AMC 20-1
Certification of Aircraft Propulsion Systems Equipped with Electronic Control Systems

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1 GENERAL

The existing specifications for Engine, Propeller and Aircraft certification may require special interpretation for Engines and Propellers equipped with electronic control systems. Because of the nature of this technology and because of the greater interdependence of Engine, Propeller and Aircraft systems, it has been found necessary to prepare acceptable means of compliance specifically addressing the certification of these control systems.

This AMC 20-1 addresses the compliance tasks relating to certification of the installation of propulsion systems equipped with electronic control systems. AMC 20-3 is dedicated to certification of Engine Control Systems but identifies some Engine installation related issues that should be read in conjunction with this AMC 20-1. Like any acceptable means of compliance, it is issued to outline issues to be considered during demonstration of compliance with the certification specifications.

2 RELEVANT SPECIFICATIONS

For Aircraft certification, the main related certification specifications are:

- For Aeroplanes: CS-25 (and, where applicable, CS-23)

  Paragraphs: 33, 581, 631, 899, 901, 903, 905, 933, 937, 939, 961, 994, 995, 1103(d), 1143 (except (d)), 1149, 1153, 1155, 1163, 1181, 1183, 1189, 1301, 1305, 1307(c), 1309, 1337, 1351(b)(d), 1353(a)(b), 1355(c), 1357, 1431, 1461, 1521(a), 1527.

- For Rotorcraft: equivalent specifications in CS-27 and CS-29.

3 SCOPE

This acceptable means of compliance is relevant to certification specifications for Aircraft installation of Engines or Propellers with electronic control systems, whether using electrical or electronic (analogue or digital) technology.

It gives guidance on the precautions to be taken for the use of electrical and electronic technology for Engine and Propeller control, protection and monitoring, and, where applicable, for integration of functions specific to the Aircraft. Precautions have to be adapted to the criticality of the functions. These precautions may be affected by: the degree of authority of the system; the phase of flight; and the availability of a Back-up System.

This document also discusses the division of compliance tasks between the applicants for Engine, Propeller (when applicable) and Aircraft certifications. This guidance relates to issues to be considered during Aircraft certification.

It does not cover APU control systems. APUs which are not used as "propulsion systems", are addressed in the dedicated AMC 20-2.

4 PRECAUTIONS

a) General

The introduction of electrical and electronic technology can entail the following:

- a greater dependence of the Engine or Propeller on the Aircraft owing to the use of electrical power and or data supplied from the Aircraft.
- an increased integration of control and related indication functions,
- an increased risk of significant Failures common to more than one Engine or Propeller of the Aircraft which might, for example, occur as a result of:
  - Insufficient protection from electromagnetic disturbance (lightning, internal or external radiation effects),
  - Insufficient integrity of the Aircraft electrical power supply,
  - Insufficient integrity of data supplied from the Aircraft,
  - Hidden design Faults or discrepancies contained within the design of the propulsion system control software or complex electronic hardware, or
  - Omissions or errors in the system/software specification.

Special design and integration precautions should therefore be taken to minimise these risks.

b) Objective

The introduction of electronic control systems should provide for the Aircraft at least the equivalent safety, and the related reliability level, as achieved in Aircraft equipped with Engine and Propellers using hydromechanical control and protection systems.

When possible, early co-ordination between the Engine, Propeller and Aircraft applicants is recommended in association with the Agency, as discussed under paragraph (5) of this AMC.

c) Precautions relating to electrical power supply and data from the Aircraft

When considering the objectives of paragraph 4 (a) or (b), due consideration should be given to the reliability of electrical power and data supplied to the electronic control systems and peripheral components. The potential adverse effects on Engine and Propeller operation of any loss of electrical power supply from the Aircraft or failure of data coming from the Aircraft are assessed during the Engine and Propeller certification.

During Aircraft certification, the assumptions made as part of the Engine and Propeller certification on reliability of Aircraft power and data should be checked for consistency with the actual Aircraft design.

Aircraft should be protected from unacceptable effects of Faults due to a single cause, simultaneously affecting more than one Engine or Propeller. In particular, the following cases should be considered:

- Erroneous data received from the Aircraft by the Engine/Propeller control system if the data source is common to more than one Engine/Propeller (e.g. air data sources, autothrottle synchronising), and
- Control system operating Faults propagating via data links between Engine/Propellers (e.g. maintenance recording, common bus, cross-talk, autofeathering, automatic reserve power system).

Any precautions needed may be taken either through the Aircraft system architecture or by logic internal to the electronic control system.

d) Local events

For Engine and Propeller certification, effects of local events should be assessed.

Whatever the local event, the behaviour of the electronic control system should not cause a hazard to the Aircraft. This will require consideration of effects such as the control of the thrust reverser deployment, the overspeed of the Engine, transient effects or inadvertent Propeller pitch change under any flight condition.

When the demonstration that there is no hazard to the Aircraft is based on the assumption that there exists another function to afford the necessary protection, it should be shown that this function is not rendered inoperative by the same local event (including destruction of wires, ducts, power supplies).

Such assessment should be reviewed during Aircraft certification.

e) Software and Programmable Logic Devices

The acceptability of levels and methods used for development and verification of software and Programmable Logic Devices which are part of the Engine and Propeller type designs should have been agreed between the Aircraft, Engine and Propeller designers prior to certification activity.

f) Enhvironmental effects

The validated protection levels for the Engine and Propeller electronic control systems as well as their emissions of radio frequency energy are established during the Engine and Propeller certification and are contained in the instructions for installation. For the Aircraft certification, it should be substantiated that these levels are adequate.

5 INTER-RELATION BETWEEN ENGINE, PROPELLER AND AIRCRAFT CERTIFICATION

a) Objective

To satisfy the Aircraft certification specifications, such as CS 25.901, CS 25.903 and CS 25.1309, an analysis of the consequences of failures of the system on the Aircraft has to be made. It should be ensured that the software levels and safety and reliability objectives for the electronic control system are consistent with these requirements.

b) Interface Definition

The interface has to be identified for the hardware and software aspects between the Engine, Propeller and the Aircraft systems in the appropriate documents.

The Engine/Propeller/Aircraft documents should cover in particular:

- The software quality level (per function if necessary),
- The reliability objectives for loss of Engine/Propeller control or significant change in thrust, (including IFSD due to control system malfunction), transmission of faulty parameters,
- The degree of protection against lightning or other electromagnetic effects (e.g. level of induced voltages that can be supported at the interfaces),
- Engine, Propeller and Aircraft interface data and characteristics, and
- Aircraft power supply and characteristics (if relevant).

c) Distribution of Compliance Demonstration

The certification tasks of the Aircraft propulsion system equipped with electronic control systems may be shared between the Engine, Propeller and Aircraft certification. The distribution between the different certification activities should be identified and agreed with the Agency and/or the appropriate Engine and Aircraft Authorities: (an example is given in paragraph (6)).

Appropriate evidence provided for Engine and Propeller certification should be used for Aircraft certification. For example, the quality of any Aircraft function software and Aircraft/Engine/Propeller interface logic already demonstrated for Engine or Propeller certification should need no additional substantiation for Aircraft certification.

Aircraft certification should deal with the specific precautions taken in respect of the physical and functional interfaces with the Engine/Propeller.

6 TABLE

An example of distribution between Engine and Aircraft certification. (When necessary, a similar approach should be taken for Propeller applications).

TASK	SUBSTANTIATION UNDER CS-E	SUBSTANTIATION UNDER CS-25	
		with Engine data	with Aircraft data
ENGINE CONTROL AND PROTECTION	- Safety objective - Software level	- Consideration of common mode effects (including software) - Reliability - Software level	
MONITORING	- Independence of control and monitoring parameters	- Monitoring parameter reliability	- Indication system reliability - Independence Engine/ Engine
AIRCRAFT DATA	- Protection of Engine from Aircraft data failures - Software level		- Aircraft data reliability - Independence Engine/ Engine
THRUST REVERSER CONTROL/ MONITORING	- Software level	- System reliability - Architecture - Consideration of common mode effects(including software)	- Safety objectives
CONTROL SYSTEM ELECTRICAL SUPPLY	- Reliability or quality Requirement of Aircraft supply, if used		- Reliability of quality of Aircraft supply, if used - Independence Engine/ Engine
ENVIRONMENTAL CONDITIONS	- Equipment protection	- Declared capability	- Aircraft design
LIGHTNING AND OTHER ELECTROMAGNETIC EFFECTS	- Equipment protection Electromagnetic emissions	- Declared capability - Declared emissions	- Aircraft wiring protection and electromagnetic compatibility
FIRE PROTECTION	- Equipment protection	- Declared capability	- Aircraft design

AMC 20-3
Certification of Engines Equipped with Electronic Engine Control Systems

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(1) PURPOSE

The existing certification specifications of CS-E for Engine certification may require specific interpretation for Engines equipped with Electronic Engine Control Systems (EECS), with special regard to interface with the certification of the aircraft and/or Propeller when applicable. Because of the nature of this technology, it has been considered useful to prepare acceptable means of compliance specifically addressing the certification of these control systems.

Like any acceptable means of compliance, it is issued to outline issues to be considered during demonstration of compliance with the Engine certification specifications.

(2) SCOPE

This acceptable means of compliance is relevant to Engine certification specifications for EECS, whether using electrical or electronic (analogue or digital) technology. This is in addition to other acceptable means of compliance such as AMC E 50 or AMC E 80.

It gives guidance on the precautions to be taken for the use of electrical and electronic technology for Engine control, protection, limiting and monitoring functions, and, where applicable, for integration of aircraft or Propeller functions. In these latter cases, this document is applicable to such functions integrated into the EECS, but only to the extent that these functions affect compliance with CS-E specifications.

The text deals mainly with the thrust and power functions of an EECS, since this is the prime function of the Engine. However, there are many other functions, such as bleed valve control, that may be integrated into the system for operability reasons. The principles outlined in this AMC apply to the whole system.

This document also discusses the division of compliance tasks for certification between the applicants for Engine, Propeller (when applicable) and aircraft type certificates. This guidance relates to issues to be considered during engine certification. AMC 20-1 addresses issues associated with the engine installation in the aircraft.

The introduction of electrical and electronic technology can entail the following:

- a greater dependence of the Engine on the aircraft owing to the increased use of electrical power or data supplied from the aircraft,
- an increased integration of control and related indication functions,
- an increased risk of significant Failures common to more than one Engine of the aircraft which might, for example, occur as a result of:
  - Insufficient protection from electromagnetic disturbance (lightning, internal or external radiation effects) (see CS-E 50 (a)(1), CS E-80 and CS-E 170),
  - Insufficient integrity of the aircraft electrical power supply (see CS-E 50 (h)),
  - Insufficient integrity of data supplied from the aircraft (see CS-E 50 (g)),
  - Hidden design Faults or discrepancies contained within the design of the propulsion system control software or complex electronic hardware (see CS-E 50 (f)), or
  - Omissions or errors in the system/software specification (see CS-E 50 (f)).

Special design and integration precautions should therefore be taken to minimise any adverse effects from the above.

(3) RELEVANT SPECIFICATIONS AND REFERENCE DOCUMENTS

Although compliance with many CS-E specifications might be affected by the Engine Control System, the main paragraphs relevant to the certification of the Engine Control System itself are:

CS-E Specification	Turbine Engines	Piston Engines
CS-E 20 (Engine configuration and interfaces)	✓	✓
CS-E 25 (Instructions for Continued Airworthiness),	✓	✓
CS-E 30 (Assumptions),	✓	✓
CS-E 50 (Engine Control System)	✓	✓
CS-E 60 (Provision for instruments)	✓	✓
CS-E 80 (Equipment)	✓	✓
CS-E 110 (Drawing and marking of parts - Assembly of parts)	✓	✓
CS-E 130 (Fire prevention)	✓	✓
CS-E 140 (Tests-Engine configuration)	✓	✓
CS-E 170 (Engine systems and component verification)	✓	✓
CS-E 210 (Failure analysis)		✓
CS-E 250 (Fuel System)		✓
CS-E 390 (Acceleration tests)		✓
CS-E 500 (Functioning)	✓	
CS-E-510 (Safety analysis)	✓	
CS-E 560 (Fuel system)	✓	
CS-E 745 (Engine Acceleration)	✓	
CS-E 1030 (Time limited dispatch)	✓	✓

The following documents are referenced in this AMC 20-3:

- International Electrotechnical Commission (IEC), Central Office, 3, rue de Varembé, P.O. Box 131, CH - 1211 GENEVA 20, Switzerland
  - IEC/PAS 62239, Electronic Component Management Plans, edition 1.0, dated April 2001.
  - IEC/PAS 62240, Use of Semiconductor Devices Outside Manufacturers' Specified Temperature Ranges, edition 1.0, dated April 2001.
- RTCA, Inc. 1828 L Street, NW, Suite 805, Washington, DC 20036 or EUROCAE, 17, rue Hamelin, 75116 Paris, France
  - RTCA DO-178A/EUROCAE ED-12A, Software Considerations in Airborne Systems and Equipment Certification, dated March 1985
  - RTCA DO-178B/EUROCAE ED-12B, Software Considerations in Airborne Systems and Equipment Certification, dated December 1, 1992
  - RTCA DO-254/ EUROCAE ED-80, Design Assurance Guidance for Airborne Electronic Hardware, dated April 19, 2000.

- RTCA DO-160/EUROCAE ED 14, Environmental Conditions and Test Procedures for Airborne Equipment.

- Aeronautical Systems Center, ASC/ENOI, Bldg 560, 2530 Loop Road West, Wright-Patterson AFB, OH, USA, 45433-7101

  - MIL-STD-461E, Requirements for the Control of Electromagnetic Interference Characteristics, dated August 20, 1999

  - MIL-STD-810 E or F, Test Method Standard for Environmental Engineering, E dated July 14, 1989, F dated January 1, 2000

- U.S. Department of Transportation, Subsequent Distribution, Office Ardmore East Business Center, 3341 Q 75th Ave, Landover, MD, USA, 20785

  - AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning, dated March 5, 1990

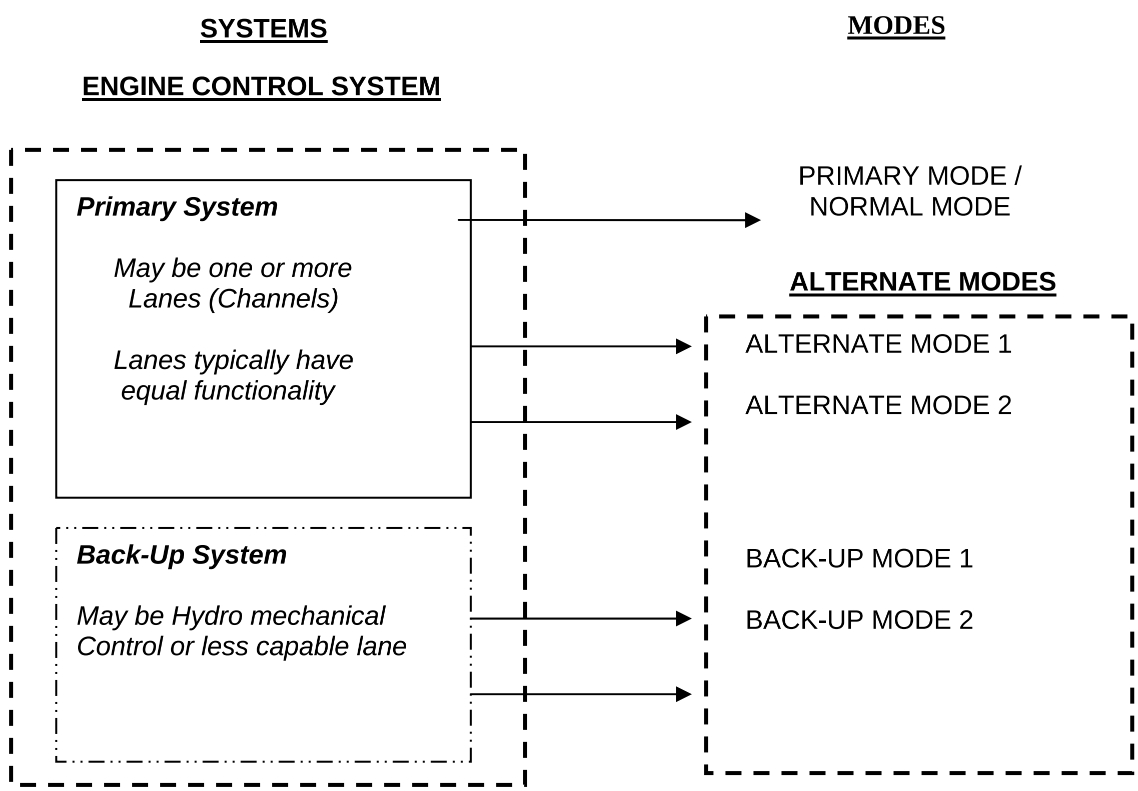
- Society of Automotive Engineers (SAE), 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA or EUROCAE, 17, rue Hamelin, 75116 Paris, France
  - SAE ARP 5412 / EUROCAE ED-84, with Amendment 1 & 2, Aircraft Lightning Environment and Related Test Waveforms, February 2005/May 2001 respectively.
  - SAE ARP 5413 / EUROCAE ED-81, with Amendment 1, Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning, November 1999/August 1999 respectively.
  - SAE ARP 5414 / EUROCAE ED-91, with Amendment 1, Aircraft Lightning Zoning, February 2005/June 1999 respectively.
  - SAE ARP 5416 / EUROCAE ED-105, Aircraft Lightning Test Methods, March 2005/April 2005 respectively.

(4) DEFINITIONS

The words defined in CS-Definitions and in CS-E 15 are identified by capital letter.

The following figure and associated definitions are provided to facilitate a clear understanding of the terms used in this AMC.

DEFINITIONS VISUALISED



(5) GENERAL

It is recognised that the determination of compliance of the Engine Control System with applicable aircraft certification specifications will only be made during the aircraft certification.

In the case where the installation is unknown at the time of Engine certification, the applicant for Engine certification should make reasonable installation and operational assumptions for the target installation. Any installation limitations or operational issues will be noted in the instructions for installation or operation, and/or the Type Certificate Data Sheet (TCDS) (see CS-E 30).

When possible, early co-ordination between the Engine and the aircraft applicants is recommended in association with the relevant authorities as discussed under paragraph (15) of this AMC.

(6) SYSTEM DESIGN AND VALIDATION

(a) Control Modes - General

Under CS-E 50 (a) the applicant should perform all necessary testing and analysis to ensure that all Control Modes, including those which occur as a result of control Fault Accommodation strategies, are implemented as required.

The need to provide protective functions, such as over-speed protection, for all Control Modes, including any Alternate Modes, should be reviewed under the specifications of CS-E 50 (c), (d) and (e), and CS-E 210 or CS-E 510.

Any limitations on operations in Alternate Modes should be clearly stated in the Engine instructions for installation and operation.

Descriptions of the functioning of the Engine Control System operating in its Primary and any Alternate Modes should be provided in the Engine instructions for installation and operation.

Analyses and/or testing are necessary to substantiate that operating in the Alternate Modes has no unacceptable effect on Engine durability or endurance. Demonstration of the durability and reliability of the control system in all modes is primarily addressed by the component testing of CS-E 170. Performing some portion of the Engine certification testing in the Alternate Mode(s) and during transition between modes can be used as part of the system validation required under CS-E 50 (a).

(i) Engine Test Considerations

If the Engine certification tests defined in CS-E are performed using only the Engine Control System's Primary Mode in the Full-up Configuration and if approval for dispatch in the Alternate Mode is requested by the applicant under CS-E 1030, it should be demonstrated, by analysis and/or test, that the Engine can meet the defined test-success criteria when operating in any Alternate mode that is proposed as a dispatchable configuration as required by CS E-1030.

Some capabilities, such as operability, blade-off, rain, hail, bird ingestion, etc, may be lost in some control modes that are not dispatchable. These modes do not require engine test demonstration as long as the installation and operating instructions reflect this loss of capability.

(ii) Availability

Availability of any Back-up Mode should be established by routine testing or monitoring to ensure that the Back-up Mode will be available when needed. The frequency of establishing its availability should be documented in the instructions for continued airworthiness.

(b) Crew Training Modes

This acceptable means of compliance is not specifically intended to apply to any crew training modes. These modes are usually installation, and possibly operator, specific and need to be negotiated on a case-by-case basis. As an example, one common application of crew training modes is for simulation of the 'failed-fixed' mode on a twin-engine rotorcraft. Training modes should be described in the Engine instructions for installation and operation as appropriate. Also, precautions should be taken in the design of the Engine Control System and its crew interfaces to prevent inadvertent entry into any training modes. Crew training modes, including lock-out systems, should be assessed as part of the System Safety Analysis (SSA) of CS-E 50 (d).

