SOFEMA
AVIATION SERVICES

ICAO Structural Integrity Expectations I.A.W. ICAO Doc 9760 Airworthiness Manual

Steve Bentley FRAeS, CEO of Sofema Aviation Services (SAS) www.sassofia.com Considers the obligation of the State & Operator to demonstrate compliance with Aircraft Structural Integrity Obligations

- How to Check Operator Compliance with Aircraft Structural Obligations
- What is the difference between Design Service Goal (DSG) & Limit of Validity (LOV)

Introduction – Compliance with Structural Integrity Program

- ICAO Annex 6 requires the maintenance programme to contain, when applicable, a continuing structural integrity programme.
- Annex 8, provides that the State of Design of an aircraft ensures that, in respect of aeroplanes over 5 700 kg MTOM, a continuing structural integrity programme exists to ensure the airworthiness of the aeroplane.
- The programme should include specific information concerning corrosion prevention and control.

Service experience has indicated a need for knowledge concerning the structural integrity of aircraft, especially as they age.!

- Structural integrity is a concern to manufacturers and operators as fatigue cracking and corrosion are cycle and calendar time dependent, respectively, and knowledge about them can best be assessed:
    - On the basis of real-time service experience.
    - Increased operational demand,
    - longer service life and
    - strict safety standards

Indicated the need for a programme to ensure a high level of structural integrity. Structural integrity programme (SIP) development should be initiated by the type design organization and developed jointly with representatives of air operators and airworthiness authorities and approved by the State of Design of the aircraft.

Note - If the State of the Operator is not the State of Registry, it is recommended to contact the State of Registry to determine if an SIP is applicable for the aircraft it operates.

Contact with the manufacturer of the aircraft is also recommended to obtain information and advice on structural integrity programmes for the aircraft being operated.

An SIP should include:

- Approved damage-tolerance-based inspections and procedures for the aircraft structure susceptible to fatigue cracking that could contribute to a catastrophic failure.

- The purpose of the inspection programme is to supplement the current inspection programme as necessary to ensure the safe operation of the aircraft type;

Note that aircraft certified using MSG 3 processes have the SIP integrated into the Maintenance Review Board Report (MRBR) rather than a standalone "Supplemental Inspection Program" (SIP)

- **A corrosion prevention control programme** with the objective of controlling corrosion in the aircraft's primary structure.
    - The corrosion prevention control programme should include periodic inspections to detect and define levels of corrosion.
    - Treatment of the corrosion is critical and limits the material loss and assists in maintaining the airworthiness of the aircraft;
    - Maintenance programme procedures which address the adverse effects of fatigue cracking on critical structure and may include repetitive inspections of these areas to ensure structural integrity.
    - The programme may also include modifications or replacement actions in areas where there is a known history or hazard of fatigue cracking.
    - The modifications or replacement action may reduce or eliminate the need for repetitive inspections to maintain structural integrity.
    - The type design organization may have issued SBs that contain terminating modifications to inspections and contact with the design organization is recommended;

- **A repair assessment programme to evaluate aircraft repairs.**
    - The programme ensures that existing repairs do not deteriorate due to accidental, fatigue or environmental damage beyond the remaining usage life of the aircraft.
    - In order to establish the scope of the repair assessment programme contact with the type design organization of the aircraft may be necessary to determine if the aircraft was evaluated for damage tolerance during initial certification;

- **Provisions for preventing widespread fatigue damage (WFD). Multiple site damage and multiple element**
    - Cracks are typically too small initially to be reliably detected with normal inspection methods.
    - Without intervention, these cracks can grow, link up and eventually compromise the structural integrity of the aeroplane, in a condition known as WFD.
    - WFD is increasingly likely as the aeroplane ages, and is certain if the aeroplane is operated long enough without any intervention.

The role of the State of Registry in the implementation of the SIP:

- Develop or adopt requirements to ensure the continuing airworthiness of the aircraft during its service life;
- Upon receipt of "Mandatory Continuing Airworthiness Information" (MCAI) from the State of Design, adopt the mandatory information directly or assess the information received and take appropriate action; and

- Approve the structural integrity provisions contained in the maintenance programme.

The SIP developed and updated by the organization responsible for the type design under the responsibility of the State of Design is one important element of continuing airworthiness, and it will include many specific items that are intended to be made mandatory.

The programme should include:

- Damage tolerance based supplemental inspections
- corrosion prevention and control, structural modifications and associated inspections,
- Repair assessment, and WFD assessment as described above.

