MASAAG Paper 106

REPAIR ASSESSMENT PROGRAMME FOR MILITARY TRANSPORT AIRCRAFT

1 GENERAL

1.1 PURPOSE

This MASAAG Paper 106 presents recommendations for the assessment of the long-term airworthiness characteristics of repaired aircraft structures. This forms part of the Ageing Aircraft Structural Audit (AASA, see MASAAG Paper 104). The basis of the recommendations is described in terms of the equivalent civil requirements pertaining to large transport aircraft* that have evolved since the Aloha Boeing 737 accident in 1988. The relevance of those requirements to the UK MOD fixed-wing transport aircraft fleets is considered and an outline strategy for the satisfaction of the recommendations is provided. The applicability of the recommendations to combat aircraft types will be the subject of future MASAAG considerations.

To a large extent this Paper is based on the relevant civil regulatory documentation and supporting material which provides a repair assessment framework for aircraft designed to the corresponding civil regulations. The damage tolerance design philosophy is mandated in the civil requirements but, in this Paper, allowance has been made for the application of other design philosophies, where appropriate.

It is intended that this Paper should form the basis of future policy involving the Integrated Project Teams (IPTs) of UK MOD and the Design Authorities (DAs) for the various fixed-wing transport aircraft fleets affected by the recommendations.

2 BACKGROUND

2.1 HISTORY

The investigation into the Aloha accident highlighted a number of concerns relating to the maintenance of structural integrity in ageing commercial transport aircraft. As a direct result of that investigation, the Airworthiness Assurance Working Group (AAWG, formerly Aging Aircraft Task Force (AATF)) was set up under the auspices of the Federal Aviation Administration (FAA) in the US. Notwithstanding the lead taken by the FAA, the AAWG is international in nature, with representation from regulatory authorities, manufacturers and operators from both sides of the Atlantic.

The initial focus of the AAWG activity concerned 11 specific large commercial jet transport aircraft types in widespread use; this has since been extended to cover all ageing transport aircraft. The result of that activity was the identification of FIVE key issues where action would be required to ensure the maintenance of acceptable degrees of structural integrity. These issues are summarised as:

1. Supplemental Structural Inspection Programme
2. Corrosion Prevention & Control Programme
3. Ageing Aircraft Modification Programme
4. Repair Assessment Programme
5. Evaluation for Widespread Fatigue Damage

* For the purposes of this paper a “transport aircraft” is defined as one capable of carrying personnel other than the flight deck crew.

Details of these elements of the overall ageing aircraft programme can be found in a JAA leaflet issued in 2001, Reference 1. However, the subject of this MASAAG Paper 106 is limited to that of item no. 4, i.e. the repair assessment programme (RAP).

2.2 CIVIL AIRWORTHINESS REQUIREMENTS

Service experience has shown that there is a need for continuing scrutiny of the structural integrity of all aircraft types, especially as they become older. Consequently, the recommendations from the AAWG are to be adopted into the mandatory civil airworthiness codes of both the US and European authorities. For the UK this objective has been achieved by the re-issue of the CAA Airworthiness Notice No. 89, Reference 2. This both re-states the objectives of the AAWG recommendations and provides guidance for the practical implementation of the various inspection and assessment programmes. The RAP is summarised as the requirement to "assess the adequacy of structural repairs and their influence on inspection intervals" and the applicability of the requirements is defined as "all ageing transport aeroplanes used for commercial operation and certificated to JAA, USA or UK requirements at a MTWA (maximum take-off weight ??) exceeding 2730kg ... Ageing aeroplanes are considered to be those that have exceeded half their published design life goal or 15 years since manufacture ..." This definition clearly encompasses a large number and variety of aircraft types as the weight limitation ensures that any older type used in commercial transport activities is likely to be covered.