(c) Non-Dispatchable Configurations and Modes

For control configurations which are not dispatchable, but for which the applicant seeks to take credit in the system LOTC/LOPC analysis, it may be acceptable to have specific operating limitations. In addition, compliance with CS-E 50 (a) does not imply strict compliance with the operability specifications of CS-E 390, CS-E 500 and CS-E 745 in these non-dispatchable configurations, if it can be demonstrated that, in the intended installation, no likely pilot control system inputs will result in Engine surge, stall, flame-out or unmanageable delay in power recovery. For example, in a twin-engine rotorcraft, a rudimentary Back-up System may be adequate since frequent and rapid changes in power setting with the Back-up System may not be necessary.

In addition to these operability considerations, other factors which should be considered in assessing the acceptability of such reduced-capability Back-up Modes include:

- The installed operating characteristics of the Back-up Mode and the differences from the Primary Mode.

- The likely impact of the Back-up Mode operations on pilot workload, if the aircraft installation is known.

- The frequency of transfer from the Primary Mode to the Back-up Mode (i.e. the reliability of the Primary Mode). Frequencies of transfer of less than 1 per 20 000 engine flight hours have been considered acceptable.

(d) Control Transitions

The intent of CS-E 50 (b) is to ensure that any control transitions, which occur as a result of Fault Accommodation, occur in an acceptable manner.

In general, transition to Alternate Modes should be accomplished automatically by the Engine Control System. However, systems wherein pilot action is required to engage the Back-up Mode may also be acceptable. For instance, a Fault in the Primary System may result in a “failed-fixed” fuel flow and some action is required by the pilot to engage the Back-up System in order to modulate Engine power. Care should be taken to ensure that any reliance on manual transition is not expected to pose an unacceptable operating characteristic, unacceptable crew workload or require exceptional skill.

The transient change in power or thrust associated with transfer to Alternate Modes should be reviewed for compliance with CS-E 50 (b). If available, input from the installer should be considered. Although this is not to be considered a complete list, some of the items that should be considered when reviewing the acceptability of Control Mode transitions are:

- The frequency of occurrence of transfers to any Alternate Mode and the capability of the Alternate Mode. Computed frequency-of-transfer rates should be supported with data from endurance or reliability testing, in-service experience on similar equipment, or other appropriate data.

- The magnitude of the power, thrust, rotor or Propeller speed transients.

- Successful demonstration, by simulation or other means, of the ability of the Engine Control System to control the Engine safely during the transition. In some cases, particularly those involving rotorcraft, it may not be possible to make a determination that the mode transition provides a safe system based solely on analytical or simulation data. Therefore, a flight test programme to support this data will normally be expected.

- An analysis should be provided to identify those Faults that cause Control Mode transitions either automatically or through pilot action.

- For turboprop or turboshaft engines, the transition should not result in excessive over-speed or under-speed of the rotor or Propeller which could cause emergency shutdown, loss of electrical generator power or the setting-off of warning devices.

The power or thrust change associated with the transition should be declared in the instructions for installing the Engine.

(i) Time Delays

Any observable time delays associated with Control Mode, channel or system transitions or in re-establishing the pilot’s ability to modulate Engine thrust or power should be identified in the Engine instructions for installation and operation (see CS-E 50 (b)). These delays should be assessed during aircraft certification.

(ii) Annunciation to the Flight Crew

If annunciation is necessary to comply with CS-E 50(b)(3), the type of annunciation to the flight crew should be commensurate with the nature of the transition. For instance, reversion to an Alternate Mode of control where the transition is automatic and the only observable changes in operation of the Engine are different thrust control schedules, would require a very different form of annunciation to that required if timely action by the pilot is required in order to maintain control of the aircraft.

The intent and purpose of the cockpit annunciation should be clearly stated in the Engine instructions for installation and operation, as appropriate.

(e) Environmental conditions

Environmental conditions include EMI, HIRF and lightning. The environmental conditions are addressed under CS E-80 and CS-E 170. The following provides additional guidance for EMI, HIRF and lightning.

(i) Declared levels

When the installation is known during the Engine type certification programme, the Engine Control System should be tested at levels that have been determined and agreed by the Engine and aircraft applicants. It is assumed that, by this agreement, the installation can meet the aircraft certification specifications. Successful completion of the testing to the agreed levels would be accepted for Engine type certification. This, however, may make the possibility of installing the Engine dependent on a specific aircraft.

If the aircraft installation is not known or defined at the time of the Engine certification, in order to determine the levels to be declared for the Engine certification, the Engine applicant may use the external threat level defined at the aircraft level and use assumptions on installation attenuation effects.

If none of the options defined above are available, it is recommended that the procedures and minimum default levels for HIRF testing are agreed with the Agency.

(ii) Test procedures

(A) General

The installed Engine Control System, including representative Engine-aircraft interface cables, should be the basis for certification testing.

Electro-Magnetic Interference (EMI) test procedures and test levels conducted in accordance with MIL-STD-461 or EUROCAE ED 14/DO-160 have been considered acceptable.

The applicant should use the HIRF test guidelines provided in EUROCAE ED 14/RTCA DO-160 or equivalent. However, it should be recognised that the tests defined in EUROCAE ED 14/RTCA DO-160 are applicable at a component test level, requiring the applicant to adapt these test procedures to a system level HIRF test to demonstrate compliance with CS-E 80 and CS-E 170.

For lightning tests, the guidelines of SAE ARP 5412, 5413, 5414, and 5416 and EUROCAE ED 14/RTCA DO-160 would be applicable.

Pin Injection Tests (PIT) are normally conducted as component tests on the EECS unit and other system components as required. PIT levels are selected as appropriate from the tables of EUROCAE ED 14/DO-160.

Environmental tests such as MIL-STD-810 may be accepted in lieu of EUROCAE ED-14/DO-160 tests where these tests are equal to or more rigorous than those defined in EUROCAE ED 14/DO-160.

(B) Open loop and Closed loop Testing

HIRF and lightning tests should be conducted as system tests on closed loop or open loop laboratory set-ups.

The closed loop set-up is usually provided with hydraulic pressure to move actuators to close the inner actuating loops. A simplified Engine simulation may be used to close the outer Engine loop.

Testing should be conducted with the Engine Control System controlling at the most sensitive operating point, as selected and detailed in the test plans by the applicant. The system should be exposed to the HIRF and lightning environmental threats while operating at the selected condition. There may be a different operating point for HIRF and lightning environmental threats.

For tests in open and closed loop set ups, the following factors should also be considered:

- If special EECS test software is used, that software should be developed and implemented by guidelines defined for software levels of at least Level 2 in DO-178A, Level C in DO-178B, or equivalent. In some cases, the application code is modified to include the required test code features.
- The system test set-up should be capable of monitoring both the output drive signals and the input signals.
- Anomalies observed during open loop testing on inputs or outputs should be duplicated on the Engine simulation to determine whether the resulting power or thrust perturbations comply with the pass/fail criteria.

(iii) Pass/Fail Criteria

The pass/fail criteria of CS-E 170 for HIRF and lightning should be interpreted as "no adverse effect" on the functionality of the system.

The following are considered adverse effects:

- A greater than 3 % change of Take-off Power or Thrust for a period of more than two seconds.
- Transfers to alternate channels, Back-up Systems, or Alternate Modes.
- Component damage.
- False annunciation to the crew which could cause unnecessary or inappropriate crew action.
- Erroneous operation of protection systems, such as over-speed or thrust reverser circuits.

Hardware or Software design changes implemented after initial environmental testing should be evaluated for their effects with respect to the EMI, HIRF and lightning environment.

(iv) Maintenance Actions

CS-E 25 requires that the applicant prepare Instructions for Continued Airworthiness (ICA). This includes a maintenance plan. Therefore, for any protection system that is part of the type design of the Engine Control System and is required by the system to meet the qualified levels of EMI, HIRF and lightning, a maintenance plan should be provided to ensure the continued airworthiness for the parts of the installed system which are supplied by the Engine type certificate holder.

.The maintenance actions to be considered include periodic inspections or tests for required structural shielding, wire shields, connectors, and equipment protection components. Inspections or tests when the part is exposed may also be considered. The applicant should provide the engineering validation and substantiation of these maintenance actions.

(v) Time Limited Dispatch (TLD) Environmental Tests

Although TLD is only an optional requirement for certification (see CS-E 1000 and CS-E 1030), EMI, HIRF and lightning tests for TLD are usually conducted together with tests conducted for certification. Acceptable means of compliance are provided in AMC E 1030.

(7) INTEGRITY OF THE ENGINE CONTROL SYSTEM

(a) Objective

The intent of CS-E 50 (c) is to establish Engine Control System integrity requirements consistent with operational requirements of the various installations. (See also paragraph (4) of AMC E 50).

(b) Definition of an LOTC/LOPC event

(i) For turbine Engines intended for CS-25 installations

An LOTC/LOPC event is defined as an event where the Engine Control System:

- has lost the capability of modulating thrust or power between idle and 90% of maximum rated power or thrust, or
- suffers a Fault which results in a thrust or power oscillation greater than the levels given in paragraph (7)(c) of this AMC, or
- has lost the capability to govern the Engine in a manner which allows compliance with the operability specifications given in CS-E 500 (a) and CS-E 745.

(ii) For turbine Engines intended for rotorcraft

An LOPC event is defined as an event where the Engine Control System:

- has lost the capability of modulating power between idle and 90% of maximum rated power at the flight condition, except OEI power ratings, or
- suffers a Fault which results in a power oscillation greater than the levels given in paragraph (7)(c) of this AMC, or

- has lost the capability to govern the Engine in a manner which allows compliance with the operability specifications given in CS-E 500 (a) and CS-E 745, with the exception that the inability to meet the operability specifications in the Alternate Modes may not be included as LOPC events.

- Single Engine rotorcraft will be required to meet the operability specifications in the Alternate Mode(s), unless the lack of this capability is demonstrated to be acceptable at the aircraft level. Engine operability in the Alternate Mode(s) is considered a necessity if:

- the control transitions to the Alternate Mode more frequently than the acceptable LOPC rate, or

- normal flight crew activity requires rapid changes in power to safely fly the aircraft.

- For multi-Engine rotorcraft, the LOPC definition may not need to include the inability to meet the operability specifications in the Alternate Mode(s). This may be considered acceptable because when one Engine control transitions to an Alternate Mode, which may not have robust operability, that Engine can be left at reasonably fixed power conditions. The Engine(s) with the normally operating control(s) can change power – as necessary – to complete aircraft manoeuvres and safely land the aircraft. Demonstration of the acceptability of this type of operation may be required at aircraft certification.

(iii) For turbine Engines intended for other installations

A LOTC/LOPC event is defined as an event where the Engine Control System:

- has lost the capability of modulating thrust or power between idle and 90% of maximum rated power or thrust, or

- suffers a Fault which results in a thrust or power oscillation that would impact controllability in the intended installation, or

- has lost the capability to govern the Engine in a manner which allows compliance with the operability specifications given in CS-E 500 (a) and CS-E 745, as appropriate.

(iv) For piston Engines

An LOPC event is defined as an event where the Engine Control System:

- has lost the capability of modulating power between idle and 85% of maximum rated power at all operating conditions, or

- suffers a Fault which results in a power oscillation greater than the levels given in paragraph (7)(c) of this AMC, or

- has lost the capability to govern the Engine in a manner which allows compliance with the operability specifications given in CS-E 390.

(v) For engines incorporating functions for Propeller control integrated in the EECS

The following Faults or Failures should be considered as additional LOPC events:

- inability to command a change in pitch,

- uncommanded change in pitch,

- uncontrollable Propeller torque or speed fluctuation.

(c) Uncommanded thrust or power oscillations

Any uncommanded thrust or power oscillations should be of such a magnitude as not to impact aircraft controllability in the intended installation. Thrust or power oscillations less than 10% peak to peak of Take-off Power and/or Thrust have been considered acceptable in some installations, where the failure affects one engine only. Regardless of the levels discussed herein, if the flight crew has to shut down an Engine because of unacceptable thrust or power oscillations caused by the control system, such an event would be deemed an in-service LOTC/LOPC event.

(d) Acceptable LOTC/LOPC rate

The applicant may propose an LOTC/LOPC rate other than those below. Such a proposal should be substantiated in relation to the criticality of the Engine and control system relative to the intended installation. The intent is to show equivalence of the LOTC/LOPC rate to existing systems in comparable installations.

(i) For turbine Engines

The EECS should not cause more than one LOTC/LOPC event per 100 000 engine flight hours.

(ii) For piston Engines

An LOPC rate of 45 per million engine flight hours (or 1 per 22,222 engine flight hours) has been shown to represent an acceptable level for the most complex EECS. As a result of the architectures used in many of the EECS for these engines, the functions are implemented in independent system elements. These system elements or sub-systems can be fuel control, or ignition control, or others. If a system were to contain only one element such as fuel control, then the appropriate total system level would be 15 LOPC events per million engine flight hours. So the system elements are then additive up to a max of 45 LOPC events per million hours. For example, an EEC system comprised of fuel, ignition, and wastegate control functions should meet a total system reliability of 15+15+15 = 45 LOPC events per million engine flight hours. This criterion is then applied to the entire system and not allocated to each of the subsystems. Note that a maximum of 45 LOPC events per million engine flight hours are allowed, regardless of the number of subsystems. For example, if the EEC system includes more than three subsystems, the sum of the LOPC rates for the total system should not exceed 45 LOPC events per million engine flight hours for all of the electrical and electronic elements.

(e) LOTC/LOPC Analysis

A system reliability analysis should be submitted to substantiate the agreed LOTC/LOPC rate for the Engine Control System. A numerical analysis such as a Markov model analysis, fault tree analysis or equivalent analytical approach is expected.

The analysis should address all components in the system that can contribute to LOTC/LOPC events. This includes all electrical, mechanical, hydromechanical, and pneumatic elements of the Engine Control System. This LOTC/LOPC analysis should be done in conjunction with the System Safety Assessment required under CS-E 50 (d). Paragraph (8) of this AMC provides additional guidance material.

The engine fuel pump is generally not included in the definition of the Engine Control System. It is usually considered part of the fuel delivery system.

The LOTC/LOPC analysis should include those sensors or elements which may not be part of the Engine type design, but which may contribute to LOTC/LOPC events. An example of this is the throttle or power lever transducer, which is usually supplied by the installer. The effects of loss, corruption or Failure of Aircraft-Supplied Data should be included in the Engine Control System's LOTC/LOPC analysis. The reliability and interface requirements for these non-Engine type design elements should be contained in the Engine instructions for installation. It needs to be ensured that there is no double counting of the rate of Failure of non-engine parts within the aircraft system safety analyses.

The LOTC/LOPC analysis should consider all Faults, both detected and undetected. Any periodic maintenance actions needed to find and repair both Covered and Uncovered Faults, in order to meet the LOTC/LOPC rate, should be contained in the Engine instructions for continued airworthiness.

(f) Commercial or Industrial Grade Electronic Parts

When the Engine type design specifies commercial or industrial grade electronic components, which are parts not manufactured to military standards, the applicant should have the following data available for review, as applicable:

- Reliability data that substantiates the Failure rate for each component used in the LOTC/LOPC analysis and the SSA for each commercial and industrial grade electrical component specified in the design.

- The applicant's procurement, quality assurance, and process control plans for the vendor-supplied commercial and industrial grade parts. These plans should ensure that the parts will be able to maintain the reliability level specified in the approved Engine type design.

- Unique databases for similar components obtained from different vendors, because commercial and industrial grade parts may not all be manufactured to the same accepted industry standard, such as military component standards.

- Commercial and industrial grade parts have typical operating ranges of 0 degrees to +70 degrees Celsius and -40 degrees to +85 degrees Celsius, respectively. Military grade parts are typically rated at -54 degrees to 125 degrees Celsius. Commercial and industrial grade parts are typically defined in these temperature ranges in vendor parts catalogues. If the declared temperature environment for the Engine Control System exceeds the stated capability of the commercial or industrial grade electronic components, the applicant should substantiate that the proposed extended range of the specified components is suitable for the installation and that the Failure rates used for those components in the SSA and LOTC/LOPC analyses is appropriately adjusted for the extended temperature environment. Additionally, if commercial or industrial parts are used in an environment beyond their specified rating and cooling provisions are required in the design of the EECS, the applicant should specify these provisions in the instructions for installation to ensure that the provisions for cooling are not compromised. . Failure modes of the cooling provisions included in the EECS design that cause these limits to be exceeded should be considered in determining the probability of Failure.

- Two examples of industry published documents which provide guidance on the application of commercial or industrial grade components are:

  – IEC/PAS 62239, Electronic Component Management Plans

  – IEC/PAS 62240, Use of Semiconductor Devices Outside Manufacturers' Specified Temperature Ranges

When any electrical or electronic components are changed, the SSA and LOTC/LOPC analyses should be reviewed with regard to the impact of any changes in component reliability. Component, subassembly or assembly level testing may be required by the Agency to substantiate a change that introduces a commercial or industrial part(s). However, such a change would not be classified as 'significant' with respect to Part 21A.101(b)1.

(g) Single Fault Accommodation

Compliance with the single Fault specifications of CS-E 50 (c)(2) and (3) may be substantiated by a combination of tests and analyses. The intent is that single Failures or malfunctions in the Engine Control System's components, in its fully operational condition, do not result in a Hazardous Engine Effect. In addition, in its full-up configuration the control system should be essentially single Fault tolerant of electrical/electronic component Failures with respect to LOTC/LOPC events. For dispatchable configurations refer to CS-E 1030 and AMC E 1030.

It is recognised that to achieve true single Fault tolerance for LOTC/LOPC events could require a triplicated design approach or a design approach with 100% Fault detection. Currently, systems have been designed with dual, redundant channels or with Back-up Systems that provide what has been called an "essentially single Fault tolerant" system. Although these systems may have some Faults that are not Covered Faults, they have demonstrated excellent in-service safety and reliability, and have proven to be acceptable.

The objective, of course, is to have all the Faults addressed as Covered Faults. Indeed, the dual channel or Back-up system configurations do cover the vast majority of potential electrical and electronic Faults. However, on a case-by-case basis, it may be appropriate for the applicant to omit some coverage because detection or accommodation of some electrical/electronic Faults may not be practical. In these cases, it is recognised that single, simple electrical or electronic components or circuits can be employed in a reliable manner, and that requiring redundancy in some situations may not be appropriate. In these circumstances, Failures in some single electrical or electronic components, elements or circuits may result in an LOTC/LOPC event. This is what is meant by the use of the term "essentially", and such a system may be acceptable.

(h) Local Events

Examples of local events to be considered under CS-E 50 (c)(4) include:

- Overheat conditions, for example, those resulting from hot air duct bursts,
- Fires, and
- Fluid leaks or mechanical disruptions which could lead to damage to control system electrical harnesses, connectors, or the control unit(s).

These local events would normally be limited to one Engine. Therefore, a local event is not usually considered to be a common mode event, and common mode threats, such as HIRF, lightning and rain, are not considered local events.

When demonstration that there is no Hazardous Engine Effect is based on the assumption that another function exists to afford the necessary protection, it should be shown that this function is not rendered inoperative by the same local event on the Engine (including destruction of wires, ducts, power supplies).

It is considered that an overheat condition exists when the temperature of the system components is greater than the maximum safe design operating temperature for the components, as declared by the Engine applicant in the Engine instructions for installation. The Engine Control System should not cause a Hazardous Engine Effect when the components or units of the system are exposed to an overheat or over-temperature condition. Specific design features or analysis methods may be used to show compliance with respect to the prevention of Hazardous Engine Effects. Where this is not possible, for example, due to the variability or the complexity of the Failure sequence, then testing may be required.

The Engine Control System, including the electrical, electronic and mechanical parts of the system, should comply with the fire specifications of CS-E 130 and the interpretative material of AMC E 130 is relevant. This rule applies to the elements of the Engine Control System which are installed in designated fire zones.

There is no probability associated with CS-E 50 (c)(4). Hence, all foreseeable local events should be considered. It is recognised, however, that it is difficult to address all possible local events in the intended aircraft installation at the time of Engine certification. Therefore, sound Engineering judgement should be applied in order to identify the reasonably foreseeable local events. Compliance with this specification may be shown by considering the end result of the local event on the Engine Control System. The local events analysed should be well documented to aid in certification of the Engine installation.

The following guidance applies to Engine Control System wiring:

- Each wire or combination of wires interfacing with the EECS that could be affected by a local event should be tested or analysed with respect to local events. The assessment should include opens, shorts to ground and shorts to power (when appropriate) and the results should show that Faults result in identified responses and do not result in Hazardous Engine Effects.

- Engine control unit aircraft interface wiring should be tested or analysed for shorts to aircraft power, and these “hot” shorts should result in an identified and non-Hazardous Engine Effect. Where aircraft interface wiring is involved, the installer should be informed of the potential effects of interface wiring Faults by means of information provided in the Engine instructions for installation. It is the installer’s responsibility to ensure that there are no wiring Faults which could affect more than one Engine. Where practical, wiring Faults should not affect more than one channel. Any assumptions made by the Engine applicant regarding channel separation should be included in the LOTC/LOPC analysis.