The State of Registry, in approving a maintenance programme, should therefore:

- Review and assess the latest SIP and all related continuing airworthiness information and, if appropriate, adopt the requirements in national regulations.
- All requirements made mandatory by the State of Design should also be assessed and made mandatory for all applicable aircraft on the State's Registry unless local operating conditions or operator experience provide a strong basis for deviation;
- Ensure that all the requirements of the SIP have been incorporated in the operator's maintenance programme before it is approved.
- Each operator should make an individual determination as to how the data that are in the continuing structural integrity programme should be incorporated in the maintenance programme owing to the differences in the various operators' maintenance programmes, operating environment and fleet modification status;
- Ensure that the air operator's maintenance programme procedures provide an adequate system for recording and reporting in a timely way to the type design organization (and to the State of Registry),
    - The operational usage,
    - The structural discrepancies experienced in service (including fatigue, wear, corrosion, accidental damage) and, where available, the results of initial analysis.
        - These data should include a description and the location of the damage, identification of the aircraft, relevant data on its modification status and operating history, time since beginning operations, time since the last maintenance check, the means by which the discrepancy was detected and its probable cause.
        - The operator's existing record-keeping requirements still apply, e.g., aircraft inspection status, and reports of major repairs and modifications, if applicable.

- A separate report to the State of Registry may be necessary should structural discrepancies that exceed repairable limits established by the type design organization be noted;
- Ensure that the air operator's MCM contains procedures for review of all recommended or mandatory changes to the SIP and will result in timely revision of the maintenance programme to include these changes;

- Ensure that the items in the SIP are accomplished on each aircraft for which it has issued a Certificate of Airworthiness within the time limits specified;
- Ensure that for each aircraft for which it has issued a Certificate of Airworthiness, the operator has good access to the records of all damage and repairs and modifications performed during the lifetime of the aircraft and has incorporated into the maintenance programme any specific structural inspections or life limits issued when the repair or modification was approved or when the damage was assessed; and

Concerning Limit of Validity (LOV)

- *The limit of validity (LOV) represents an operational limit based on fatigue test evidence that supports the maintenance program. The FAA defines the LOV as "the period of time (in flight cycles, flight hours, or both) up to which it has been demonstrated by test evidence, analysis and, if available, service experience and teardown inspections, that widespread fatigue damage will not occur in the airplane structure." It is further defined as the point in the structural life of an airplane at which there is significantly increased risk of uncertainties in structural performance and probable development of WFD*

LOV Establishment

- *The establishment of the LOV is based on the fatigue test evidence held by the manufacturer. Sources of this information include:*
- *Full-scale fatigue test.*
- *Full-scale component tests.*
- *Teardown and refurbishment of a high-time airplane.*
- *Less than full-scale component tests.*
- *Statistical fleet-proven life techniques.*
- *Evaluation of in-service problems/test data experienced by this model or other airplanes with similar design concepts.*
- *Analysis methods that have been parametrically developed to reflect fatigue test and service experience*

LOV – Operators Responsibility

- *Incorporate mandatory service actions into their maintenance programs.*
- *Adopt the LOV values provided by the manufacturer*

Iif the structural integrity programme issued by the organization responsible for the type design has a limit of validity (LoV) specified for the maintenance programme, the State of Registry needs to ensure that there is a system in the maintenance programme to identify when this validity limit is approaching and to stop flying if the limit is reached.

The Certificate of Airworthiness is not valid beyond this LoV unless SIPs have been reviewed and the results justify an extension of the maintenance programme.

Approval of Aircraft Maintenance Programmes

- As part of the maintenance programme approval process the operator should submit a reliability programme description that supports the effectiveness of the maintenance programme.
- The programme should be administered and controlled by the operators and monitored by the Airworthiness Inspection Division (AID) inspector.
    - The document should contain the essentials of the systems operation and any other instructions required of the particular programme or character of the maintenance organization involved.
- The operator should submit the reliability programme and appropriate information to the CAA for evaluation and approval.
- The AID inspector should use all the information necessary in evaluating the reliability programme. (Operator personnel should be available to answer questions or provide additional information concerning the reliability programme.)
    - The procedures for implementing revisions to the programme should be described in sufficient detail to identify the isolated areas which require CAA approval.
    - The operator should also identify the segment of the organization having overall responsibility for the approval of amendments to the programme.
    - The areas involving reliability programme revision which require CAA approvals may include:
        - Reliability measurement;
        - Changes involving performance standards, including instructions relating to the development of these standards;
        - Data collection;
        - Data analysis methods and application to the total maintenance programme;
        - Process or task changes:
        - For statistical alert type programmes, procedures for transferring components or systems from one primary maintenance process to another; and
        - for non-alert type programmes, changing systems or components from one primary maintenance process to another;
        - Procedures for adding or deleting systems, or components;
        - Adding or deleting aircraft types;
        - Procedural and organization changes affecting administration of the programme; and
        - Procedures for transferring systems or components to other programmes.

When evaluating programme revision procedures, consideration should also be given to the following:

- Does the programme provide for periodic review to determine if the established performance standard is still realistic or in need of recalculation?
- What is the distribution circulation given to approved revisions?; and

- Are the overhaul and inspection periods, work content and rescheduled maintenance activities controlled by reliability methods reflected in the appropriate maintenance manuals?

Note - Reliability programme evaluation and approval is one of the most complex duties an AID inspector will perform.

- Special attention should be given to every aspect of the proposed programme submitted by the operator.
- Previous experience with the type of equipment the operator proposes to include in the reliability programme is recommended.
- In States where adequate technical resources are not available the CAA may consider obtaining technical assistance from regional CAAs possessing experience in these areas, or the CAA of the State of Manufacture or State of Design.