2.3 APPLICABILITY OF CIVIL REQUIREMENTS TO UK MOD AIRCRAFT FLEETS

The envisaged content of the RAP is described in detail in Appendix 3 to the JAA Notice of Proposed Amendment (NPA) 20-10, Reference 3. That document is written in terms of the civil certification criteria applicable to transport category aircraft and presupposes the established relationships between the aircraft manufacturers, operators, maintenance organisations and regulatory authorities. Those criteria and relationships are likely to be different, either subtly or maybe substantially so, for the UK MOD aircraft fleets. For this reason the applicability of the civil requirements to military aircraft was the subject of an extraordinary meeting of MASAAG in November 2003. That meeting involved participants from Design Authorities, the DLO Structures Support Group, ADRP, the CAA and QinetiQ. The consensus from the meeting was that the concerns with respect to repairs highlighted by the AAWG are equally applicable to certain military aircraft. Furthermore, whilst there are several aircraft types in use with UK MOD that are variants or derivatives of civil types that would naturally fall within the scope of the CAA Airworthiness Notice, it was concluded that the requirements for the RAP should not necessarily be limited to these types in military service.

MASAAG considers that the fleets currently affected are as listed at Annex A; further fleets will be included, once they become ageing. For UK MOD purposes, "ageing" is defined as 15 years after manufacture. Further discussions would be required regarding the interpretation of the requirements with respect to combat aircraft.

It was also agreed that the strategies for addressing these requirements with respect to military aircraft would require some considerable refinement to be effective in the context of the UK MOD airworthiness framework. It is the purpose of this MASAAG Paper 106 to consider the objectives of the civil RAP in relation to that framework and provide the basis of further debate involving, in particular, the various IPTs concerned with the support of ageing aircraft fleets in UK military service.

3 ELEMENTS OF REPAIR ASSESSMENT

3.1 INTRODUCTION

As described in the previous Chapter, and in accordance with the expectation that UK MOD "regulatory arrangements should be at least as effective as those in respect of civil aircraft" (JSP 553), MASAAG recommends the adoption of a RAP similar to that required by civilian airworthiness authorities. Under civil airworthiness regulations, the manufacturers are required to consider 3 principal aspects of repairs, namely:

Provision of guidelines to enable operators to assess existing structural repairs;

Updating of the Structural Repair Manual (SRM) to include damage tolerance considerations;

Review of repairs identified in Service Bulletins (SBs) to determine any requirements for supplemental inspections.

The intent is that all repairs to critical structure will be evaluated for fatigue performance by modern damage tolerance methods and criteria, and that the resulting inspections, modifications and corrective actions (if any) be accomplished in accordance with type-specific repair assessment guidelines.

The civil authorities have generally accepted that the fuselage pressure cabin is frequently repaired and is likely to be the most vulnerable to repairs which might limit the fatigue life of the aircraft. Therefore, the civil RAP requirement has been limited to the pressure boundary for the moment. MASAAG agrees that this approach is applicable to the affected military fleets. However, it is expected that the civil requirement will be extended to cover other areas and the military requirement should be extended in a consistent way.

3.2 CONCERNS POSED BY OLDER REPAIRS

Repairs are a concern on older aeroplanes because of the possibility that they may develop, cause, or obscure metal fatigue, corrosion, or other damage during service. This damage might occur within the repair itself or in the adjacent structure and might ultimately lead to structural failure. In general, repairs present a more challenging problem to solve than the original structure because they are tailored in design to correct particular damage to the original structure. Such damage is likely to vary from airframe to airframe with consequent differences in the repairs themselves. The performance of the original structure may be predicted from tests and from experience on other aeroplanes in service, but the behaviour of a repair and its effect on the fatigue characteristics of the original structure are generally known to a lesser extent.

Repairs may be of concern as time in service increases for the following reasons:

a. As aeroplanes age, both the number and age of the existing repairs increase with a corresponding increase in the possibility of unforeseen repair interaction, failure, or other damage occurring in the repaired area. The continued operational safety of these aeroplanes depends primarily on a satisfactory maintenance programme (inspections conducted at the right time, in the right place, using the most appropriate technique). To develop this programme, a fatigue evaluation of repairs to aircraft structure is essential. The longer an aeroplane is in service, the more important this evaluation and subsequent inspection programme becomes.

b. In accordance with design requirements in force at the time, the fatigue implications of a structural repair may not have been routinely assessed. The fatigue performance of repaired structures may therefore vary widely and could be largely unknown.

c. In the case of civil-derivative aircraft operating in the military environment, even if a repair fatigue life assessment has been done, changes in usage between the civil and military environment may mean that the life of repaired structures is not as originally determined.