- Where physical separation of conductors is not practical, co-ordination between the Engine applicant and the installer should ensure that the potential for common mode Faults between Engine Control Systems is eliminated, and between channels on one Engine is minimised.

The applicant should assess by analysis or test the effects of fluid leaks impinging on components of the Electronic Engine Control System. Such conditions should not result in a Hazardous Engine Effect, nor should the fluids be allowed to impinge on circuitry or printed circuit boards and result in a potential latent Failure condition.

(8) SYSTEM SAFETY ASSESSMENT

(a) Scope of the assessment

The system safety assessment (SSA) required under CS-E 50 (d) should address all operating modes, and the data used in the SSA should be substantiated.

The LOTC/LOPC analysis described in Section 7 is a subset of the SSA. The LOTC/LOPC analysis and SSA may be separate or combined as a single analysis.

The SSA should consider all Faults, both detected and undetected, and their effects on the Engine Control System and the Engine itself. The intent is primarily to address the Faults or malfunctions which only affect one Engine Control System, and therefore only one Engine. However, Faults or malfunctions in aircraft signals, including those in a multi-engine installation that could affect more than one Engine, should also be included in the SSA; these types of Faults are addressed under CS-E 50 (g).

The Engine Control System SSA and LOTC/LOPC analysis, or combined analyses, should identify the applicable assumptions and installation requirements and establish any limitations relating to Engine Control System operation. These assumptions, requirements, and limitations should be stated in the Engine instructions for installation and operation as appropriate. If necessary, the limitations should be contained in the airworthiness limitations section of the instructions for continued airworthiness in accordance with CS-E 25 (b)(1).

The SSA should address all Failure effects identified under CS-E 510 or CS-E 210, as appropriate. A summary should be provided, listing the malfunctions or Failures and their effects caused by the Engine Control System, such as:

- Failures affecting power or thrust resulting in LOTC/LOPC events.
- Failures which result in the Engine's inability to meet the operability specifications. If these Failure cases are not considered as LOPC events according to paragraph (7)(b)(ii) of this AMC, the expected frequency of occurrence for these events should be documented.
- Transmission of erroneous parameters which could lead to thrust or power changes greater than 3% of Take-off Power or Thrust (10% for piston engines installations) (e.g., false high indication of the thrust or power setting parameter) or to Engine shutdown (e.g., high EGT or turbine temperatures or low oil pressure).
- Failures affecting functions included in the Engine Control System, which may be considered aircraft functions (e.g. Propeller control, thrust reverser control, control of cooling air, control of fuel recirculation)
- Failures resulting in Major Engine Effects and Hazardous Engine Effects.

The SSA should also consider all signals used by the Engine Control System, in particular any cross-Engine control signals and air signals as described in CS-E 50 (i).

The criticality of functions included in the Engine Control System for aircraft level functions needs to be defined by the aircraft applicant.

(b) Criteria

The SSA should demonstrate or provide the following:

(i) Compliance with CS-E 510 or CS-E 210, as appropriate.

(ii) For Failures leading to LOTC/LOPC events,

compliance with the agreed LOTC/LOPC rate for the intended installation (see paragraph (7)(d) of this AMC).

(iii) For Failures affecting Engine operability but not leading to LOPC events,

compliance with the expected total frequency of occurrence of Failures that result in Engine response that is non-compliant with CS-E 390, CS-E 500 (a) and CS-E 745 specifications (as appropriate). The acceptability of the frequency of occurrence for these events - along with any aircraft flight deck indications deemed necessary to inform the flight crew of such a condition - will be determined at aircraft certification.

(iv) The consequence of the transmission of a faulty parameter

The consequence of the transmission of a faulty parameter by the Engine Control System should be identified and included, as appropriate, in the LOTC/LOPC analysis. Any information necessary to mitigate the consequence of a faulty parameter transmission should be contained in the Engine operating instructions.

For example, the Engine operating instructions may indicate that a display of zero oil pressure be ignored in-flight if the oil quantity and temperature displays appear normal. In this situation, Failure to transmit oil pressure or transmitting a zero oil pressure signal should not lead to an Engine shutdown or LOTC/LOPC event. Admittedly, flight crew initiated shutdowns have occurred in-service during such conditions. In this regard, if the Engine operating instructions provide information to mitigate the condition, then control system Faults or malfunctions leading to the condition do not have to be included in the LOTC/LOPC analysis. In such a situation, the loss of multiple functions should be included in the LOTC/LOPC analysis. If the display of zero oil pressure and zero oil quantity (or high oil temperature) would result in a crew initiated shutdown, then those conditions should be included in the systems LOTC/LOPC analysis.

(c) Malfunctions or Faults affecting thrust or power

In multi-engine aeroplanes, Faults that result in thrust or power changes of less than approximately 10% of Take-off Power or Thrust may be undetectable by the flight crew. This level is based on pilot assessment and has been in use for a number of years. The pilots indicated that flight crews will note the Engine operating differences when the difference is greater than 10% in asymmetric thrust or power.

The detectable difference level for Engines for other installations should be agreed with the installer.

When operating in the take-off envelope, Uncovered Faults in the Engine Control System which result in a thrust or power change of less than 3% (10% for piston engines installations), are generally considered acceptable. However, this does not detract from the applicant’s obligation to ensure that the full-up system is capable of providing the declared minimum rated thrust or power. In this regard, Faults which could result in small thrust changes should be random in nature and detectable and correctable during routine inspections, overhauls or power-checks.

The frequency of occurrence of Uncovered Faults that result in a thrust or power change greater than 3% of Take-off Power or Thrust , but less than the change defined as an LOTC/LOPC event, should be contained in the SSA documentation. There are no firm specifications relating to this class of Faults for Engine certification; however the rate of occurrence of these types of Faults should be reasonably low, in the order of 10^{-4} events per Engine flight hour or less. These Faults may be required to be included in aircraft certification analysis.

Signals sent from one Engine Control System to another in an aeroplane installation, such as signals used for an Automatic Take-off Thrust Control System (ATTCS), synchrophasing, etc., are addressed under CS-E 50 (g). They should be limited in authority by the receiving Engine Control System, so that undetected Faults do not result in an unacceptable change in thrust or power on the Engine using those signals. The maximum thrust or power loss on the Engine using a cross-Engine signal should generally be limited to 3% absolute difference of the current operating condition.

Note: It is recognised that ATTCS, when activated, may command a thrust or power increase of 10% or more on the remaining Engine(s). It is also recognised that signals sent from one Engine control to another in a rotorcraft installation, such as load sharing and One Engine Inoperative (OEI), can have a much greater impact on Engine power when those signals fail. Data of these Failure modes should be contained in the SSA.

When operating in the take-off envelope, detected Faults in the Engine Control System, which result in a thrust or power change of up to 10% (15% for piston engines) may be acceptable if the total frequency of occurrence for these types of Failures is relatively low. The predicted frequency of occurrence for this category of Faults should be contained in SSA documentation. It should be noted that requirements for the allowable frequency of occurrence for this category of Faults and any need for a flight deck indication of these conditions would be reviewed during aircraft certification. A total frequency of occurrence in excess of 10^{-4} events per Engine flight hour would not normally be acceptable.

Detected Faults in signals exchanged between Engine Control Systems should be accommodated so as not to result in greater than a 3% thrust or power change on the Engine using the cross-Engine signals.

(9) PROTECTIVE FUNCTIONS

(a) Rotor Over-speed Protection.

Rotor over-speed protection is usually achieved by providing an independent over-speed protection system, such that it requires two independent Faults or malfunctions (as described below) to result in an uncontrolled over-speed.

The following guidance applies if the rotor over-speed protection is provided solely by an Engine Control System protective function.

For dispatchable configurations, refer to CS-E 1030 and AMC E 1030.

The SSA should show that the probability per Engine flight hour of an uncontrolled over-speed condition from any cause in combination with a Failure of the over-speed protection system to function is less than one event per hundred million hours (a Failure rate of 10^{-8} events per Engine flight hour).

The over-speed protection system would be expected to have a Failure rate of less than 10^{-4} Failures per engine flight hour to ensure the integrity of the protected function.

A self-test of the over-speed protection system to ensure its functionality prior to each flight is normally necessary for achieving the objectives. Verifying the functionality of the over-speed protection system at Engine shutdown and/or start-up is considered adequate for compliance with this requirement. It is recognised that some Engines may routinely not be shut down between flight cycles. In this case this should be accounted for in the analyses.

Because in some over-speed protection systems there are multiple protection paths, there will always be uncertainty that all paths are functional at any given time. Where multiple paths can invoke the over-speed protection system, a test of a different path may be performed each Engine cycle. The objective is that a complete test of the over-speed system, including electro-mechanical parts, is achieved in the minimum number of Engine cycles. This is acceptable so long as the system meets a 10^{-4} Failure rate.

The applicant may provide data that demonstrates that the mechanical parts (this does not include the electro-mechanical parts) of the over-speed protection system can operate without Failure between stated periods, and a periodic inspection may be established for those parts. This data is acceptable in lieu of testing the mechanical parts of the sub-system each Engine cycle.

(b) Other protective functions

The Engine Control System may perform other protective functions. Some of these may be Engine functions, but others may be aircraft or Propeller functions. Engine functions should be considered under the guidelines of this AMC. The integrity of other protective functions provided by the Engine Control System should be consistent with a safety analysis associated with those functions, but if those functions are not Engine functions, they may not be a part of Engine certification.

As Engine Control Systems become increasingly integrated into the aircraft and Propeller systems, they are incorporating protective functions that were previously provided by the aircraft or Propeller systems. Examples are reducing the Engine to idle thrust if a thrust reverser deploys and providing the auto-feather function for the Propeller when an Engine fails.

The reliability and availability associated with these functions should be consistent with the top level hazard assessment of conditions involving these functions. This will be completed during aircraft certification.

For example, if an Engine Failure with loss of the auto-feather function is catastrophic at the aircraft level - and the auto-feather function is incorporated into the Engine Control System - the applicant will have to show for CS-25 installations (or CS-23 installations certified to CS-25 specifications) that an Engine Failure with loss of the auto-feather function cannot result from a single control system Failure, and that combinations of control system Failures, or Engine and control system Failures, which lead to a significant Engine loss of thrust or power with an associated loss of the autofeather function may be required to have an extremely improbable event rate (i.e., 10^{-9} events per Engine flight hour).

Although these functions await evaluation at the aircraft level, it is strongly recommended that, if practicable, the aircraft level hazard assessment involving these functions be available at the time of the Engine Control System certification. This will facilitate discussions and co-ordination between the Engine and aircraft certification teams under the conditions outlined in paragraph (15) of this AMC. It is recognised that this co-ordination may not occur for various reasons. Because of this, the applicant should recognise that although the Engine may be certified, it may not be installable at the aircraft level.

The overall requirement is that the safety assessment of the Engine Control System should include all Failure modes of all functions incorporated in the system. This includes those functions which are added to support aircraft certification, so that the information of those Failure modes will get properly addressed and passed on to the installer for inclusion in the airframe SSA. Information concerning the frequencies of occurrence of those Failure modes may be needed as well.

(10) SOFTWARE DESIGN AND IMPLEMENTATION

(a) Objective

For Engine Control Systems that use software, the objective of CS-E 50 (f) is to prevent as far as possible software errors that would result in an unacceptable effect on power or thrust, or any unsafe condition.

It is understood that it may be impossible to establish with certainty that the software has been designed without errors. However, if the applicant uses the software level appropriate for the criticality of the performed functions and uses an approved software development method, the Agency would consider the software to be compliant with the requirement to minimise errors. In multiple Engine installations, the possibility of software errors common to more than one Engine Control System may determine the criticality level of the software.

(b) Approved Methods

Methods for developing software, compliant with the guidelines of documents RTCA DO-178A/EUROCAE ED-12A and RTCA DO-178B/EUROCAE ED-12B, hereafter referred to as DO-178A and DO-178B, respectively, are acceptable methods. Alternative methods for developing software may be proposed by the applicant and are subject to approval by the Agency.

Software which is not developed using DO-178B is referred to as legacy software. In general, changes made to legacy software applicable to its original installation are assured in the same manner as the original certification. When legacy software is used in a new aircraft installation that requires DO-178B, the original approval of the legacy software is still valid, assuming equivalence to the required software level can be ascertained. If the software equivalence is acceptable to the Agency, the legacy software can be used in the new installation that requires DO-178B software. If equivalence cannot be substantiated, all the software changes should be assured using DO-178B.

(c) Level of software design assurance

In multiple Engine installations, the design, implementation and verification of the software in accordance with Level 1 (DO-178A) or Level A (DO-178B) is normally needed to achieve the certification objectives for aircraft to be type certificated under CS-25, CS-27-Category A and CS-29-Category A.

The criticality of functions on other aircraft may be different, and therefore, a different level of software design assurance may be acceptable. For example, in the case of a piston engine in a single-engine aircraft, level C (DO-178B) software has been found to be acceptable.

Determination of the appropriate software level may depend on the Failure modes and consequences of those Failures. For example, it is possible that Failures resulting in significant thrust or power increases or oscillations may be more severe than an Engine shutdown, and therefore, the possibility of these types of Failures should be considered when selecting a given software level.

It may be possible to partition non-critical software from the critical software and design and implement the non-critical software to a lower level as defined by the RTCA documents. The adequacy of the partitioning method should be demonstrated. This demonstration should consider whether the partitioned lower software levels are appropriate for any anticipated installations. Should the criticality level be higher in subsequent installations, it would be difficult to raise the software level.

(d) On-Board or Field Software Loading and Part Number Marking

The following guidelines should be followed when on-board or field loading of Electronic Engine Control software and associated Electronic Part Marking (EPM) is implemented.

For software changes, the software to be loaded should have been documented by an approved design change and released with a service bulletin.

For an EECS unit having separate part numbers for hardware and software, the software part number(s) need not be displayed on the unit as long as the software part number(s) is(are) embedded in the loaded software and can be verified by electronic means. When new software is loaded into the unit, the same verification requirement applies and the proper software part number should be verified before the unit is returned to service.

For an EECS unit having only one part number, which represents a combination of a software and hardware build, the unit part number on the nameplate should be changed or updated when the new software is loaded. The software build or version number should be verified before the unit is returned to service.

The configuration control system for an EECS that will be onboard/field loaded and using electronic part marking should be approved. The drawing system should provide a compatibility table that tabulates the combinations of hardware part numbers and software versions that have been approved by the Agency. The top-level compatibility table should be under configuration control, and it should be updated for each change that affects hardware/software combinations. The applicable service bulletin should define the hardware configurations with which the new software version is compatible.

The loading system should be in compliance with the guidelines of DO-178B.

If the applicant proposes more than one source for loading, (e.g., diskette, mass storage, etc.), all sources should comply with these guidelines.

The service bulletin should require verification that the correct software version has been loaded after installation on the aircraft.

(e) Software Change Category

The processes and methods used to change software should not affect the design assurance level of that software. For classification of software changes, refer to §4 in Appendix A of GM 21A.91.

(f) Software Changes by Others than the TC Holder

There are two types of potential software changes that could be implemented by someone other than the original TC holder:

- option-selectable software, or
- user-modifiable software (UMS).

Option-selectable changes would have to be pre-certified utilising a method of selection which has been shown not to be capable of causing a control malfunction.

UMS is software intended for modification by the aircraft operator without review by the certification authority, the aircraft applicant, or the equipment vendor. For Engine Control Systems, UMS has generally not been applicable. However, approval of UMS, if required, would be addressed on a case-by-case basis.

The necessary guidance for UMS is contained in DO-178B, paragraph 2.4. In essence, it conveys the position that others than the TC holder may modify the software within the modification constraints defined by the TC holder, if the system has been certified with the provision for software user modifications. To certify an Electronic Engine Control System with the provision for software modification by others than the TC holder, the TC holder should (1) provide the necessary information for approval of the design and implementation of a software change, and (2) demonstrate that the necessary precautions have been taken to prevent the user modification from affecting Engine airworthiness, whether the user modification is correctly implemented or not.

In the case where the software is changed in a manner not pre-allowed by the TC holder as “user modifiable”, the “non-TC holder” applicant will have to comply with the requirements given in Part 21, subpart E.

(11) PROGRAMMABLE LOGIC DEVICES

CS-E 50 (f) applies to devices referred to as Programmable Logic Devices.

Because of the nature and complexity of systems containing digital logic, the Programmable Logic Devices should be developed using a structured development approach, commensurate with the hazard associated with Failure or malfunction of the system in which the device is contained.

RTCA DO-254/ EUROCAE ED-80 which describes the standards for the criticality and design assurance levels associated with Programmable Logic Devices development, is an acceptable means, but not the only means, for showing compliance with CS-E 50 (f).

For off-the-shelf equipment or modified equipment, service experience may be used in showing compliance to these standards. This should be acceptable provided the worst case Failure or malfunction of the device for the new installation is no more severe than that for original installation of the same equipment on another installation. Consideration should also be given to any significant differences related to environmental, operational or the category of the aircraft where the original system was installed and certified.

(12) AIRCRAFT-SUPPLIED DATA

(a) Objective

As required by CS-E 50 (g), in case of loss, interruption, or corruption of Aircraft-Supplied Data, the Engine should continue to function in a safe and acceptable manner, without unacceptable effects on thrust or power, Hazardous Engine Effects, or loss of ability to comply with the operating specifications of CS-E 390, CS-E 500 (a) and CS-E 745, as appropriate.

(b) Background

Historically, regulatory practice was to preserve the Engine independence from the aircraft. Hence even with very reliable architecture, such as triply redundant air data computer (ADC) systems, it was required that the Engine Control System provided an independent control means that could be used to safely fly the aircraft should all the ADC signals be lost.

However, with the increased Engine-aircraft integration that is currently occurring in the aviation industry and with the improvement in reliability and implementation of Aircraft-Supplied Data, the regulatory intent is being revised to require that Fault Accommodation be provided against single Failures of Aircraft-Supplied Data. This may include Fault Accommodation by transition into another Control Mode that is independent of Aircraft-Supplied Data.

The Engine Control System's LOTC/LOPC analysis should contain the effects of air data system Failures in all allowable Engine Control System and air data system dispatch configurations.

When Aircraft-Supplied Data can affect Engine Control System operation, the applicant should address the following items, as applicable, in the SSA or other appropriate documents:

- Software in the data path to the EECS should be at a level consistent with that defined for the EECS. The data path may include other aircraft equipment, such as aircraft thrust management computers, or other avionics equipment.

- The applicant should state in the instructions for installation that the aircraft applicant is responsible for ensuring that changes to aircraft equipment, including software, in the data path to the Engine do not affect the integrity of the data provided to the Engine as defined by the Engine instructions for installation.

- The applicant should supply the effects of faulty and corrupted Aircraft-Supplied Data on the EECS in the Engine instructions for installation.

- The instructions for installation should state that the installer should ensure that those sensors and equipment involved in delivering information to the EECS are capable of operating in the EMI, HIRF and lightning environments, as defined in the certification basis for the aircraft, without affecting their proper and continued operation.

- The applicant should state the reliability level for the Aircraft-Supplied Data that was used as part of the SSA and LOTC/LOPC analysis as an "assumed value" in the instructions for installation.

As stated in CS-E 50 (g), thrust and power command signals sent from the aircraft are not subject to the specifications of CS-E 50 (g)(2). If the aircraft thrust or power command system is configured to move the Engine thrust or power levers or transmit an electronic signal to command a thrust or power change, the Engine Control System merely responds to the command and changes Engine thrust or power as appropriate. The Engine Control System may have no way of knowing that the sensed throttle or power lever movement was correct or erroneous.

In both the moving throttle (or power lever) and non-moving throttle (or power lever) configurations, it is the installer's responsibility to show that a proper functional hazard analysis is performed on the aircraft system involved in generating Engine thrust or power commands, and that the system meets the appropriate aircraft's functional hazard assessment safety related specifications. This task is an aircraft certification issue, however Failures of the system should be included in the Engine's LOTC/LOPC analysis.

(c) Design assessment

The applicant should prepare a Fault Accommodation chart that defines the Fault Accommodation architecture for the Aircraft-Supplied Data.

There may be elements of the Engine Control System that are mounted in the aircraft and are not part of the Engine type design, but which are dedicated to the Engine Control System and powered by it, such as a throttle position resolver. In these instances, such elements are considered to be an integral component of the Electronic Engine Control System and are not considered aircraft data.

In the case where the particular Failure modes of the aircraft air data may be unknown, the typical Failure modes of loss of data and erroneous data should be assumed. The term "erroneous data" is used herein to describe a condition where the data appears to be valid but is incorrect.

Such assumptions and the results of the evaluation of erroneous aircraft data should be provided to the installer.