Widespread Fatigue Damage

The likelihood of the occurrence of fatigue damage in an aeroplanes structure increase with aeroplane usage.

The design process generally establishes a design service goal (DSG) in terms of flight cycles or hours for the airframe. It is expected that any cracking that occurs on an aeroplane operated up to the DSG will occur in isolation (i.e. local cracking), originating from a single source, such as a random manufacturing flaw (e.g. a mis-drilled fastener hole) or a localized design detail.

Concerning Design Service Goal (DSG)

Does Design Service Goal Limit the Operation of an Aircraft?

The original DSG is generally established at the time of type certification and is NOT intended to limit the life of the structure, or to define the point at which the aircraft cannot continue its operation.
Example - Airbus has developed new, extended service goals (ESG) To justify a further period of operation up to the new ESG, it is necessary to review service experience and re-assess the existing inspection programmes.

This may lead to a modification of the maintenance strategy, including the inspection of additional items or an increased level of surveillance in some areas.

The following activities are typical of the process associated with the Full Life Extension.
- *Fatigue and damage tolerance analysis of the original structure and modifications including:*
- *Detailed identification of the concerned area*
- *Review of Full Scale Fatigue Test and in-service experiences*
- *Loads comparison for all variants*
- *Review of former fatigue justifications*
- *Review of Service Bulletins and current inspection programme*

- *Widespread Fatigue Damage Analysis*
- *Update of all inspection programmes incl. MRB, SSIP and the definition of new programmes*

Source of Structural Inspection Requirements (both processes are intended to find this form of damage before it becomes critical.)

- The supplementary structural inspection programme (SSIP) (described above)
- Maintenance review board (MRB)-derived inspections for damage

Note concerning assessment for WFD

- If the aircraft is not operated beyond the initial limit of validity of the maintenance programme, it may not be required to perform a widespread fatigue damage (WFD) assessment.
- With extended usage, a uniformly loaded structure may develop cracks in adjacent fastener holes or in adjacent similar structural details. These cracks, while they may or may not interact, can have an adverse effect on the structural capability before the cracks become detectable.
- The development of cracks at multiple locations may also result in strong interactions that can affect subsequent crack growth, in which case the predictions for local cracking would no longer apply. (An example of this situation may occur at any skin joint where load transfer occurs. Simultaneous cracking at many fasteners along a common rivet line may reduce the residual strength of the joint below required levels before the cracks are detectable under the routine maintenance programme established at the time of certification.)
- The type design organization, in conjunction with the operator, and in some cases the operator itself, is expected to initiate development of a maintenance programme with the intent of predicting the onset of WFD and establishing an appropriate limit of validity (LoV) of the maintenance programme for the operation without multiple site damage or multiple element damage.
- Such programmes should be implemented before analysis, tests, and/or service experience indicates that widespread fatigue damage may develop in the fleet and substantially before LoV is reached on any aeroplane in service.

Note This may be based on typical construction and may require a different methodology for composite structure.

Limit of validity of maintenance programmes

- Associated with these programmes is the need to identify a LoV of the maintenance programme that contains them.
- Operators may not operate aeroplanes beyond this LoV unless the structural integrity programmes have been reviewed and been found valid for an extension of the maintenance programme. A new LoV will then be defined.

Performing an Assessment of Operator Compliance – Desk Top Exercise - For The Operators Continuing Airworthiness Manager to Review and answer the following questions

Aircraft Maintenance Program

Does the Aircraft Maintenance Programme (AMP) reflect all airworthiness limitations and associated instructions (standard or alternative) issued by the relevant design approval holders and is approved by the competent authority, if applicable.

Provide update & status regarding ALI compliance in respect of the following:

- Safe Life ALI (SL ALI)/Life-limited parts,
- Damage Tolerant ALI (DT ALI)/Structure, including ageing aircraft structure,
- Certification Maintenance Requirements (CMR),
- Ageing Systems Maintenance (ASM), including Airworthiness Limitations for Electrical Wiring Interconnection System (EWIS),
- Fuel Tank Ignition Prevention (FTIP)/Flammability Reduction Means (FRM),
- CDCCL, check wiring if any maintenance carried out in same area - wiring separation,
- Ageing fleet inspections mandated through ALS or AD are included in the AMP.

Corrosion Prevention Control Programme (CPCP)

Provide evidence of the following:

- Maintenance programme procedures which address the adverse effects of fatigue cracking on critical structure and may include repetitive inspections of these areas to ensure structural integrity.

Limit of Validity - LOV

Provide Evidence of the following:

- Incorporate mandatory service actions into their maintenance programs.
- Adoption of the LOV values provided by the manufacturer

Next Steps

Sofema Aviation Services www.sassofia.com & Sofema Online www.sofemaonline.com provide classroom, webinar & online training offering over 650 EASA & other Regulatory Compliant & Vocational short courses – please see the websites or email team@sassofia.com