In view of these concerns, it is necessary to perform an assessment of repairs to establish their fatigue life characteristics. The civil RAP mandates the use of damage tolerance criteria. However, MASAAG has agreed that, for military aircraft, alternative methods may also be considered in the context of the existing qualification basis for the basic airframe structure.

4 REPAIR ASSESSMENT PROGRAMME

4.1 CRITERIA TO ASSIST IN DEVELOPING THE REPAIR ASSESSMENT GUIDELINES

The first requirement of the RAP is to provide guidelines that will enable existing repairs to be assessed in a consistent and methodical manner. The assessment criteria may differ between different aircraft types depending on such considerations as the original design philosophy and construction methods. However, in generic terms, the following criteria have been initially identified to assist in the development of the guidance material:

Repairs that are not in accordance with authorised standards (*e.g. SRM or repair drawings provided by the DA*) must be reviewed and may require further action;

Repairs installed in accordance with authorised standards but where no specific fatigue qualification exists must be reviewed and may require further action;

Repairs in close proximity to other repairs or modifications require review to determine any detrimental effects due to interaction;

Repairs that exhibit structural distress should be replaced before further flight;

These criteria were derived from the civil requirement and are by no means exhaustive; they are likely to evolve as the RAP for any specific aircraft type develops.

4.2 REPAIR ASSESSMENT METHODOLOGY

The next step in the RAP is to develop a repair assessment methodology that is effective in evaluating the continued airworthiness of repaired structure. Older aircraft may have many structural repairs, so the efficiency of the assessment procedure is an important consideration. In the past the fatigue/damage tolerance evaluation of repairs would, by necessity, have been undertaken by, or under the auspices of, the aircraft DA. Considering the number of variables that characterise typical repairs, a comprehensive RAP conducted in that way is likely to be unmanageable. Therefore, an alternative approach derived from that envisaged by the civil authorities can be considered, as follows:

a. Since repair assessment results will depend on the type-specific structure and loading environment, the DA should create an assessment methodology for the various types of repairs expected to be found on the affected aircraft. The technical records on many of these repairs may not be readily available so determining the locations of the repairs will necessitate a survey of each aircraft at an appropriate maintenance opportunity. A standard form of survey documentation would be used to record the key repair design parameters that will then enable the appropriate analysis of the repairs to be completed by the DA according to the previously established assessment criteria.

b. The DA may be able to develop simplified methods for using the information from the survey records as input data to a standardised process for determining the fatigue and/or damage tolerance characteristics of the surveyed repairs. These repair assessments would then be performed by well-trained personnel familiar with the type-specific repair assessment guidelines.

c. From the information on the survey form, it is also possible to classify repairs into one of three categories for the purposes of both recording the result of the assessment and the action to be taken to maintain the structural airworthiness of the repaired structure in the future:

Category A: A permanent repair for which the existing structural inspection programmes are sufficient to ensure continued airworthiness.

Category B: A permanent repair that requires supplemental inspections to ensure continued airworthiness.

Category C: A temporary repair that will need to be reworked or replaced prior to an established time limit. Supplemental inspections may be necessary to ensure continued airworthiness prior to this limit.

The processes underpinning the assessment of the survey results will obviously vary between aircraft types. In each case, it will be the responsibility of the IPT to ensure that the DA develops the analytical techniques; the degree to which these may be standardised will depend on many considerations. For instance, for a large fleet, the assessment could be incorporated into the routine maintenance programme using the approach outlined in b), above. For small fleets, this may not be cost-effective and the route suggested at a), above, might be more appropriate.

An outline flow chart of the process for applying the repair assessment methodology is provided in Annex B to this Paper. The chart is intended as a generic guide only, but it illustrates a pragmatic interpretation of the RAP objectives as recommended by MASAAG.

4.3 STRUCTURAL REPAIR MANUAL

Repairs embodied according to the standards defined in the SRM (or Topic 6 of the Air Publications) are unlikely to be recorded other than on the job cards that control the work being done on the aircraft. The knowledge of the DA of such repairs is consequently limited and incomplete. This is a particular reason for the necessity to survey each aircraft for the purposes of the RAP as it will not be possible to otherwise ascertain the status of the structure in question with respect to SRM repairs.