The following are examples of possible means of accommodation:

- Provision of an Alternate Mode that is independent of Aircraft-Supplied Data.

- Dual sources of aircraft-supplied sensor data with local Engine sensors provided as voters and alternate data sources.

- Use of synthesised Engine parameters to control or as voters. When synthesised parameters are used for control or voting purposes, the analysis should consider the impact of temperature and other environmental effects on those sensors whose data are used in the synthesis. The variability of any data or information necessary to relate the data from the sensors used in the synthesis to the parameters being synthesised should also be assessed.

- Triple redundant ADC systems that provide the required data.

If for aircraft certification it is intended to show that the complete loss of the aircraft air data system itself is extremely improbable, then it should be shown that the aircraft air data system is unaffected by a complete loss of aircraft generated power, for example, backed up by battery power. (See AMC 20-1)

(d) Effects on the Engine

CS-E 510 defines the Hazardous Engine Effects for turbine Engines.

CS-E 50 (g) is primarily intended to address the effects of aircraft signals, such as aircraft air data information, or other signals which could be common to all Engine Control Systems in a multi-Engine installation. The control system design should ensure that the full-up system is capable of providing the declared minimum rated thrust or power throughout the Engine operating envelope.

CS-E 50 (g) requires the applicant to provide an analysis of the effect of loss or corruption of aircraft data on Engine thrust or power. The effects of Failures in Aircraft-Supplied Data should be documented in the

SSA as described in Section (8) above. Where appropriate, aircraft data Failures or malfunctions that contribute to LOTC/LOPC events should be included in the LOTC/LOPC analysis.

(e) Validation

Functionality of the Fault Accommodation logic should be demonstrated by test, analysis, or combination thereof. In the case where the aircraft air data system is not functional because of the loss of all aircraft generated power, the Engine Control System should include validated Fault Accommodation logic which allows the Engine to operate acceptably with the loss of all aircraft-supplied air data. Engine operation in this system configuration should be demonstrated by test.

For all dispatchable Control Modes, see CS-E 1030 and AMC E 1030.

If an Alternate Mode, independent of Aircraft-Supplied Data, has been provided to accommodate the loss of all data, sufficient testing should be conducted to demonstrate that the operability specifications have been met when operating in this mode. Characteristics of operation in this mode should be included in the instructions for installation and operation as appropriate. This Alternate Mode need not be dispatchable.

(13) AIRCRAFT SUPPLIED ELECTRICAL POWER

(a) Objective

The objective is to provide an electrical power source that is single Fault tolerant (including common cause or mode) in order to allow the EECS to comply with CS-E 50 (c)(2). The most common practice for achieving this objective has been to provide a dedicated electrical power source for the EECS. When aircraft electrical power is used, the assumed quality and reliability levels of this aircraft power should be contained in the instructions for installation.

(b) Electrical power sources

An Engine dedicated power source is defined herein as an electric power source providing electrical power generated and supplied solely for use by a single Engine Control System. Such a source is usually provided by an alternator(s), mechanically driven by the Engine or the transmission system of rotorcraft. However, with the increased integration of the Engine-aircraft systems and with the application of EECS to small Engines, both piston and turbine, use of an Engine-mounted alternator may not necessarily be the only design approach for meeting the objective.

Batteries are considered an Aircraft-Supplied Power source except in the case of piston Engines. For piston Engines, a battery source dedicated solely to the Engine Control System may be accepted as an Engine dedicated power source. In such applications, appropriate information for the installer should be provided including, for example, health status and maintenance requirements for the dedicated battery system.

(c) Analysis of the design architecture

An analysis and a review of the design architecture should identify the requirements for Engine dedicated power sources and Aircraft-Supplied Power sources. The analysis should include the effects of losing these sources. If the Engine is dependent on Aircraft-Supplied Power for any operational functions, the analysis should result in a definition of the requirements for Aircraft-Supplied Power.

The following configurations have been used:

- EECS dependent on Aircraft-Supplied Power

- EECS independent of Aircraft-Supplied Power (Engine dedicated power source)
- Aircraft-Supplied Power used for functions, switched by the EECS
- Aircraft-Supplied Power directly used for Engine functions, independently from the EECS
- Aircraft-Supplied Power used to back up the Engine dedicated power source

The capacity of any Engine dedicated power source, required to comply with CS-E 50 (h)(2), should provide sufficient margin to maintain confidence that the Engine Control System will continue to function in all anticipated Engine operating conditions where the control system is designed and expected to recover Engine operation automatically in-flight. The autonomy of the Engine Control System should be sufficient to ensure its functioning in the case of immediate automatic relight after unintended shutdown. Conversely, the autonomy of the Engine Control System in the whole envelope of restart in windmilling conditions is not always required. This margin should account for any other anticipated variations in the output of the dedicated power source such as those due to temperature variations, manufacturing tolerances and idle speed variations. The design margin should be substantiated by test and/or analysis and should also take into account any deterioration over the life of the Engine.

(d) Aircraft-Supplied Power Reliability

Any Aircraft-Supplied Power reliability values used in system analyses, whether supplied by the aircraft manufacturer or assumed, should be contained in the instructions for installation.

When Aircraft-Supplied Power is used in any architecture, if aircraft power Faults or Failures can contribute to LOTC/LOPC or Hazardous Engine Effects, these events should be included in the Engine SSA and LOTC/LOPC analyses.

When compliance with CS-E 50 (h)(1) imposes an Engine dedicated power source, Failure of this source should be addressed in the LOTC/LOPC analysis required under CS-E 50 (c). While no credit is normally necessary to be given in the LOTC/LOPC analysis for the use of Aircraft-Supplied Power as a back-up power source, Aircraft-Supplied Power has typically been provided for the purpose of accommodating the loss of the Engine dedicated power source. However, LOTC/LOPC allowance and any impact on the SSA for the use of Aircraft-Supplied Power as the sole power source for an Engine control Back-up System or as a back-up power source would be reviewed on a case-by-case basis.

In some system architectures, an Engine dedicated power source may not be required and Aircraft-Supplied Power may be acceptable as the sole source of power.

An example is a system that consists of a primary electronic single channel and a full capability hydromechanical Back-up System that is independent of electrical power (a full capability hydromechanical control system is one that meets all CS-E specifications and is not dependent on aircraft power). In this type of architecture, loss or interruption of Aircraft-Supplied Power is accommodated by transferring control to the hydromechanical system. Transition from the electronic to the hydromechanical control system is addressed under CS-E 50 (b).

Another example is an EECS powered by an aircraft power system that could support a critical fly-by-wire flight control system. Such a power system may be acceptable as the sole source of power for an EECS. In this example, it should be stated in the instructions for installation that a detailed design review and safety analysis is to be conducted to identify latent failures and common cause failures that could result in the loss of all electrical power. The instructions should also state that any emergency power sources must be known to be operational at the beginning of the flight. Any emergency power sources must be isolated from the normal electrical power system in such a way that the emergency power system will be available no matter what happens to the normal generated power system. If batteries are the source of emergency power, there must be a means of determining their condition prior to flight, and their capacity must be shown to be sufficient to assure exhaustion will not occur before getting the aircraft safely back on the ground.

This will satisfy that appropriate reliability assumptions are provided to the installer.

(e) Aircraft-Supplied Power Quality

When Aircraft-Supplied Power is necessary for operation of the Engine Control System, CS-E 50 (h)(3) specifies that the Engine instructions for installation contain the Engine Control System's electrical power supply quality requirements. This applies to any of the configurations listed in paragraph (13)(c) or any new configurations or novel approach not listed that use Aircraft-Supplied Power. These quality requirements should include steady state and transient under-voltage and over-voltage limits for the equipment. The power input standards of RTCA DO-160/EUROCAE ED-14 are considered to provide an acceptable definition of such requirements. If RTCA DO-160/EUROCAE ED-14 is used, any exceptions to the power quality standards cited for the particular category of equipment specified should be stated.

It is recognised that the electrical or electronic components of the Engine Control System when operated on Aircraft-Supplied Power may cease to operate during some low voltage aircraft power supply conditions beyond those required to sustain normal operation, but in no case should the operation of the Engine control result in a Hazardous Engine Effect. In addition, low voltage transients outside the control system's declared capability should not cause permanent loss of function of the control system, or result in inappropriate control system operation which could cause the Engine to exceed any operational limits, or cause the transmission of unacceptable erroneous data.

When aircraft power recovers from a low-voltage condition to a condition within which the control system is expected to operate normally, the Engine Control System should resume normal operation. The time interval associated with this recovery should be contained in the Engine instructions for installation. It is recognised that Aircraft-Supplied Power conditions may lead to an Engine shutdown or Engine condition which is not recoverable automatically. In these cases the Engine should be capable of being restarted, and any special flight crew procedures for executing an Engine restart during such conditions should be contained in the Engine instructions for operation. The acceptability of any non-recoverable Engine operating conditions - as a result of these Aircraft-Supplied Power conditions - will be determined at aircraft certification.

If Aircraft-Supplied Power supplied by a battery is required to meet an "all Engines out" restart requirement, the analysis according to paragraph 13(c) should result in a definition of the requirements for this Aircraft-Supplied Power. In any installation where aircraft electrical power is used to operate the Engine Control System, such as low Engine speed in-flight re-starting conditions, the effects of any aircraft electrical bus-switching transients or power transients associated with application of electrical loads, which could cause an interruption in voltage or a decay in voltage below that level required for proper control functioning, should be considered.

(f) Effects on the Engine

Where loss of aircraft power results in a change in Engine Control Mode, the Control Mode transition should meet the specifications of CS-E 50 (b).

For some Engine control functions that rely exclusively upon Aircraft-Supplied Power, the loss of electrical power may still be acceptable. Acceptability is based on evaluation of the change in Engine operating characteristics, experience with similar designs, or the accommodation designed into the control system.

Examples of such Engine control functions that have traditionally been reliant on aircraft power include:

- Engine start and ignition

- Thrust Reverser deployment
- Anti-Icing (Engine probe heat)
- Fuel Shut-Off
- Over-speed Protection Systems
- Non-critical functions that are primarily performance enhancement functions which, if inoperative, do not affect the safe operation of the Engine.

(g) Validation

The applicant should demonstrate the effects of loss of Aircraft-Supplied Power by Engine test, system validation test or bench test or combination thereof.

(14) PISTON ENGINES

Piston Engines are addressed by the sections above; no additional specific guidance is necessary.

CS-E 50 specifications are applicable to these Engines but, when interpretation is necessary, the conditions which would be acceptable for the aircraft installation should be considered.

(15) ENGINE, PROPELLER AND AIRCRAFT SYSTEMS INTEGRATION AND INTER-RELATION BETWEEN ENGINE, PROPELLER AND AIRCRAFT CERTIFICATION ACTIVITIES

(a) Aircraft or Propeller Functions Integrated into the Engine Control System

This involves the integration of aircraft or Propeller functions (i.e., those that have traditionally not been considered Engine control functions), into the Electronic Engine Control System's hardware and software.

Examples of this include thrust reverser control systems, Propeller speed governors, which govern speed by varying pitch, and ATTCS. When this type of integration activity is pursued, the EECS becomes part of - and should be included in the aircraft's SSA, and although the aircraft functions incorporated into the EECS may receive review at Engine certification, the acceptability of the safety analysis involving these functions should be determined at aircraft certification.

The EECS may be configured to contain only part of the aircraft system's functionality, or it may contain virtually all of it. Thrust reverser control systems are an example where only part of the functionality is included in the EECS. In such cases, the aircraft is configured to have separate switches and logic (i.e., independent from the EECS) as part of the thrust reverser control system. This separation of reverser control system elements and logic provides an architectural means to limit the criticality of the functions provided by the EECS.

However, in some cases the EECS may be configured to incorporate virtually all of a critical aircraft function. Examples of this "virtual completeness" in aircraft functionality are EECS which contain full authority to govern Propeller speed in turboprop powered aircraft and ATTCS in turbofan power aircraft.

The first of these examples is considered critical because, if an Engine fails, the logic in the Engine Control System should be configured to feather the Propeller on that Engine. Failure to rapidly feather the Propeller following an Engine Failure results in excessive drag on the aircraft, and such a condition can be critical to the aircraft. When functions like these are integrated into the Engine control such that they render an EECS critical, special attention should be paid to assuring that no single (including common cause/mode) Failures could cause the critical Failure condition, e.g. exposure of the EECS to overheat should not cause both an Engine shutdown and Failure of the Propeller to feather.

The second example, that of an ATTCS, is considered critical because the system is required to increase the thrust of the remaining Engine(s) following an Engine Failure during takeoff, and the increased thrust on the remaining Engines is necessary to achieve the required aircraft performance.

All of the above examples of integration involve aircraft functionality that would receive significant review during aircraft certification.

(b) Integration of Engine Control Functions into Aircraft Systems

The trend toward systems integration may lead to aircraft systems performing functions traditionally considered part of the Engine Control System. Some designs may use aircraft systems to implement a significant number of the Engine Control System functions. An example would be the complex integrated flight and Engine Control Systems – integrated in aircraft avionics units - which govern Engine speed, rotor speed, rotor pitch angle and rotor tilt angle in tilt-rotor aircraft.

In these designs, aircraft systems may be required to be used during Engine certification. In such cases, the Engine applicant is responsible for specifying the requirements for the EECS in the instructions for installation and substantiating the adequacy of those requirements.

An example of limited integration would be an Engine control which receives a torque output demand signal from the aircraft and responds by changing the Engine's fuel flow and other variables to meet that demand. However, the EECS itself, which is part of the type design, provides all the functionality required to safely operate the Engine in accordance with CS-E or other applicable specifications.

(c) Certification activities

(i) Objective

To satisfy the aircraft specifications, such as CS 25.901, CS 25.903 and CS 25.1309, an analysis of the consequences of Failures of the Engine Control System on the aircraft has to be made. The Engine applicant should, together with the aircraft applicant, ensure that the software levels and safety and reliability objectives for the Engine electronic control system are consistent with these specifications.

(ii) Interface Definition and System Responsibilities

System responsibilities as well as interface definitions should be identified for the functional and hardware and software aspects between the Engine, Propeller and the aircraft systems in the appropriate documents.

The Engine/Propeller/aircraft documents should cover in particular:

- Functional requirements and criticality (which may be based on Engine, Propeller and aircraft considerations)
- Fault Accommodation strategies
- Maintenance strategies
- The software level (per function if necessary),
- The reliability objectives for:

– LOTC/LOPC events

– Transmission of faulty parameters

- The environmental requirements including the degree of protection against lightning or other electromagnetic effects (e.g. level of induced voltages that can be supported at the interfaces)

- Engine, Propeller and aircraft interface data and characteristics

- Aircraft power supply requirements and characteristics (if relevant).

(iii) Distribution of Compliance Tasks

The tasks for the certification of the aircraft propulsion system equipped with Electronic Engine Control Systems may be shared between the Engine, Propeller and aircraft applicants. The distribution of these tasks between the applicants should be identified and agreed with the appropriate Engine, Propeller and aircraft authorities. For further information refer to AMC 20-1.

The aircraft certification should deal with the overall integration of the Engine and Propeller in compliance with the applicable aircraft specifications.

The Engine certification will address the functional aspects of the Engine Control System in compliance with the applicable Engine specifications.

Appropriate evidence provided for Engine certification should be used for aircraft certification. For example, the quality of any aircraft function software and aircraft/Engine interface logic already demonstrated for Engine certification should need no additional substantiation for aircraft certification.

Two examples are given below to illustrate this principle.

(A) Case of an EECS performing the functions for the control of the Engine and the functions for the control of the Propeller.

The Engine certification would address all general requirements such as software quality assurance procedures, EMI, HIRF and lightning protection levels, effects of loss of aircraft-supplied power.

The Engine certification would address the functional aspects for the Engine functions (safety analysis, rate for LOTC/LOPC events, effect of loss of Aircraft-Supplied Data, etc.). The Fault Accommodation logic affecting the control of the Engine, for example, will be reviewed at that time.

The Propeller certification will similarly address the functional aspects for the Propeller functions. The Fault Accommodation logic affecting the control of the Propeller, for example, will be reviewed at that time.

In this example, the Propeller functions and characteristics defined by the Propeller applicant, that are to be provided by the Engine Control System, would normally need to be refined by flight test. The Propeller applicant is responsible for ensuring that these functions and characteristics, that are provided for use during the Engine certification programme, define an airworthy Propeller configuration, even if they have not yet been refined by flight test.

With regard to changes in design, agreement by all parties involved should be reached so that changes to the Engine Control System that affect the Propeller system, or vice versa, do not lead to any inadvertent effects on the other system.

(B) Case of an aircraft computer performing the functions for the control of the Engine.

The aircraft certification will address all general requirements such as software quality assurance procedures, EMI, HIRF and lightning protection levels.

The aircraft certification will address the functional aspects for the aircraft functions.

The Engine certification will address the functional aspects for the Engine functions (safety analysis, rate for LOTC/LOPC events, effect of loss of Aircraft-Supplied Data, etc.) The Fault Accommodation logic affecting the control of the Engine, for example, will be reviewed at that time.

AMC 20-11 Acceptable Means of Compliance for the Approval of use of Initial Services for Air-Ground Data Link in Continental Airspace

1 PREAMBLE

Controller Pilot Data Link Communications, CPDLC is identified in the ATM Strategy for the years 2000+ as an enabler for operational improvement. They reduce controller workload and increase sector capacity. Simulations show that the sector capacity is increased by 11% if 75% of all controlled flights have CPDLC data link capability. The deployment strategy of CPDLC data link services is a three-step plan:

- Pioneer support for at least the first 150 aircraft.
- Incentives mechanisms for aircraft with CPDLC capability to foster the aircraft equipage with data link capability.
- Single European Sky interoperability implementing rules on data link services.

2 PURPOSE

This AMC is for aircraft operators seeking approval to use initial data link services in continental airspace. It contains:

- a set of assumptions relating to the implementation of data link services by air navigation service providers, communications service providers, aeronautical information service providers;
- an initial basis relating to the implementation of data link services in the flight deck to guide the airworthiness certification process;
- an initial basis relating to the operational use of data link services by aircraft operators to guide the operational approval process.

3 SCOPE

3.1 This AMC is applicable to services for with the following capabilities:

a) Data Link Initiation Capability (DLIC) enables initial contact between the aircraft and an ATC unit that supports data communications, to unambiguously identify the aircraft, and to ensure compatibility of aircraft equipage with ATC. It is a prerequisite to any other operational data link services.

b) ATC Communication Management (ACM) provides the necessary information to the aircraft to enable transfer of frequencies for both voice and data communications, either within the same sector, between two sectors or between two ATC centres.

c) ATC Clearances (ACL) enables uplink of a set of clearance and information messages and downlink of pilot responses and requests.

d) ATC Microphone Check (AMC) enables the controller to send a message to data link equipped aircraft (of appropriate interoperability) to request a stuck microphone check.

e) Departure Clearance (DCL) enables the request and the delivery of departure information and clearance.

f) Downstream Clearance (DSC) enables the request and the delivery of clearance with a downstream ATC centre (i.e. oceanic clearance).

g) D-ATIS enables the request and the delivery of ATIS via data link.

Note : Implementations of DCL, D-ATIS and OCL over ACARS are not the subject of this AMC. Reference should be made to other applicable JAA or EASA documents based on ED85A, ED89A and ED106A.

4 REFERENCE DOCUMENTS

4.1 Related Requirements

CS/FAR 25.1301, 25.1307, 25.1309, 25.1322, 25.1431, 25.1581, or equivalent requirements of CS 23, 27 and 29, if applicable.

4.2 Related Standards and Guidance Material

ICAO	Annex 2	Rules of the Air.
	Annex 6	Operation of Aircraft, Part I - International Commercial Air Transport – Aeroplanes.
	Annex 10	Aeronautical Telecommunications - Volume II (Communications Procedures including those with PANS status).
	Annex 11	Air Traffic Services.
	Annex 15	Aeronautical Information Services.
	Doc 4444	Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM)
	Doc 8585	Designators for Aircraft Operating agencies, Aeronautical Authorities and Services.
	Doc 9694	Manual of Air Traffic Services (ATS) Data Link Applications.
EASA	AMC 25-11	Electronic Display Systems.
EUROCONTROL	LINK 2000+/PM/BASE LINE/	LINK Baseline, Version 1.4, November 2006
	AGC-ORD-01	EATCHIP/ODIAC Operational Requirements for Air ground cooperative air traffic services Edition1.0. 2 April 2001.
	ESARR 4	Risk assessment and mitigation in ATM.
FAA	AC 25-11	Electronic Display Systems.
	AC 120-70	Initial Air Carrier Operational Approval for use of Digital Communication Systems.
	AC 20-140	Guidelines for design approval of aircraft data communications systems.
EUROCAE	ED-78A	Guidelines for Approval of the Provision and Use of Air Traffic Services supported by Data communications.
	ED-92A	Minimum Operational Performance Specification for an Airborne VDL System.
	ED-112	Minimum operational performance specification for Crash protected airborne recorder systems
	ED-110B	Interoperability Requirements Standard for ATN Baseline 1 (INTEROP ATN B1).
	ED-120	Safety and Performance Requirements Standard for Initial Data Link Services In Continental Airspace (SPR IC) including change 1 and change 2.
RTCA	DO-224A	Signal-in-Space Minimum Aviation System Performance Standards (MASPS) for Advanced VHF Digital Data Communications Including Compatibility with Digital Voice Techniques.
	DO-264	Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications. (Equivalent to ED-78A)
	DO-280B	Interoperability Requirements Standard for ATN B1 (Equivalent to ED-110B)
	DO-290	Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard) including change 1 and change 2. (Equivalent to ED-120)
SAE	ARP 4791	Human Machine Interface on the flight deck.

