any OLM/ODR programmes.

Experience has shown that, for many aircraft projects, changes in usage once in service mean that fatigue clearances from the initial fatigue testing may be inadequate. Furthermore, major fatigue tests usually represent a compromise in the loadings which can be represented, and service experience often highlights areas where the initial fatigue clearance is inadequate or unforeseen loading actions.

2.3 Review the results of operational loads measurement/operational data recording (OLM/ODR) programmes. Establish what OLM/ODR exercises have been carried out and review the need to tackle specific areas or to repeat any OLM/ODR programmes following change in usage. Establish how comprehensive the OLM/ODR programmes have been, for example, has undercarriage loading been considered in addition to flight loads. Establish whether recommendations resulting from any OLM/ODR programmes have been followed up and implemented.

2.4 Review the adequacy of monitoring methods and systems. This is to establish whether parameters are being monitored with sufficient accuracy (for example, is manual recording adequate, or should an automated system be considered), when compared with OLM/ODR programme results, or in some cases, to allow clearances to be extended (for example, to differentiate between different types of landing (of differing severity)).

2.5 Confirm that all removable fatigue-critical items have Engineering Record Cards (ERCs) on which their usage will be tracked in terms of relevant clearance parameters.

Experience with past projects has shown that some items do not have ERCs, despite the fact that they are exchanged between aircraft, and should be traced because they have a finite fatigue life.

2.6 Where there are individually lifed components, compare the retirement lives achieved in service with the calculated Safe Lives and review the causes of any notable shortfalls to determine whether there is a need to re-evaluate the Safe Lives. Maintenance records should also be reviewed to highlight any components showing frequent or early signs of distress which may be indicative of unanticipated usage or operating conditions.

2.7 Review that the systems (which should be) in place for the recording of concessions, repairs and modifications are recording data correctly, and that these data can be retrieved. The build standard of the aircraft should also be reviewed. The purpose of this is to establish whether modifications have been embodied in a timely manner and whether all significant fatigue test arisings have been swept up into modification programmes.

Accidental and environmental damage issues

3. Review available data concerned with environmental and accidental damage to establish whether any pattern of accidental damage, corrosion damage, disbonding, or remedial action is emerging. Any degradation, caused for example by maintenance damage, plus normal wear and tear, should be included. This list should not be considered definitive, and consideration should be given to any other factors that could compromise structural integrity. This review should consider, but not necessarily be confined to, the following activities.

3.1 Review of the Structurally Significant Item (SSI) list. Check that SSIs have been identified correctly. Review SSI inspection results, including ‘no fault found’, where possible. Consider whether inspection frequencies are adequate, in the light of usage experience/change.

3.2 Review of all mods/STIs/SIs/schedule amendments deemed to affect structural integrity. The purpose of this review would be to ensure that inspections or remedial actions were not being repeated needlessly, but were either being addressed by modification programmes or had been incorporated into the scheduled inspection/maintenance programmes.

3.3 Review repairs, especially those concerned with environmental and accidental damage, to establish whether there are adjacent repair problems that may affect structural integrity. Include in this review a consideration of the qualification basis of repairs to establish the validity of the safe life or inspection interval in the light of (any changes in) usage.

Results

The findings of the Audit should be reported: specific conclusions and recommendations should be drawn, where appropriate, giving indications of incipient SI problems, and recommending a strategy for future SI activities, for example, targeted teardown inspections or structural sampling programmes, further fatigue tests or specific OLM/ODR programmes.

> *One of the major shortcomings in the first round of audits was a lack, in the majority of audit reports, of conclusions and recommendations. Furthermore, in the two audit reports that did provide conclusions and recommendations, these were confined to structural problems that had already been identified.*

The results, conclusions and recommendations of the Audit should be discussed at an extraordinary meeting of the Structural Integrity Working Group. Where appropriate, the recommendations should be implemented and reflected in amendments to the SI plan.