The civil requirements for the RAP dictate that the SRM should be reviewed to include damage tolerance considerations. However, MASAAG believe that this is likely to be a prohibitively complex task given the number of standard repairs and the scope for variation in both detail and location on any aircraft. For UK MOD aircraft it is suggested that, in the first instance, all SRM repairs should be made notifiable to both the IPT and the DA for the particular aircraft. This would establish that only the repairs actually being applied to aircraft will be subject to assessment according to the RAP guidelines; the IPT should ensure that comprehensive records of repairs will be collated for future reference.

Ultimately, for older aircraft, the application of SRM repairs may need to be referred to the DA before embodiment as the effects of cumulative repairs for fatigue, corrosion and environmental damage may invalidate the original assessment criteria. The necessary understanding of the condition of the primary structure of any aircraft will be engendered by the collation of the results from the initial survey and the subsequent reporting of *all* repairs to the DA.

4.4 TECHNICAL INSTRUCTIONS

In the context of civil transport category aircraft, service bulletins (SBs) provide a mechanism for affecting changes to an aircraft. Such changes may include the embodiment of standard repairs where service experience has identified such a need. However, in the military environment there is a variety of technical instructions that may introduce repairs.

As such, the subject documents may not contain instructions for future structural inspections taking into account the presence and effect of the repairs. It is, however, equally important to include the assessment of these repairs in the scope of the RAP. A complete review of all relevant instructions by the DA is likely to be necessary to identify all the repairs that should be assessed according to the repair assessment guidelines for each aircraft type.

5 SUMMARY

5.1 Events concerning civil transport category aircraft have resulted in the evolution of a number of initiatives designed to underwrite the long-term structural integrity of ageing airframe structures. Of these initiatives, the requirements of a repair assessment programme (RAP) and their applicability to military transport aircraft operated by the UK MOD are considered in this paper.

5.2 The consensus from an extraordinary MASAAG meeting convened to discuss the requirements for a RAP was that the civil concerns are equally applicable to all types of military aircraft. However, the strategies for addressing these concerns would require some considerable refinement in order to be effective in the context of the UK MOD airworthiness framework.

5.3 The elements of the process for assessing the fatigue and/or damage tolerance characteristics of repaired structures are outlined and initial guidance on the likely scope and content of the RAP are discussed. In particular, the elements of the civil strategy which are likely to be overly restrictive or inappropriate for application to UK MOD fleets are considered with alternatives proposed.

5.4 MASAAG recommends the implemetation of a RAP for affected tranport aircraft fleets operated by the UK MOD.

5.5 The benefit to be gained by the adoption of this policy will be an improvement in the assurance of flight safety through a greater knowledge of the integrity of repairs to each aircraft.

6 REFERENCES

1. Leaflet No. 11 - Continued Airworthiness of Ageing Aircraft Structures, JAR.AGM.S1.P3.LF11, 1 March 2001
2. Continuing Structural Integrity of Transport Aeroplanes, CAA Airworthiness Notice No. 89 Issue 4, 22 March 2002
3. Continued Airworthiness of Ageing Aircraft Structures, JAA NPA 20-10 Draft 3, 25 October 2002

7 BIBLIOGRAPHY

A. Some Authority Views on Ageing Aircraft, D.O.N. James, CAA, London, UK (Paper presented to the Royal Aeronautical Society, London, April 1990)

B. MASAAG - Ageing Aircraft, R.G.M. Martin, CAA (Paper presented to extraordinary meeting of MASAAG, Farnborough, November 2003)

C. VC10 - A Survey of Fuselage Repairs, M.J. Duffield, QinetiQ (Paper presented to extraordinary meeting of MASAAG, Farnborough, November 2003)

D. Military Airworthiness Regulations, Joint Services Publication (JSP) 553

ANNEX A AIRCRAFT AFFECTED BY MASAAG 106

Aircraft affected at 2004

VC10 - all Marks
TriStar - all Marks
BAe 146
BAe 125/Dominie
C-130 K - all Marks
Jetstream
Nimrod - all Marks
Andover (QinetiQ)
BAe 748
BAC 1-11

Aircraft to be reviewed in the future

E3D
C-17
Sentinel
C-130 J - all Marks

ANNEX B REPAIR ASSESSMENT OUTLINE METHODOLOGY