5 ASSUMPTIONS

Applicants should note that this AMC is based on the following assumptions.

5.1 Air Navigation Service Provider (ANSP)

5.1.1 Air navigation service providers implement all services or a subset compliant with relevant requirements of:

- the Safety and Performance Requirements of EUROCAE standard SPR ED-120,
- and the interoperability requirements of EUROCAE standard INTEROP ED-110B.

Deviations from these standards are assessed by ANSPs. Deviations that potentially impact the airborne domain should be assessed in coordination with relevant stakeholders as per ED-78A.

5.1.2 ANSP procedures specify the actions to be taken in case of failure of data link communication.

5.2 Communications Service Provider (CSP)

5.2.1 The CSP is committed to provide communication services to ANSPs and aircraft operators with the expected Quality of Service as defined in a specific Service Level Agreement. The Service Level Agreement is bilaterally agreed between the CSP and an ANSP. The terms of reference of the Service Level Agreement are consistent with the performance requirements of the SPR ED-120 document.

5.2.2 The CSP does not modify intentionally the operational information (content and format) of messages exchanged between the ANSP and the aircraft

5.3 Aeronautical Information Service (AIS)

5.3.1 Each State publishes in its AIP/NOTAM, or equivalent notification, information related to the data link service provisions, service schedule, relevant procedures, and confirmation of compliance with EUROCAE standard SPR, ED-120 and INTEROP ED-110B.

5.3.2 The publication will comprise a list of communication service providers that may be used by aircraft operators for the Link 2000+ services, taking into account internetworking arrangements between service providers.

6 AIRWORTHINESS CONSIDERATIONS

6.1 General

6.1.1 Qualification criteria requiring coordination is provided in ED-78A.

6.1.2 The installation should be shown to meet the safety and performance requirements allocated to the aircraft as provided in SPR ED-120, and the applicable interoperability requirements INTEROP ED-110B.

6.1.3 The VDL mode 2 radio transceiver should be compliant with ED-92A.

6.1.4 The airborne ATN router should be compliant with an ATN MOPS acceptable to the certification authority. In the absence of a published generic MOPS, the applicant may propose alternative minimum performance criteria for which interoperability and testability can be demonstrated.

6.1.5 Recording of ATS messages for accident investigation will need to be implemented when required by the applicable operational rules or by national regulation.

6.2 Human-machine interface on the flight deck

6.2.1 Compatibility. The human-machine interface should be compatible with the crew interface and flight deck design of the particular aircraft in which the data communications system and applications are installed.

6.2.1.1 If multiple ATS data link applications are available to the aircraft, the crew interface and related crew procedures should be based on a common and compatible philosophy.

6.2.2 Flight deck annunciation. The data communications system should have the following annunciation capability, which should be integrated into the flight deck so as to be compatible with the overall alerting scheme of the aircraft.

6.2.2.1 Unless otherwise substantiated by means acceptable to the certification authority, an audible and visual indication should be given for each uplink ATS message intended to be displayed to the flight crew, including those messages not be displayed immediately because of lack of crew acknowledgement to an earlier ATS message. Visual alerts alone may be used for non-ATS messages

6.2.2.2 The status of the data communications system should be available to the flight crew, e.g., loss of the data communications connection with communications management unit or its equivalent.

6.2.2.3 If message storage and/or printing capability is provided, the system should indicate when storage and/or printing is not possible.

6.2.2.4 Annunciation of the receipt of a message during critical flight phases (e.g., takeoff and landing) should be inhibited until after the critical flight phase. The criteria that define critical flight phases should be consistent with the particular flight deck philosophy and the particular data link services supported.

6.2.3 Flight deck controls. Control capability for the data communications system and applications should meet the following criteria:

6.2.3.1 Means should be provided for the flight crew to activate or deactivate each of the data communication applications.

6.2.3.2 Means should be provided to the aircrew to know in real time the identity of the ATS provider(s) connecting with the aircraft, and the applications involved with each connection.

6.2.3.3 Means should be provided for the flight crew to acknowledge receipt of ATS messages.

6.2.3.4 Means should be provided for the flight crew to list, select, and retrieve the most recent (e.g. ten) ATS messages received and sent by the flight crew during the flight segment. The status of each message, the time it was received or sent, should be accessible.

6.2.3.5 Means should be provided for the flight crew to clear uplinked messages from the display. However this capability should be protected against inadvertent clearing.

6.2.3.6 Means should be provided for the flight crew to create, store, retrieve, edit, delete, and send messages.

6.2.3.7 If a direct interface exists between the data communications application and other computer functions, (e.g. flight planning and navigation), a means should be provided for the flight crew to activate the computer function to use the data contained in the message. The means provided should be separate from that used to acknowledge receipt of a message.

6.2.4 Flight deck displays. Display capability of the data communications system and applications should meet the following criteria:

6.2.4.1 All messages should be displayed, without being truncated, in a format that the flight crew can comprehend without the need for translation from English into another language.

6.2.4.2 The flight crew should be able to read displayed messages without leaving their seats.

6.2.4.3 Except for the ATIS, messages from the ATS should be displayed without the need for flight crew action, and remain displayed until acknowledged, unless the flight crew selects another message or, in the case of a multi-function display, another display format or function. In these cases a reminder should indicate that pending messages are waiting for a response.

6.2.4.4 ATS messages should be displayed so that messages are distinguishable from each other. The status of each message (i.e. source, time sent, open/closed) should be displayed together with the message.

6.2.4.5 When the data communications application is sharing a display with other aircraft functions, the aircraft system should ensure appropriate priority for the information to be displayed.

6.2.4.6 If a message intended for visual display is greater than the available display area and only part of the message is displayed, a visual indication shall be provided to the pilot to indicate the presence of the message remainder.

6.2.5 Flight deck Printer. A flight deck printer may be used as a means of storing data communications messages received or sent during the current flight. It should satisfy integrity and interface design criteria appropriate for this purpose

7 ACCEPTABLE MEANS OF AIRWORTHINESS COMPLIANCE

7.1 Airworthiness

7.1.1 When showing compliance with this AMC, the following points should be noted:

a) The applicant will need to submit, to the Agency, a certification plan and a compliance statement that shows how the criteria of this AMC have been satisfied, together with evidence resulting from the activities described in the following paragraphs.

b) Compliance with the certification specifications (e.g. CS 25) for intended function and safety may be demonstrated by equipment qualification, safety analysis of the interface between the communications management system and other systems, structural analyses of new antenna installations, equipment cooling verification, and evidence of a human to machine interface, suitable for ATC initial continental data link services, and taking account of the criteria of paragraph 6.

c) The aircraft data communications system and applications should be demonstrated by end-to-end ground testing that verifies system operation interoperability and performance, either with an appropriate ATS unit, or by means of test equipment that has been shown to be representative of the actual ATS unit. The testing should verify system operation, interoperability, and performance.

Notes: 1 EUROCAE ED-78A gives guidance on test equipment for this purpose.
2 This limited testing assumes that the communication systems have been shown to satisfactorily perform their intended functions in the flight environment in accordance with applicable requirements.

d) When showing compliance with CS 25.1309, consideration should be given to the possibility of unacceptable interaction between the communications management system and other essential systems.

7.1.2 To minimise the certification effort for follow-on installations, the applicant may claim credit, from the responsible authority, for applicable certification and test data obtained from equivalent aircraft installations.

7.2 Performance

Where compliance with a performance requirement cannot readily be demonstrated by a test, then the performance may be verified by an alternative method such as analysis.

7.3 Aircraft Flight Manual

7.3.1 The Normal Procedures section of the Flight Manual shall provide a statement as follows:
“The aircraft ATC data link system has been demonstrated to comply with the applicable safety and performance requirements of EUROCAE ED-120, the interoperability requirements of ED-110B and with AMC 20-11. This AFM entry does not, by itself, constitute an operational approval where such an approval is required.”

7.3.2 The following information, as applicable to the specific services approved for the aircraft, will need to be included in either the Flight Manual or other operational documents.

“The aircraft ATC data link system is intended for the following data link services:

a) Data Link Initiation Capability (DLIC) enabling initial contact between the aircraft and an ATC unit that supports data communications, to unambiguously identify the aircraft, and to ensure compatibility of aircraft equipage with ATC. It is a prerequisite to any other operational data link services.

b) ATC Communication Management (ACM) providing the necessary information to the aircraft to enable transfer of frequencies for both voice and data communications, either within the same sector, between two sectors or between two ATC centres.

c) ATC Clearances (ACL) enabling uplink of a set of clearance and information messages and downlink of pilot responses and requests.

d) ATC Microphone Check (AMC) enabling the controller to send a message to data link equipped aircraft (of appropriate interoperability) to request a stuck microphone check.

e) Departure Clearance (DCL) enabling the request and the delivery of departure information and clearance.
f) Downstream Clearance (DSC) enabling the request and the delivery of clearance with a downstream ATC centre (i.e. oceanic clearance).
g) D-ATIS "enabling the request and the delivery of ATIS via data link."

7.4 Existing installations

7.4.1 The applicant will need to submit, to the responsible authority, a compliance statement, which shows how the criteria of this AMC have been satisfied for existing installations. Compliance may be supported by design review and inspection of the installed system to confirm the availability of required features, functionality and acceptable human-machine interface.

7.4.2 Where this design review finds items of non-compliance, the applicant may offer mitigation that demonstrates an equivalent level of safety and performance. Items presented by the applicant which impact safety, performance and interoperability requirements allocation will need to be coordinated in accordance with ED-78A.

8 OPERATIONAL CONSIDERATIONS

Reserved.

9 AVAILABILITY OF DOCUMENTS

102 rue Etienne Dolet – 92240 Malakoff - France.
Telephone : +33 1 40 92 79 30 ; FAX +33 1 46 55 62 65 ;. Web site: www.eurocae.eu.

JAA documents are available from the JAA publisher Information Handling Services (IHS). Information on prices, where and how to order is available on both the JAA web site www.jaa.nl and the IHS web site www.ihs.com.

EUROCONTROL documents may be requested from EUROCONTROL, Documentation Centre, GS4, Rue de la Fusee, 96, B-1130 Brussels, Belgium; (Fax: 32 2 729 9109 or web site www.eurocontrol.int).

ICAO documents may be purchased from Document Sales Unit, International Civil Aviation Organisation, 999 University Street, Montreal, Quebec, Canada H3C 5H7, (Fax: 1 514 954 6769, e-mail: sales_unit@icao.org) or through national agencies.

FAA documents may be obtained from Department of Transportation, Subsequent Distribution Office SVC-121.23, Ardmore East Business Centre, 3341 Q 75th Avenue, Landover, MD 20785, USA.

RTCA documents may be purchased from RTCA, Incorporated, 1828 L Street, Northwest, Suite 820, Washington, D.C. 20036-4001 U.S.A. Web site: www.rtca.org.

SAE documents may be obtained from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA. Telephone 1-877-606-7323 (U.S. and Canada only) or 724/776-4970 (elsewhere). Web site www.sae.org.

Appendix 1

Common Terms

Reference should be made to EUROCAE document ED-110B and ED-120 for definitions of terms.

Abbreviations

AAC	Aeronautical Administrative Communications
ACARS	Aircraft Communications Addressing and Reporting System
ACC	Area Control Centre
ACL	ATC Clearances
ACM	ATC Communication Management
ADS	Automatic Dependent Surveillance
AIP	Aeronautical Information Publication
AMC	ATC Microphone Check (service)
AMJ	Advisory Material Joint
ANS	Air Navigation Service
ARINC	Aeronautical Radio Incorporated (USA)
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSU	Air Traffic Service Unit
CAA	Civil Aviation Authority
CFR	Code of Federal Regulations
CM	Configuration (Context) Management
CMU	Communications Management Unit
CNS	Communication, Navigation and Surveillance
CNS/ATM	Communication, Navigation and Surveillance / Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
CS	Certification Specifications
CSP	Communication Service Provider
D-ATIS	Data Link ATIS
DCL	Departure Clearance
DFIS	Data Link Flight Information Service (ICAO)
DLIC	Data Link Initiation Capability
DSC	Downstream Clearance
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme (see EATMP)
EATMP	European Air Traffic Management Programme
ECIP	European Convergence and Implementation Plan
EFIS	Electronic Flight Instrument System
ESARR	Eurocontrol Safety Regulatory Requirements
EUROCAE	EURopean Organisation for Civil Aviation Equipment
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems (ICAO)
FMS	Flight Management System
ICAO	International Civil Aviation Organisation
INTEROP	Interoperability
JAA	Joint Aviation Authorities
JAR-OPS	Joint Aviation Requirements- Operations
MASPS	Minimum Aircraft System Performance Specification or Minimum Aviation System Performance Standards
MCDU	Multi-purpose Control and Display Unit
MOPS	Minimum Operational Performance Specification or Minimum Operational Performance Standards
NOTAM	Notice to Airmen
OSED	Operational Services and Environment Definition
REF	Reference

RTCA	RTCA Inc
SAE	Society of Automotive Engineers
SARPs	Standards and Recommended Practices (ICAO)
SATCOM	Satellite Communications
SC	Standing Committee
SLA	Service Level Agreement
SPR	Safety and Performance Requirements
VDL	VHF Digital Link
VDR	VHF Digital/Data Radio
VHF	Very High Frequency
WG	Working Group

AMC 20-20
Continuing Structural Integrity Programme

TABLE OF CONTENTS

1. PURPOSE

a) This Acceptable Means of Compliance (AMC) provides guidance to type- certificate holders, STC holders, repair approval holders, maintenance organisations, operators and competent authorities in developing a continuing structural integrity programme to ensure safe operation of ageing aircraft throughout their operational life, including provision to preclude Widespread Fatigue Damage.

b) This AMC is primarily aimed at large aeroplanes that are operated in Commercial Air Transport or are maintained under Part-M. However, this material is also applicable to other aircraft types.

c) The means of compliance described in this document provides guidance to supplement the engineering and operational judgement that must form the basis of any compliance findings relative to continuing structural integrity programmes.

d) Like all acceptable means of compliance material, this AMC is not in itself mandatory, and does not constitute a requirement. It describes an acceptable means, but not the only means, for showing compliance with the requirements. While these guidelines are not mandatory, they are derived from extensive industry experience in determining compliance with the relevant requirements.

2. RELATED REGULATIONS AND DOCUMENTS

a) Implementing Rules and Certification Specifications:

Part 21A.61	Instructions for continued airworthiness.
Part 21A.120	Instructions for continued airworthiness.
Part 21A	
Part 21A.433	Repair design
Part M.A.302	Maintenance programme
CS 25.571	Damage-tolerance and fatigue evaluation of structure
CS 25.903	Engines
CS 25.1529	Instructions for continued airworthiness

b) FAA Advisory Circulars

AC 91-60	The Continued Airworthiness of Older Airplanes , June 13, 1983, FAA.
AC 91-56A	Continuing Structural Integrity for Large Transport Category Airplanes April 29 1998 FAA (and later draft 91-56B)
AC 20-128A	Design Considerations for Minimising Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure, March 25, 1997, FAA.
AC 120 – 73	Damage Tolerance Assessment of Repairs to Pressurised Fuselages, FAA. December 14, 2000
AC 25.1529-1	Instructions for continued airworthiness of structural repairs on Transport Airplanes, August 1, 1991 FAA.

c) Related Documents

- “Recommendations for Regulatory Action to Prevent Widespread Fatigue Damage in the Commercial Aeroplane Fleet,” Revision A, dated June 29, 1999 [A report of the Airworthiness Assurance Working Group for the Aviation Rulemaking Advisory Committee Transport Aircraft and Engine Issues.]

- AAWG Final Report on Continued Airworthiness of Structural Repairs, Dec 1996.
- ATA report 51-93-01 structural maintenance programme guidelines for continuing airworthiness May 1993.
- AAWG Report on Structures Task Group Guidelines, Rev 1 June 1996
- AAWG Report: Recommendations concerning ARAC taskings FR Doc.04-10816 Re: Aging Airplane safety final rule. 14 CFR 121.370a and 129.16

3. BACKGROUND

Service experience has shown there is a need to have continuing updated knowledge on the structural integrity of aircraft, especially as they become older. The structural integrity of aircraft is of concern because such factors as fatigue cracking and corrosion are time-dependent, and our knowledge about them can best be assessed based on real-time operational experience and the use of the most modern tools of analysis and testing.

In April 1988, a high-cycle transport aeroplane en-route from Hilo to Honolulu, Hawaii, suffered major structural damage to its pressurised fuselage during flight. This accident was attributed in part to the age of the aeroplane involved. The economic benefit of operating certain older technology aeroplanes has resulted in the operation of many such aeroplanes beyond their previously expected retirement age. Because of the problems revealed by the accident in Hawaii and the continued operation of older aircraft, both the competent authorities and industry generally agreed that increased attention needed to be focused on the ageing fleet and on maintaining its continued operational safety.

In June 1988, the FAA sponsored a conference on ageing aircraft. As a result of that conference, an ageing aircraft task force was established in August 1988 as a sub-group of the FAA's Research, Engineering, and Development Advisory Committee, representing the interests of the aircraft operators, aircraft manufacturers, regulatory authorities, and other aviation representatives. The task force, then known as the Airworthiness Assurance Task Force (AATF), set forth five major elements of a programme for keeping the ageing fleet safe. For each aeroplane model in the ageing transport fleet these elements consisted of the following:

a) Select service bulletins describing modifications and inspections necessary to maintain structural integrity;
b) Develop inspection and prevention programmes to address corrosion;
c) Develop generic structural maintenance programme guidelines for ageing aeroplanes;
d) Review and update the Supplemental Structural Inspection Documents (SSID) which describe inspection programmes to detect fatigue cracking; and
e) Assess damage-tolerance of structural repairs.

Subsequent to these 5 major elements being identified, it was recognised that an additional factor in the Aloha accident was widespread fatigue cracking. Regulatory and Industry experts agreed that, as the transport aircraft fleet continues to age, eventually Widespread Fatigue Damage (WFD) is inevitable. Therefore the FAA determined, and the EASA concurred, that an additional major element of WFD' must be added to the Ageing Aircraft programme. Structures Task Groups sponsored by the Task Force were assigned the task of developing these elements into usable programmes. The Task Force was later re-established as the AAWG of the ARAC. Although there was JAA membership and European Operators and Industry representatives participated in the AAWG, recommendations for action focussed on FAA operational rules which are not applicable in Europe. It was therefore decided to establish the EAAWG on this subject to implement Ageing Aircraft activities into the Agency's regulatory system, not only for the initial "AATF eleven" aeroplanes, but also other old aircraft and more recently certificated ones. This AMC is a major part of the European adoption and adaptation of the AAWG recommendations which it follows as closely as practicable.

It is acknowledged that the various competent authorities, type certificate holders and operators have continually worked to maintain the structural integrity of older aircraft on an international basis. This has been achieved through an exchange of in-service information, subsequent changes to inspection programmes and by the development and installation of modifications on particular aircraft. However, it is evident that with the increased use, longer operational lives and experience from in-service aircraft, there is a need for a programme to ensure a high level of structural integrity for all aircraft, and in particular those in the transport fleet. Accordingly, the inspection and evaluation programmes outlined in this AMC are intended to provide:

- a continuing structural integrity assessment by each type-certificate holder, and
- the incorporation of the results of each assessment into the maintenance programme of each operator.

4. DEFINITIONS AND ACRONYMS

a) For the purposes of this AMC, the following definitions apply:

- **Damage-tolerance (DT)** is the attribute of the structure that permits it to retain its required residual strength without detrimental structural deformation for a period of use after the structure has sustained a given level of fatigue, corrosion, and accidental or discrete source damage.
- **Design Approval Holder (DAH)** is the holder of any design approval, including type certificate, supplemental type certificate or repair approval.
- **Design Service Goal (DSG)** is the period of time (in flight cycles/hours) established at design and/or certification during which the principal structure will be reasonably free from significant cracking including widespread fatigue damage.
- **Fatigue Critical Structure (FCS)** is structure that is susceptible to fatigue cracking that could lead to a catastrophic failure of an aircraft. For the purposes of this AMC, FCS refers to the same class of structure that would need to be assessed for compliance with § 25.571(a) at Amendment 25-45, or later. The term FCS may refer to fatigue critical baseline structure, fatigue critical modified structure, or both.
- **Limit of validity (LOV)** is the period of time, expressed in appropriate units (e.g. flight cycles) for which it has been shown that the established inspections and replacement times will be sufficient to allow safe operation and in particular to preclude development of widespread fatigue damage.
- **Multiple Element Damage (MED)** is a source of widespread fatigue damage characterised by the simultaneous presence of fatigue cracks in similar adjacent structural elements.
- **Multiple Site Damage (MSD)** is a source of widespread fatigue damage characterised by the simultaneous presence of fatigue cracks in the same structural element (i.e., fatigue cracks that may coalesce with or without other damage leading to a loss of required residual strength).
- **Primary Structure** is structure that carries flight, ground, crash or pressurisation loads.
- **Repair Evaluation Guidelines (REG**) provide a process to establish damage-tolerance inspections for repairs that affect Fatigue Critical Structure.
- **Repair Assessment Programme (RAP)** is a programme to incorporate damage tolerance-based inspections for repairs to the fuselage pressure boundary structure (fuselage skin, door skin, and bulkhead webs) into the operator's maintenance and/or inspection programme.
- **Widespread Fatigue Damage (WFD)** in a structure is characterised by the simultaneous presence of cracks at multiple structural details that are of sufficient size and density whereby the structure will no longer meet its damage-tolerance

requirement (i.e., to maintain its required residual strength after partial structural failure).

b) The following list defines the acronyms that are used throughout this AMC:

AAWG	irworthiness Assurance Working Group
AC	Advisory Circular
AD	Airworthiness Directive
ALS	Airworthiness Limitations Section
AMC	Acceptable Means of Compliance
ARAC	Aviation Rulemaking Advisory Committee
BZI	Baseline Zonal Inspection
CPCP	Corrosion Prevention and Control Programme
CS	Certification Specification
DAH	Design Approval Holder
DSD	Discrete Source Damage
DSG	Design Service Goal
EAAWG	European Ageing Aircraft Working Group
EASA	European Aviation Safety Agency
ESG	Extended Service Goal
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCBS	Fatigue Critical Baseline Structure
FCS	Fatigue Critical Structure
ICA	Instructions for Continued Airworthiness
ISP	Inspection Start Point
JAA	Joint Aviation Authorities
JAR	Joint Aviation Regulation
LDC	Large Damage Capability
LOV	Limit of Validity
MED	Multiple Element Damage
MRB	Maintenance Review Board
MSD	Multiple Site Damage
MSG	Maintenance Steering Group
NAA	National Airworthiness Authority
NDI	Non-Destructive Inspection
NTSB	National Transportation Safety Board
PSE	Principal Structural Element
RAP	Repairs Assessment Programme
REG	Repair Evaluation Guidelines
SB	Service Bulletin
SMP	Structural Modification Point
SRM	Structural Repair Manual
SSID	Supplemental Structural Inspection Document
SSIP	Supplemental Structural Inspection Programme
STG	Structural Task Group
TCH	Type-Certificate Holder
WFD	Widespread Fatigue Damage

5. WAY OF WORKING

a) General

On the initiative of the TCH and the Agency, a STG should be formed for each aircraft model for which it is decided to put in place an ageing aircraft programme. The STG shall consist of the TCH, selected operator members and Agency representative(s). The objective of the STG is to complete all tasks covered in this AMC in relation to their respective model types, including the following:

--Develop model specific programmes
--Define programme implementation
--Conduct recurrent programme reviews as necessary.

It is recognised that it might not always be possible to form or to maintain an STG, due to a potential lack of resources with the operators or TCH. In this case the above objective would remain with the Agency and operators or TCH as applicable.

An acceptable way of working for STGs is described in “Report on Structures Task Group Guidelines” that was established by the AAWG with the additional clarifications provided in the following sub-paragraphs.

b) Meeting scheduling

It is the responsibility of the TCH to schedule STG meetings. However if it is found by the Agency that the meeting scheduling is inadequate to meet the STG working objectives, the Agency might initiate themselves additional STG meetings.

c) Reporting

The STG would make recommendations for actions via the TCH to the Agency. Additionally, the STG should give periodic reports (for information only) to AAWG/EASA as appropriate with the objective of maintaining a consistent approach.

d) Recommendations and decision making

The decision making process described in the AAWG Report on Structures Task Group Guidelines paragraph 7 leads to recommendations for mandatory action from the TCH to the Agency. In addition it should be noted that the Agency is entitled to mandate safety measures related to ageing aircraft structures, in addition to those recommended by the STG, if they find it necessary.

e) Responsibilities

(i) The TCH is responsible for developing the ageing aircraft structures programme for each aircraft type, detailing the actions necessary to maintain airworthiness. Other DAH should develop programmes or actions appropriate to the modification/repair for which they hold approval, unless addressed by the TCH. All DAHs will be responsible for monitoring the effectiveness of their specific programme, and to amend the programme as necessary.

(ii) The Operator is responsible for incorporating approved DAH actions necessary to maintain airworthiness into its aircraft specific maintenance programmes, in accordance with Part-M.

(iii) The competent authority of the state of registry is responsible for ensuring the implementation of the ageing aircraft programme by their operators.

(iv) The Agency will approve ageing aircraft structures programmes and may issue ADs to support implementation, where necessary. The Agency, in conjunction with the DAH, will monitor the overall effectiveness of ageing aircraft structures programmes.

6. SUPPLEMENTAL STRUCTURAL INSPECTION PROGRAMME (SSIP)

In the absence of a damage-tolerance based structural maintenance inspection programme (e.g. MRB report, ALS), the TCH, in conjunction with operators, is expected to initiate the development of a SSIP for each aircraft model. Such a programme must be implemented before analysis, tests, and/or service experience indicates that a significant increase in inspection and/or modification is necessary to maintain structural integrity of the aircraft. This should ensure that an acceptable programme is available to the operators when needed. The programme should include procedures for obtaining service information, and assessment of service information, available test data, and new analysis and test data. A SSID should be developed, as outlined in Appendix 1 of this AMC, from this body of data. The role of the operator is principally to comment on the practicality of the inspections and any other procedures defined by the TCH and to implement them effectively.

The SSID, along with the criteria used and the basis for the criteria should be submitted to the Agency for review and approval. The SSIP should be adequately defined in the SSID. The SSID should include inspection threshold, repeat interval, inspection methods and procedures. The applicable modification status, associated life limitation and types of operations for which the SSID is valid should also be identified and stated. In addition, the inspection access, the type of damage being considered, likely damage sites and details of the resulting fatigue cracking scenario should be included as necessary to support the prescribed inspections.

The Agency's review of the SSID will include both engineering and maintenance aspects of the proposal. Because the SSID is applicable to all operators and is intended to address potential safety concerns on older aircraft, the Agency expects these essential elements to be included in maintenance programmes developed in compliance with Part-M. In addition, the Agency will issue ADs to implement any service bulletins or other service information publications found to be essential for safety during the initial SSID assessment process should the SSID not be available in time to effectively control the safety concern. Service bulletins or other service information publications revised or issued as a result of in-service findings resulting from implementation of the SSID should be added to the SSID or will be implemented by separate AD action, as appropriate.

In the event an acceptable SSID cannot be obtained on a timely basis, the Agency may impose service life, operational, or inspection limitations to assure structural integrity.

As a result of a periodic review, the TCH should revise the SSID whenever additional information shows a need. The original SSID will normally be based on predictions or assumptions (from analyses, tests, and/or service experience) of failure modes, time to initial damage, frequency of damage, typically detectable damage, and the damage growth period. Consequently, a change in these factors sufficient to justify a revision would have to be substantiated by test data or additional service information. Any revision to SSID criteria and the basis for these revisions should be submitted to the Agency for review and approval of both engineering and maintenance aspects.

7. SERVICE BULLETIN REVIEW and MANDATORY MODIFICATION PROGRAMME

Service Bulletins issued early in the life of an aircraft fleet may utilise inspections (in some cases non-mandatory inspections) alone to maintain structural integrity. Inspections may be adequate in this early stage, when cracking is possible, but not highly likely. However, as aircraft age the probability of fatigue cracking becomes more likely. In this later stage it is not prudent to rely only on inspections alone because there are more opportunities for cracks to be missed and cracks may no longer occur in isolation. In this later stage in the life of a fleet it is prudent to reduce the reliance strictly on inspections, with its inherent human factors limitations, and incorporate modifications to the structure to eliminate the source of the cracking. In some cases reliance on an inspection programme, in lieu of modification, may be acceptable through the increased use of mandatory versus non-mandatory inspections.

The TCH, in conjunction with operators, is expected to initiate a review of all structurally related inspection and modification SBs and determine which require further actions to ensure continued airworthiness, including mandatory modification action or enforcement of special repetitive inspections

Any aircraft primary structural components that would require frequent repeat inspection, or where the inspection is difficult to perform, taking into account the potential airworthiness concern, should be reviewed to preclude the human factors issues associated with repetitive inspections

The SB review is an iterative process (see Appendix 5) consisting of the following items:

a) The TCH should review all issued structural inspection - and modification SBs to select candidate bulletins, using the following 4 criteria:

   i) There is a high probability that structural cracking exists
   ii) Potential structural airworthiness concern.
   iii) Damage is difficult to detect during routine maintenance
   iv) There is Adjacent Structural damage or the potential for it.

   This may be done by the TCH alone or in conjunction with the operators at a preliminary STG meeting.

b) The TCH and operator members will be requested to submit information on individual fleet experience relating to candidate SBs. This information will be collected and evaluated by the TCH. The summarised results will then be reviewed in detail at a STG meeting (see c. below).

c) The final selection of SBs for recommendation of the appropriate corrective action to assure structural continued airworthiness taking into account the in-service experience, will be made during an STG meeting by the voting members of the STG, either by consensus or majority vote, depending on the preference of the individual STGs.

d) An assessment will be made by the TCH as to whether or not any subsequent revisions to SBs affect the previous decision made. Any subsequent revisions to SBs previously chosen by the STG for mandatory inspection or incorporation of modification action that would affect the previous STG recommended action should be submitted to the STG for review.

e) The TCH should review all new structural SBs periodically to select further candidate bulletins. The TCH should schedule a meeting of the STG to address the candidates. Operator members and the competent authority will be advised of the candidate selection and provided the opportunity to submit additional candidates.

8. CORROSION PREVENTION AND CONTROL PROGRAMME

A corrosion prevention and control programme (CPCP) is a systematic approach to prevent and to control corrosion in the aircraft's Primary Structure. The objective of a CPCP is to limit the deterioration due to corrosion to a level necessary to maintain airworthiness and where necessary to restore the corrosion protection schemes for the structure. A CPCP consists of a basic corrosion inspection task, task areas, defined corrosion levels, and compliance times (implementation thresholds and repeat intervals). The CPCP also includes procedures to notify the competent authority and TCH of the findings and data associated with Level 2 and Level 3 corrosion and the actions taken to reduce future findings to Level 1 or better. See Appendix 4 for definitions and further details.

As part of the ICA, the TCH should provide an inspection programme that includes the frequency and extent of inspections necessary to provide the continued airworthiness of the aircraft. Furthermore, the ICA should include the information needed to apply protective treatments to the structure after inspection. In order for the inspections to be effectively accomplished, the TCH should provide corrosion removal and cleaning procedures and reference allowable limits. The TCH should include all of these corrosion-related activities in a manual referred to as the Baseline Programme. This Baseline Programme manual is intended to form a basis for operators to derive a systematic and comprehensive CPCP for inclusion in the operator's maintenance programme. The TCH is responsible for monitoring the effectiveness of the Baseline Programme and, if necessary, to recommend changes based on operators reports of findings. In line with Part-M requirements, when the TCH publishes revisions to their Baseline Programme, these should be reviewed and the operator's programme adjusted as necessary in order to maintain corrosion to Level 1 or better.

An operator may adopt the Baseline Programme provided by the TCH or it may choose to develop its own CPCP, or may be required to if none is available from the TCH. In developing its own CPCP an operator may join with other operators and develop a Baseline Programme similar to a TCH developed Baseline Programme for use by all operators in the group.

Before an operator may include a CPCP in its maintenance or inspection programme, the competent authority should review and approve that CPCP. The operator should show that the CPCP is comprehensive in that it addresses all corrosion likely to affect Primary Structure, and is systematic in that it provides:

a) Step-by-step procedures that are applied on a regular basis to each identified task area or zone, and

b) These procedures are adjusted when they result in evidence that corrosion is not being controlled to an established acceptable level (Level 1 or better).

Note: For an aeroplane with an ALS, in addition to providing a suitable baseline programme in the ICA and to ensure compliance with CS 25.571 it is appropriate for the TCH to place an entry in the ALS stating that all corrosion should be maintained to Level 1 or better. (This practice is also described in ATA MSG-3)

9. REPAIR EVALUATION GUIDELINES AND REPAIR ASSESSMENT PROGRAMMES

Early fatigue or fail-safe requirements (pre-Amdt 45) did not necessarily provide for timely inspection of critical structure so that damaged or failed components could be dependably identified and repaired or replaced before a hazardous condition developed. Furthermore, it is known that application of later fatigue and damage tolerance requirements to repairs was not always fully implemented according to the relevant certification bases.

Repair Evaluation Guidelines (REG) are intended to assure the continued structural integrity of all relevant repaired and adjacent structure, based on damage-tolerance principles, consistent with the safety level provided by the SSID or ALS as applied to the baseline structure. To achieve this, the REG should be developed by the TCH and implemented by the Operator to ensure that an evaluation is performed of all repairs to structure that is susceptible to fatigue cracking and could contribute to a catastrophic failure.

Even the best maintained aircraft will accumulate structural repairs when being operated. The AAWG conducted two separate surveys of repairs placed on aircraft to collect data. The evaluation of these surveys revealed that 90% of all repairs found were on the fuselage, hence these are a priority and RAPs have already been developed for the fuselage pressure shell of many large transport aeroplanes not originally certificated to damage-tolerance requirements. 40% of the repairs were classified as adequate and 60% of the repairs required consideration for possible additional supplemental inspection during service. Nonetheless, following further studies by AAWG working groups it has been agreed that repairs to all structure susceptible to fatigue and whose failure could contribute to catastrophic failure will be considered. (Ref. AAWG

Report: Recommendations concerning ARAC taskings FR Doc.04-10816 Re: Aging Airplane safety final rule. 14 CFR 121.370a and 129.16.)

As aircraft operate into high cycles and high times the ageing repaired structure needs the same considerations as the original structure in respect of damage-tolerance. Existing repairs may not have been assessed for damage-tolerance and appropriate inspections or other actions implemented. Repairs are to be assessed, replaced if necessary or repeat inspections determined and carried out as supplemental inspections or within the baseline zonal inspection programme. A damage-tolerance based inspection programme for repairs will be required to detect damage which may develop in a repaired area, before that damage degrades the load carrying capability of the structure below the levels required by the applicable airworthiness standards.

The REG should provide data to address repairs to all structure that is susceptible to fatigue cracking and could contribute to a catastrophic failure. The REG may refer to the RAP, other existing approved data such as SRM and SBs or provide specific means for obtaining data for individual repairs.
Documentation such as the Structural Repair Manual and service bulletins needs to be reviewed for compliance with damage-tolerance principles and be updated and promulgated consistent with the intent of the REGs.

Where repair evaluation guidelines, repair assessment programmes or similar documents have been published by the TCH they should be incorporated into the aircraft's maintenance programme according to Part-M requirements.

This fatigue and damage-tolerance evaluation of repairs will establish an appropriate inspection programme or a replacement schedule if the necessary inspection programme is too demanding or not possible. Details of the means by which the REGs and the maintenance programme may be developed are incorporated in Appendix 3.

10. LIMIT OF VALIDITY OF THE MAINTENANCE PROGRAMME AND EVALUATION FOR WIDESPREAD FATIGUE DAMAGE

a) Initial WFD Evaluation and LOV

All fatigue and damage tolerance evaluations are finite in scope and also therefore in their long term ability to ensure continued airworthiness. The maintenance requirements that evolve from these evaluations have a finite period of validity defined by the extent of testing, analysis and service experience that make up the evaluation and the degree of associated uncertainties. **Limit of validity (LOV)** is the period of time, expressed in appropriate units (e.g. flight cycles) for which it has been shown that the established inspections and replacement times will be sufficient to allow safe operation and in particular to preclude development of widespread fatigue damage. The LOV should be based on fatigue test evidence.

The likelihood of the occurrence of fatigue damage in an aircraft's structure increases with aircraft usage. The design process generally establishes a design service goal (DSG) in terms of flight cycles/hours for the airframe. It is generally expected that any cracking that occurs on an aircraft 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 localised design detail. It is considered unlikely that cracks from manufacturing flaws or localised design issues will interact strongly as they grow. The SSIP described in paragraph 6 and Appendix 1 of this AMC are intended to find all forms of fatigue damage before they become critical. Nonetheless, it has become apparent that as aircraft have approached and exceeded their DSG only some SSIPs have correctly addressed Widespread Fatigue Damage (WFD) as described below.

With extended usage, uniformly loaded structure may develop cracks in adjacent fastener holes, or in adjacent similar structural details. The development of cracks at multiple locations (both MSD and MED) 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 maintenance programme established at time of certification. Furthermore, these cracks, while they may or may not interact, can have an adverse effect on the large damage capability (LDC) of the airframe before the cracks become detectable.

The TCH's role is to perform a WFD evaluation and, in conjunction with operators, is expected to initiate development of a maintenance programme with the intent of precluding operation with WFD. Appendix 2 provides guidelines for development of a programme to preclude the occurrence of WFD. Such a programme must be implemented before analysis, tests, and/or service experience indicates that widespread fatigue damage may develop in the fleet. The operator's role is to provide service experience, to help ensure the practicality of the programme and to ensure it is implemented effectively.

The results of the WFD evaluation should be presented for review and approval to the Agency for the aircraft model being considered. Since the objective of this evaluation is to preclude WFD from the fleet, it is expected that the results will include recommendations for necessary inspections or modification and/or replacement of structure, as appropriate to support the LOV. It is expected that the TCH will work closely with operators in the development of these programmes to assure that the expertise and resources are available when implemented.

The Agency's review of the WFD evaluation results will include both engineering and maintenance aspects of the proposal. The Agency expects any actions necessary to preclude WFD (including the LOV) to be incorporated in maintenance programmes developed in compliance with Part-M. Any service bulletins or other service information publications revised or issued as a result of in-service MSD/MED findings resulting from implementation of these programmes may require separate AD action.

In the event an acceptable WFD evaluation cannot be completed on a timely basis, the Agency may impose service life, operational, or inspection limitations to assure structural integrity of the subject type design.

b) Revision of WFD evaluation and LOV

New service experience findings, improvements in the prediction methodology, better load spectrum data, a change in any of the factors upon which the WFD evaluation is based or economic considerations, may dictate a revision to the evaluation. Accordingly, associated new recommendations for service action should be developed including a revised LOV, if appropriate, and submitted to the Agency for review and approval of both engineering and maintenance aspects.

In order to operate an individual aircraft up to the revised LOV, a WFD evaluation should also be performed for all applicable modified or repaired structure to determine if any new structure or any structure affected by the change is susceptible to WFD. This evaluation should be conducted by the DAH for the changed structure in conjunction with the operator prior to the aircraft reaching its existing LOV. The results together with any necessary actions required to preclude WFD from occurring before the aircraft reaches the revised LOV should be presented for review and approval by the Agency.

This process may be repeated such that, subject to Agency approval of the evaluations, a revised LOV may be established and incorporated in the operator's maintenance programme, together with any necessary actions to preclude WFD from occurring before the aircraft reaches the revised LOV.

The LOV and associated actions should be incorporated in the ALS. For an aircraft without an ALS, it may be appropriate for the DAH to create an ALS and to enter the LOV in the ALS, together with a clear identification of inspections and modifications required to allow safe operation up to that limit.

In any case, should instructions provided by the DAH in their ICA (e.g. maintenance manual revision) clearly indicate that the maintenance programme is not valid beyond a certain limit, this limit and associated instructions must be adhered to in the operator's maintenance programme as approved by the competent authority under Part-M requirements, unless an EASA approved alternative programme is incorporated and approved.

11. SUPPLEMENTAL TYPE-CERTIFICATES AND MODIFICATIONS

Any modification or supplemental type-certificates (STC) affecting an aircraft's structure could have an effect on one or all aspects of ageing aircraft assessment as listed above. Such structural changes will need the same consideration as the basic aircraft and the operator should seek support from the STC holder (who has primary responsibility for the design/certification of the STC), or an approved Design Organisation, where, for example an STC holder no longer exists. Appendix 3 provides further details.

STC holders are expected to review existing designs that may have implications for continued airworthiness in the context of ageing aircraft programmes and collaborate with operators and TCHs, where appropriate.

12. IMPLEMENTATION

In compliance with Part-M, operators must amend their current structural maintenance programmes to comply with and to account for new and/or modified maintenance instructions promulgated by the DAH.

From the industry/Agency discussions leading to the definition of the programmes detailed in paragraphs 6 to 10, above, appropriate implementation times have emerged. These programme implementation times are expressed as a fraction of the aircraft model's DSG.

Programme	Affected Structure*	Implementation
CPCP	All Primary Structure	½ DSG
SSID	PSEs as defined in CS25.571	½ DSG
SB-Review	SBs that address a potentially unsafe structural condition	¾ DSG
REGs and RAPs	Repairs to fatigue critical structure (FCS).	¾ DSG
WFD	Prmary structure susceptible to WFD	1 DSG

* Note: The certification philosophy for safe-life items under CS 25.571 neccessitates no further investigation under ageing aircraft programmes that would provide damage tolerance based inspections. However, this does not exclude safe-life items such as landing gear from the CPCP and SB Review or from re-assessment of their safe-life if the aircraft usage or structural loading is known to have changed.

In the absence of other information prior to the implementation of these programmes the limit of validity of the existing maintenance programmes should be considered as the DSG.

Programme implementation times in flight hours, flight or landing cycles, or calendar period, as appropriate, should be established by the TC/STC Holder based on the above table.

A period of up to one year may be allowed to incorporate the necessary actions into the operator's maintenance programme once they become available from the DAH. Grace periods for accomplishment of actions beyond threshold should address the level of risk and for large fleets the practicalities of scheduling maintenance activities. Typically, for maintenance actions beyond threshold, full implementation of these maintenance actions across the whole fleet should be accomplished within 4 years of the operator's programme being approved by the competent authority.

Unless data is available on the dates of incorporation of repairs and modifications [STCs] they will need to be assumed as having the same age as the airframe.

APPENDIX 1

Guidelines for the development of a Supplementary Structural Inspection Programme

1. GENERAL

1.1 Purpose

This Appendix 1 gives interpretations, guidelines and acceptable means of compliance for the SSIP actions.

1.2 Background

Service experience has demonstrated that there is a need to have continuing updated knowledge concerning the structural integrity of aircraft, especially as they become older. Early fatigue requirements, such as "fail safe" regulations did not provide for timely inspection of an aircraft's critical structure to ensure that damaged or failed components could be dependably identified and then repaired or replaced before hazardous conditions developed.

In 1978 the damage-tolerance concept was adopted for transport category aeroplanes in the USA as Amendment 25-45 to FAR 25.571. This amended rule required damage-tolerance analyses as part of the type design of transport category aeroplanes for which application for type-certification was received after the effective date of the amendment. In 1980 the requirement for damage-tolerance analyses was also included in JAR 25.571 Change 7.

One prerequisite for the successful application of the damage tolerance approach for managing fatigue is that crack growth and residual strength can be anticipated with sufficient precision to allow inspections to be established that will detect cracking before it reaches a size that will degrade the strength below a specified level. When damage is discovered, airworthiness is ensured by repair or revised maintenance action. Evidence to date suggests that when all critical structure is included, fatigue and damage-tolerance based inspections and procedures (including modification and replacement when necessary) provide the best approach to address aircraft fatigue.

Pre FAR Part 25 Amendment 25-45 (JAR-25 Change 7) aeroplanes were built to varying standards that embodied fatigue and fail-safe requirements. These aeroplanes, as certified, had no specific mandated requirements to perform inspections for fatigue. Following the amendment of FAR 25 to embody damage-tolerance requirements, the FAA published Advisory Circular 91-56A. That AC was applicable to pre-Amendment 25-45 aeroplanes with a maximum gross weight greater than 75.000 pounds. According to the AC the TCH, in conjunction with operators, was expected to initiate development of a SSIP for each aeroplane model.

AC 91-56A provided guidance material for the development of such programmes based on damage-tolerance principles. Many TCH's of large aeroplanes developed SSIPs for their pre-Amendment 25-45 aeroplanes. The documents containing the SSIP are designated Supplemental Structural Inspection Documents (SSID) or Supplemental Inspection Documents (SID)

The competent authorities have in the past issued a series of ADs requiring compliance with these SSIPs. Generally these ADs require the operators to incorporate the SSIPs into their maintenance programmes. Under Part-M requirements it is expected that an operator will automatically incorporate the SSID into their maintenance programmeme.

For post Amendment 25-45 aeroplanes, it was required that inspections or other procedures should be developed based on the damage-tolerance evaluations required by FAR 25.571, and included in the maintenance data. In Amendment 25-54 to FAR 25 and change 7 to JAR-25 it was required to include these inspections and procedures in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by 25.1529. At the same amendment, 25.1529 was changed to require applicants for type-certificates to prepare Instructions for Continued Airworthiness in accordance with Appendix H of FAR/JAR-25. Appendix H requires that the Instructions for Continued

Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section shall contain the information concerning inspections and other procedures as required by FAR/JAR/CS 25.571.

The content of the Airworthiness Limitations Section of the Instructions for Continued Airworthiness is designated by some TCH's as Airworthiness Limitations Instructions (ALI). Other TCH's have decided to designate the same items as Airworthiness Limitations Items (ALI).

Compliance with FAR/JAR 25.571 at Amendment 25-45 and Change 7 respectively, or later amendments, results in requirements to periodically inspect aeroplanes for potential fatigue damage in areas where it is most likely to occur.

2. SUPPLEMENTAL STRUCTURAL INSPECTION PROGRAMME (SSIP)

Increased utilisation, longer operational lives, and the high safety demands imposed on the current fleet of transport aeroplanes indicate the need for a programme to ensure a high level of structural integrity for all aeroplanes in the transport fleet.

This AMC is intended to provide guidance to TCHs and other DAHs to develop or review existing inspection programmes for effectiveness. SSIPs are based on a thorough technical review of the damage-tolerance characteristics of the aircraft structure using the latest techniques and changes in operational usage. They lead to revised or new inspection requirements primarily for structural cracking and replacement or modification of structure where inspection is not practical.

Large transport aeroplanes that were certificated according to FAR 25.571 Amendment 25-45/54 or JAR 25 Change 7 are damage-tolerant. The fatigue requirements are part of the MRB Report, as required by ATA MSG-3. However, for pre ATA MSG-3 rev 2 aeroplanes there are no requirements for regular MRB Report review and for post ATA MSG-3 rev 2 aeroplanes there is only a requirement for regular MRB Report review in order to assess if the CPCP is effective. Concerning ageing aircraft activities, it is important to regularly review the part of the MRB Report containing the structural inspections resulting from the fatigue and damage-tolerance analysis for effectiveness.

2.1 Pre-Amendment 25-45 aeroplanes

The TCH is expected to initiate development of a SSIP for each aeroplane model. Such a programme must be implemented before analysis, test and/or service experience indicate that a significant increase in inspection and or modification is necessary to maintain structural integrity of the aeroplane. This should ensure that an acceptable programme is available to the operators when needed. The programme should include procedures for obtaining service information, and assessment of service information, available test data, and new analysis and test data.

A SSID should be developed in accordance with Paragraph 3 of this Appendix 1. The recommended SSIP, along with the criteria used and the basis for the criteria, should be submitted by the TCH to the Agency for approval. The SSIP should be adequately defined in the SSID and presented in a manner that is effective. The SSID should include the type of damage being considered, and likely sites; inspection access, threshold, interval method and procedures; applicable modification status and/or life limitation; and types of operation for which the SSID is valid.

The review of the SSID by the Agency will include both engineering and maintenance aspects of the proposal. In the event an acceptable SSID cannot be obtained on a timely basis the competent authority may impose service life, operational, or inspection limitations to assure structural integrity

The TCH should check the SSID periodically against current service experience. This should include an evaluation of current methods and findings. Any unexpected defect occurring should be assessed as part of the continuing assessment of structural integrity to determine a need for revision to the document.

2.2. Post-Amendment 25-45 aeroplanes

Aeroplanes certificated to FAR 25.571 Amendment 25-45, JAR 25.571 Change 7 and CS-25 or later amendments are damage-tolerant. The airworthiness limitations including the inspections and procedures established in accordance with FAR/JAR/CS 25.571 shall be included in the Instructions for Continuing Airworthiness, ref. FAR/JAR/CS 25.1529. Further guidance for the actual contents is incorporated in FAR/JAR/CS-25 Appendix H.

To maintain the structural integrity of these aeroplanes it is necessary to follow up the effectiveness of these inspections and procedures. The DAH should therefore check this information periodically against current service experience. Any unexpected defect occurring should be assessed as part of the continuing assessment of structural integrity to determine a need for revision to this information. The revised data should be developed in accordance with the same procedures as at type-certification giving consideration to any additional test or service data available and changes to aeroplanes operating patterns.

3. GUIDELINES FOR DEVELOPMENT OF THE SUPPLEMENTAL STRUCTURAL INSPECTION DOCUMENT

This paragraph is based directly on Appendix 1 to FAA AC 91-56A which applies to transport category aeroplanes that were certificated prior to Amendment 25-45 of FAR 25 or equivalent requirement.

3.1. General

Amendment 25-45 to § 25.571 introduced wording which emphasises damage-tolerant design. However, the structure to be evaluated, the type of damage considered (fatigue, corrosion, service, and production damage), and the inspection and/or modification criteria should, to the extent practicable, be in accordance with the damage-tolerance principles of the current § 25.571 standards. An acceptable means of compliance can be found in AC 25.571-1C (“Damage-Tolerance and Fatigue Evaluation of Structure,” dated April 29, 1998) or the latest revision.

It is essential to identify the structural parts and components that contribute significantly to carrying flight, ground, pressure, or control loads, and whose failure could affect the structural integrity necessary for the continued safe operation of the aeroplane. The damage-tolerance or safe-life characteristics of these parts and components must be established or confirmed.

Analyses made in respect to the continuing assessment of structural integrity should be based on supporting evidence, including test and service data. This supporting evidence should include consideration of the operating loading spectra, structural loading distributions, and material behaviour. An appropriate allowance should be made for the scatter in life to crack initiation and rate of crack propagation in establishing the inspection threshold, inspection frequency, and, where appropriate, retirement life. Alternatively, an inspection threshold may be based solely on a statistical assessment of fleet experience, if it can be shown that equal confidence can be placed in such an approach.

An effective method of evaluating the structural condition of older aeroplanes is selective inspection with intensive use of non-destructive techniques, and the inspection of individual aeroplanes, involving partial or complete dismantling (“teardown”) of available structure.

The effect of repairs and modifications approved by the TCH should be considered. In addition, it may be necessary to consider the effect of repairs and operator-approved or other DAH modifications on individual aircraft. The operator has the responsibility for ensuring notification and consideration of any such aspects in conjunction with the DAH.

3.2. Damage-tolerant structures

The damage-tolerance assessment of the aircraft structure should be based on the best information available. The assessment should include a review of analysis, test data, operational experience, and any special inspections related to the type design.

A determination should then be made of the site or sites within each structural part or component considered likely to crack, and the time or number of flights at which this might occur.

The growth characteristics of damage and interactive effects on adjacent parts in promoting more rapid or extensive damage should be determined. This determination should be based on study of those sites that may be subject to the possibility of crack initiation due to fatigue, corrosion, stress corrosion, disbonding, accidental damage, or manufacturing defects in those areas shown to be vulnerable by service experience or design judgement. The damage tolerance certification specification of CS 25.571 requires not only fatigue damage to be addressed but also accidental and environmental damage. Some types of accidental damage (e.g. scribe marks) can not be easily addressed by the MSG process and require specific inspections based on fatigue and damage tolerance analysis and tests. Furthermore, some applicants may chose to address other types of accidental damage and environmental damage in the SSID or ALS by modelling the damage as a crack and performing a fatigue and damage tolerance analysis. The resulting inspection programme may be tailored to look for the initial type of damage or the resulting fatigue cracking scenario, or both.

The minimum size of damage that is practical to detect and the proposed method of inspection should be determined. This determination should take into account the number of flights required for the crack to grow from detectable to the allowable limit, such that the structure has a residual strength corresponding to the conditions stated under CS 25.571.

> **Note:** In determining the proposed method of inspection, consideration should be given to visual inspection, non-destructive testing, and analysis of data from built-in load and defect monitoring devices.

The continuing assessment of structural integrity may involve more extensive damage than might have been considered in the original fail-safe evaluation of the aircraft, such as:

(a) A number of small adjacent cracks, each of which may be less than the typically detectable length, developing suddenly into a long crack;

(b) Failures or partial failures in other locations following an initial failure due to redistribution of loading causing a more rapid spread of fatigue; and

(c) Concurrent failure or partial failure of multiple load path elements (e.g., lugs, planks, or crack arrest features) working at similar stress levels.

3.3. Information to be included in the assessment

The continuing assessment of structural integrity for the particular aircraft type should be based on the principles outlined in paragraph 3.2 of this Appendix 1. The following information should be included in the assessment and kept by the TCH in a form available to the Agency:

(a) The current operational statistics of the fleet in terms of hours or flights;

(b) The typical operational mission or missions assumed in the assessment;

(c) The structural loading conditions from the chosen missions; and

(d) Supporting test evidence and relevant service experience.

In addition to the information specified in paragraph 3.3. above, the following should be included for each critical part or component:

(a) The basis used for evaluating the damage-tolerance characteristics of the part or component;

(b) The site or sites within the part or component where damage could affect the structural integrity of the aircraft;

(c) The recommended inspection methods for the area;

(d) For damage-tolerant structures, the maximum damage size at which the residual strength capability can be demonstrated and the critical design loading case for the latter; and

(e) For damage-tolerant structures, at each damage site the inspection threshold and the damage growth interval between detectable and critical, including any likely interaction effect from other damage sites.

Note: Where re-evaluation of fail-safety or damage-tolerance of certain parts or components indicates that these qualities cannot be achieved, or can only be demonstrated using an inspection procedure whose practicability or reliability may be in doubt, replacement or modification action may need to be defined.

3.4. Inspection programme

The purpose of a continuing airworthiness assessment in its most basic terms is to adjust the current maintenance inspection programme, as required, to assure continued safety of the aircraft type.

In accordance with Paragraphs 1 and 2 of this Appendix 1, an allowable limit of the size of damage should be determined for each site such that the structure has a residual strength for the load conditions specified in CS 25.571. The size of damage that is practical to detect by the proposed method of inspection should be determined, along with the number of flights required for the crack to grow from detectable to the allowable limit.

The recommended inspection programme should be determined from the data described in paragraph 3.3 above, giving due consideration to the following:

(a) Fleet experience, including all of the scheduled maintenance checks;

(b) Confidence in the proposed inspection technique; and

(c) The joint probability of reaching the load levels described above and the final size of damage in those instances where probabilistic methods can be used with acceptable confidence.

Inspection thresholds for supplemental inspections should be established. These inspections would be supplemental to the normal inspections, including the detailed internal inspections.

(a) For structure with reported cracking, the threshold for inspection should be determined by analysis of the service data and available test data for each individual case.

(b) For structure with no reported cracking, it may be acceptable, provided sufficient fleet experience is available, to determine the inspection threshold on the basis of analysis of existing fleet data alone. This threshold should be set such as to include the inspection of a sufficient number of high-time aircraft to develop added confidence in the integrity of the structure (see Paragraph 1 of this Appendix 1).

3.5. The supplemental structural inspection document

The SSID should contain the recommendations for the inspection procedures and replacement or modification of parts or components necessary for the continued safe operation of the aircraft up to the LOV. The document should be prefaced by the following information:

(a) Identification of the variants of the basic aircraft type to which the document relates;

(b) Reference to documents giving any existing inspections or modifications of parts or components;

(c) The types of operations for which the inspection programme are considered valid;

(d) A list of service bulletins (or other service information publication) revised as a result of the structural reassessment undertaken to develop the SSID, including a statement that the operator must account for these service bulletins.

(e) The type of damage which is being considered (i.e., fatigue, corrosion and/or accidental damage).

(f) Guidance to the operator on which inspection findings should be reported to the type-certificate holder.

The document should contain at least the following information for each critical part or component:

(a) A description of the part or component and any relevant adjacent structure, including means of access to the part.

(b) Relevant service experience.

(c) Likely site(s) of damage.

(d) Inspection method and procedure, and alternatives.

(e) Minimum size of damage considered detectable by the method(s) of inspection.

(f) Service bulletins (or other service information publication) revised or issued as a result of in-service findings resulting from implementation of the SSID (added as revision to the initial SID).

(g) Initial inspection threshold.

(h) Repeat inspection interval.

(i) Reference to any optional modification or replacement of part or component as terminating action to inspection.

(j) Reference to the mandatory modification or replacement of the part or component at given life, if fail-safety by inspection is impractical; and

(k) Information related to any variations found necessary to “safe lives” already declared.

The SSID should be compared from time to time against current service experience. Any unexpected defect occurring should be assessed as part of the continuing assessment of structural integrity to determine the need for revision of the SSID. Future structural service bulletins should state their effect on the SSID.

APPENDIX 2

Guidelines for the development of a programme to preclude the occurrence of widespread fatigue damage.

1. INTRODUCTION

The terminology and methodology in this appendix is based upon material developed by the AAWG.

2. DEFINITIONS

- **Extended Service Goal (ESG)** is an adjustment to the design service goal established by service experience, analysis, and/or test during which the principal structure will be reasonably free from significant cracking including widespread fatigue damage.

- **Inspection Start Point (ISP)** is the point in time when special inspections of the fleet are initiated due to a specific probability of having a MSD/MED condition.

- **Large Damage Capability (LDC)** is the ability of the structure to sustain damage visually detectable under an operator's normal maintenance that is caused by accidental damage, fatigue damage, and environmental degradation, and still maintain limit load capability with MSD to the extent expected at SMP.

- **Monitoring period** is the period of time when special inspections of the fleet are initiated due to an increased risk of MSD/MED (ISP) and ending when the SMP is reached.

- **Scatter Factor** is a life reduction factor used in the interpretation of fatigue analysis and fatigue test results.

- **Structural Modification Point (SMP)** is a point reduced from the WFD average behaviour (i.e., lower bound), so that operation up to that point provides equivalent protection to that of a two-lifetime fatigue test. No aircraft should be operated beyond the SMP without modification or part replacement.

- **Test-to-Structure Factor** is a series of factors used to adjust test results to full-scale structure. These factors could include, but are not limited to, differences in:
  - stress spectrum,
  - boundary conditions,
  - specimen configuration,
  - material differences,
  - geometric considerations, and
  - environmental effects.

- **Teardown** inspections can be destructive and can be performed on fatigue tested structural components or those that have been removed from service. Alternatively they involve local teardown (non-destructive) disassembly and subsequent refurbishment of specific areas of high-time aircraft in service. The liberated sections of structure are then inspected using visual and non-destructive inspection technology, to characterise the extent of damage within the structure with regard to corrosion, fatigue, and accidental damage.

- **WFD (average behaviour)** is the point in time when 50% of the fleet is expected to reach WFD for a particular detail.

3. GENERAL

The likelihood of the occurrence of fatigue damage in an aircraft's structure increases with aircraft usage. The design process generally establishes a design service goal (DSG) in terms of flight cycles/hours for the airframe. It is expected that any cracking that occurs on an aircraft 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 localised design detail. It is considered unlikely that cracks from manufacturing flaws or localised design issues will interact strongly as they grow.

With extended usage, uniformly loaded structure may develop cracks in adjacent fastener holes, or in adjacent similar structural details. These cracks may or may not interact, and they can have an adverse effect on the LDC of the structure before the cracks become detectable. The development of cracks at multiple locations (both MSD and MED) 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.

Because of the small probability of occurrence of MSD/MED in aircraft operation up to its DSG, maintenance programmes developed for initial certification have generally considered only local fatigue cracking. Therefore, as the aircraft reaches its DSG, it is necessary to take appropriate action in the ageing fleets to preclude WFD so that continued safe operation of the aircraft is not jeopardised. The DAH and/or the operator(s) should conduct structural evaluations to determine where and when MSD/MED may occur. Based on these evaluations the DAH and in some cases the operators would provide additional maintenance instructions for the structure, as appropriate. The maintenance instructions include, but are not limited to inspections, structural modifications, and limits of validity of the new maintenance instructions. In most cases, a combination of inspections and/or modifications/replacements is deemed necessary to achieve the required safety level. Other cases will require modification or replacement if inspections are not viable.

There is a distinct possibility that there could be a simultaneous occurrence of MSD and MED in a given structural area. This situation is possible on some details that were equally stressed. If this is possible, then this scenario should be considered in developing appropriate service actions for structural areas.

Before MSD/MED can be addressed, it is expected that the operators will incorporate an augmented structural maintenance programme that includes the Mandatory Modifications Programme, the CPCP, the SSIP and the Repair Assessment Programme.

There are alternative methods for accomplishing a WFD assessment other than that given in this AMC. For example, FAA AC 25-571-1C Paragraph 6.C or latest revision contains guidance material for the evaluation of structure using risk analysis techniques.

4. STRUCTURAL EVALUATION FOR WFD

4.1 General.

The evaluation has three objectives:

(a) Identify Primary Structure susceptible to MSD/MED, see paragraph 4.2.
(b) Predict when it is likely to occur; see paragraph 4.3 and
(c) Establish additional maintenance actions, as necessary, to ensure continued safe operation of the aircraft; see paragraph 4.4.

4.2 Structure susceptible to MSD/MED.

Susceptible structure is defined as that which has the potential to develop MSD/MED. Such structure typically has the characteristics of multiple similar details operating at similar stresses where structural capability could be affected by interaction of multiple cracking at a number of similar details. The following list provides examples of known types of structure susceptible to MSD/MED. (The list is not exhaustive):

STRUCTURAL AREA	**SEE FIGURE**
Longitudinal Skin Joints, Frames, and Tear Straps (MSD/MED)	A2-1
Circumferential Joints and Stringers (MSD/MED)	A2-2
Lap joints with Milled, Chem-milled or Bonded Radius (MSD)	A2-3
Fuselage Frames (MED)	A2-4
Stringer to Frame Attachments (MED)	A2-5
Shear Clip End Fasteners on Shear Tied Fuselage Frames (MSD/MED)	A2-6
Aft Pressure Dome Outer Ring and Dome Web Splices (MSD/MED)	A2-7
Skin Splice at Aft Pressure Bulkhead (MSD)	A2-8
Abrupt Changes in Web or Skin Thickness — Pressurised or Un-pressurised Structure (MSD/MED)	A2-9
Window Surround Structure (MSD, MED)	A2-10
Over Wing Fuselage Attachments (MED)	A2-11
Latches and Hinges of Non-plug Doors (MSD/MED)	A2-12
Skin at Runout of Large Doubler (MSD)—Fuselage, Wing or Empennage	A2-13
Wing or Empennage Chordwise Splices (MSD/MED)	A2-14
Rib to Skin Attachments (MSD/MED)	A2-15
Typical Wing and Empennage Construction (MSD/MED)	A2-16

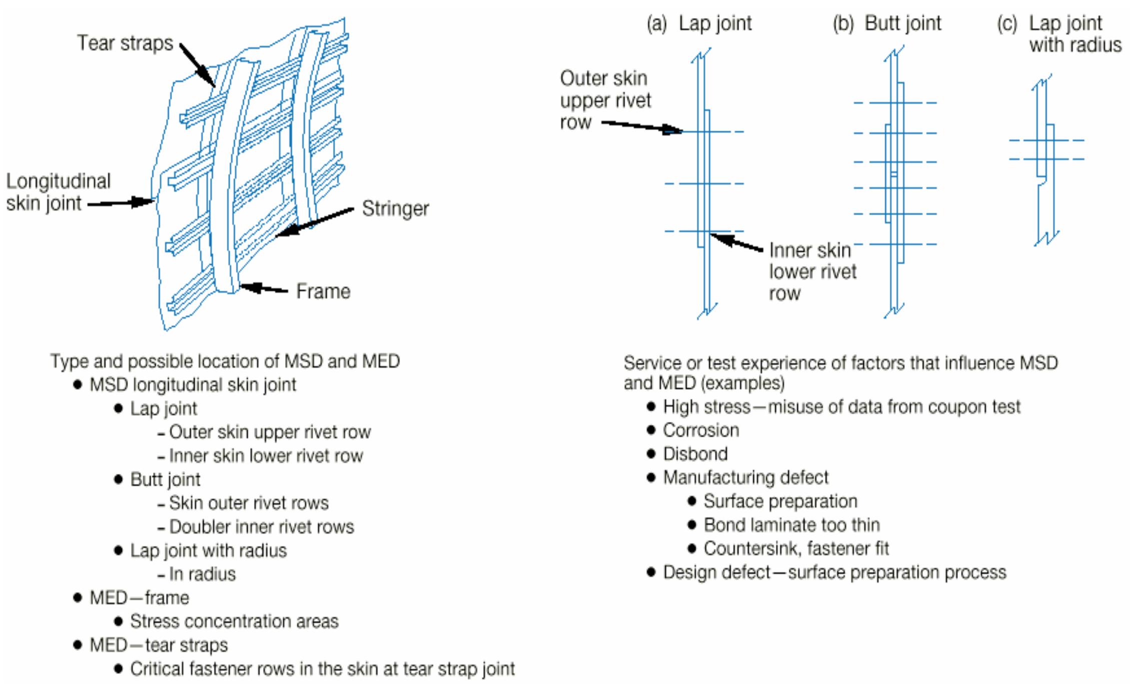
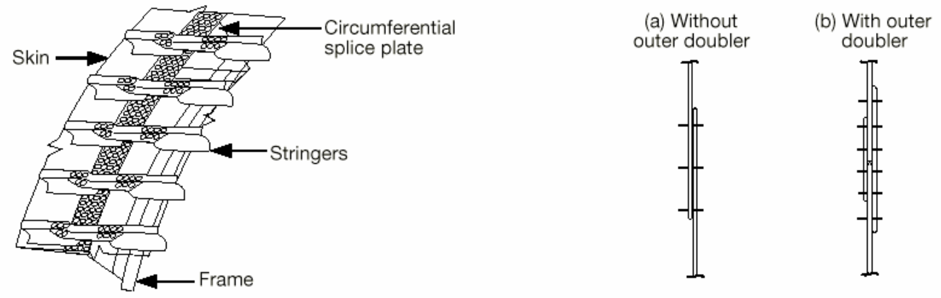


Figure A2-1 ***Longitudinal Skin Joints, Frames, and Tear Straps (MSD/MED)***



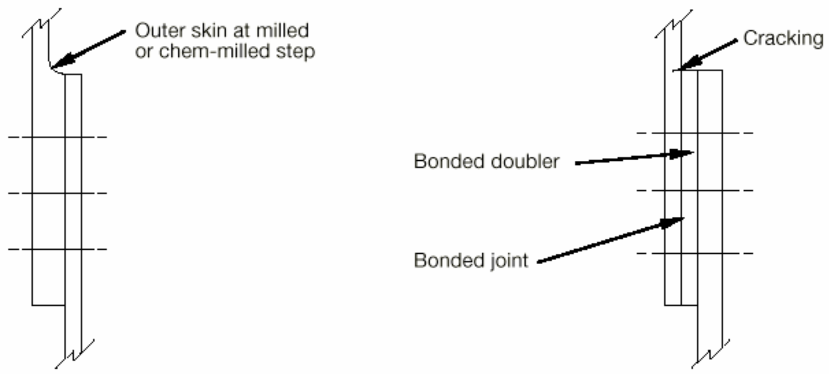
Type and possible location of MSD/MED

- MSD—circumferential joint
  - Without outer doubler
    - Splice plate—between and/or at the inner two rivet rows
    - Skin—forward and aft rivet row of splice plate
    - Skin—at first fastener of stringer coupling
  - With outer doubler
    - Skin—outer rivet rows
    - Splice plate/outer doubler—inner rivet rows
  - MED—stringer/stringer couplings
    - Stringer—at first fastener of stringer coupling
    - Stringer coupling—in splice plate area

Service or test experience of factors that influence MSD and/or MED (examples)

- High secondary bending
- High stress level in splice plate and joining stringers (misuse of data from coupon test)
- Poor design (wrong material)
- Underdesign (over-estimation of interference fit fasteners)

Figure A2-2 ***Circumferential Joints and Stringers (MSD/MED)***



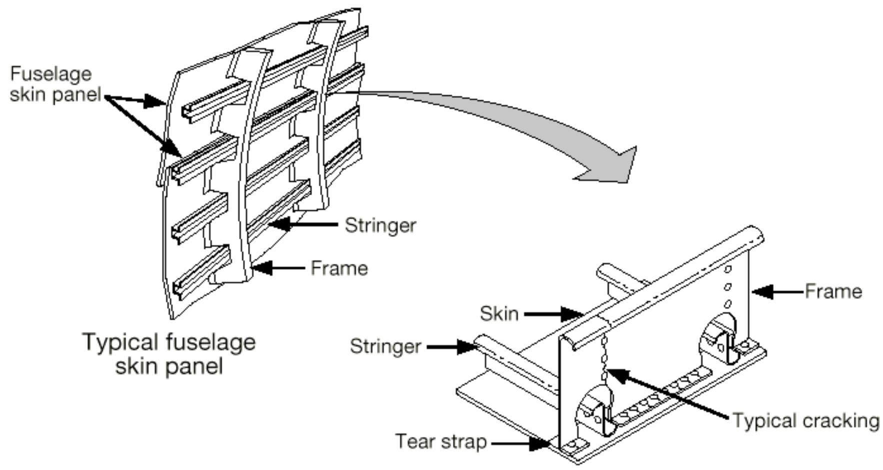
Type and possible location of MSD and MED

- MSD—abrupt cross section change
- Milled radius
- Chem-milled radius
- Bonded doubler runout

Service or test experience of factors that influence MSD and MED (examples)

- High bending stresses due to eccentricity

Figure A2-3 ***Lap joints with Milled, Chem-milled or Bonded Radius (MSD)***



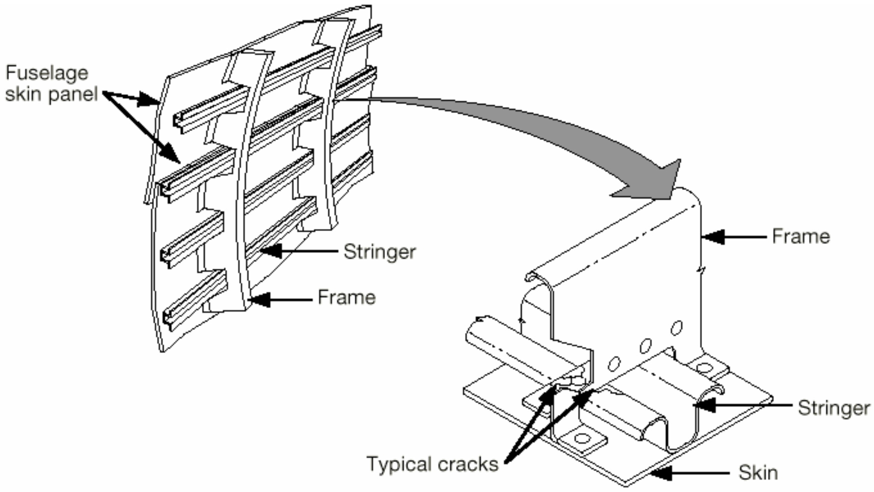
Type and possible location of MSD/MED

- MED—the cracking of frames at stringer cutouts at successive longitudinal locations in the fuselage. The primary concern is for those areas where noncircular frames exist in the fuselage structure. Fractures in those areas would result in panel instability.

Service or test experience of factors that influence MSD and/or MED (examples)

- High bending—noncircular frames
- Local stress concentrations
  - Cutouts
  - Shear attachments

Figure A2-4 ***Fuselage Frames (MED)***



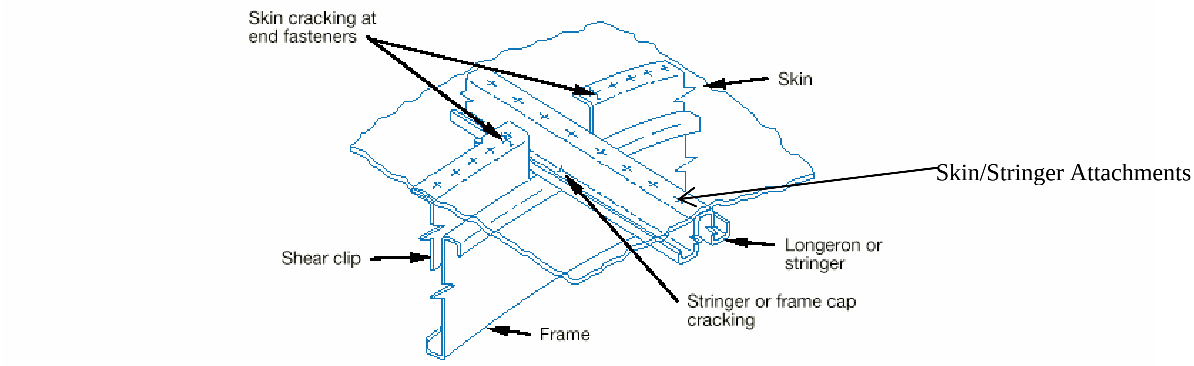
Type and possible location of MED

- MED—any combination of fracture of frames, clips, or stringers, including the attachments, resulting in the loss of the shear tie between the frame and stringer. This condition may occur at either circumferential or longitudinal locations at fuselage frame/stringer intersection.

Service or test experience of factors that influence MSD and/or MED (examples)

- Poor load path connection

Figure A2-5 ***Stringer to Frame Attachments (MED)***



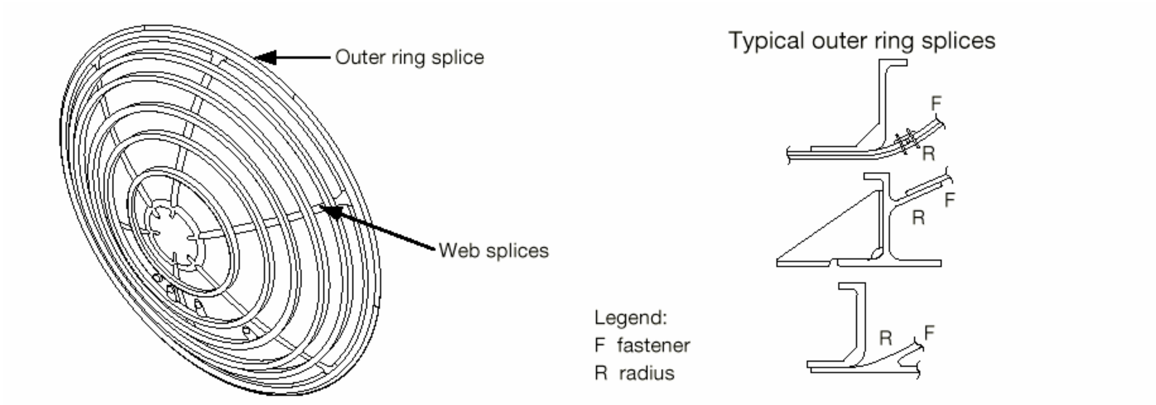
Type and possible location of MSD and MED

- MSD—skin at end fastener of shear clip
- MED—cracking in stringer or longeron at frame attachment
- MED—cracking in frame at stringer or longeron attachment

Service or test experience of factors that influence MSD and MED (examples)

- Preload
- Localized bending due to pressure
- Discontinuous load path

Figure A2-6 ***Shear Clip End Fasteners on Shear Tied Fuselage Frame (MSD/MED)***



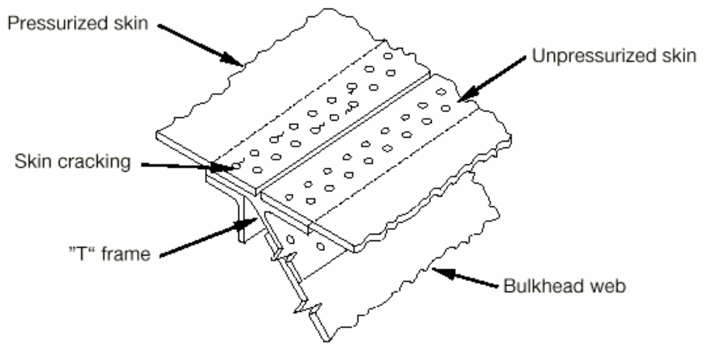
Type and possible location of MSD/MED

- MSD/MED—outer ring splice
  - Attachment profiles—at fastener rows and/or in radius area
- MED—web splices
  - Bulkhead skin and/or splice plates—at critical fastener rows

Service or test experience of factors that influence MSD and/or MED (examples)

- Corrosion
- High stresses—combined tension and compression
- High induced bending in radius
- Inadequate finish in radius—surface roughness

Figure A2-7 ***Aft Pressure Dome Outer Ring and Dome Web Splices (MSD/MED)***



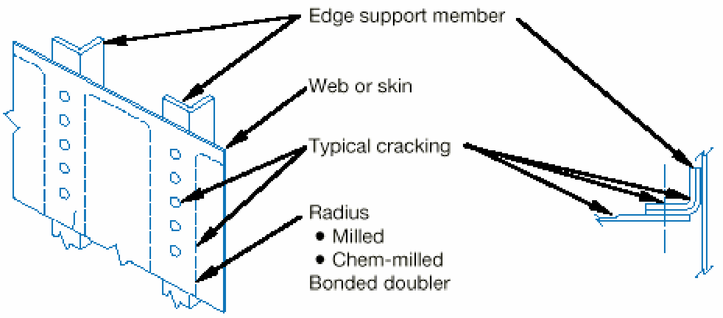
Type and possible location of MSD and MED

- MSD—skin at end fastener holes

Service or test experience of factors that influence MSD and MED (examples)

- Shell discontinuous induced bending stresses
- High load transfer at fastener

Figure A2-8 ***Skin Splice at Aft Pressure Bulkhead (MSD)***



Type and possible location of MSD and MED

Abrupt change in stiffness*

- Milled radius
- Chem-milled radius
- Bonded doubler
- Fastener row at edge support members

Edge member support structure

- Edge member - in radius areas

Service or test experience of factors that influence MSD and MED

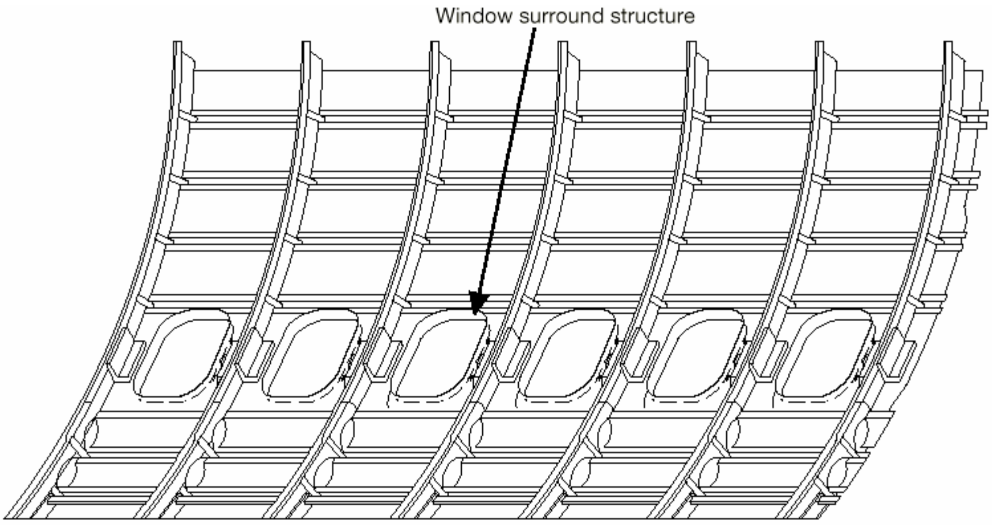
Pressure structure

- High bending stresses at edge support due to pressure

Non-pressure structure

- Structural deflections cause high stresses at edge supports

Figure A2-9 ***Abrupt Changes in Web or Skin Thickness — Pressurised or Unpressurised Structure (MSD/MED)***



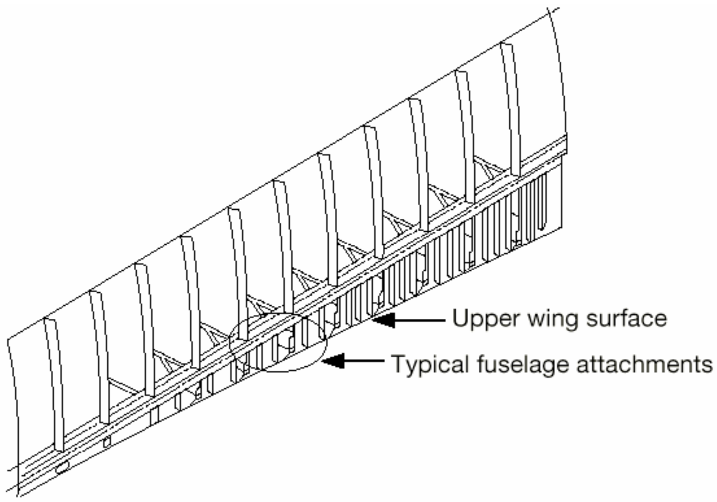
Type and possible location of MSD/MED

- MSD—skin at attachment to window surround structure
- MED—repeated details in reinforcement of window cutouts or in window corners

Service or test experience of factors that influence MSD and/or MED (examples)

- High load transfer

Figure A2-10 ***Window Surround Structure (MSD, MED)***



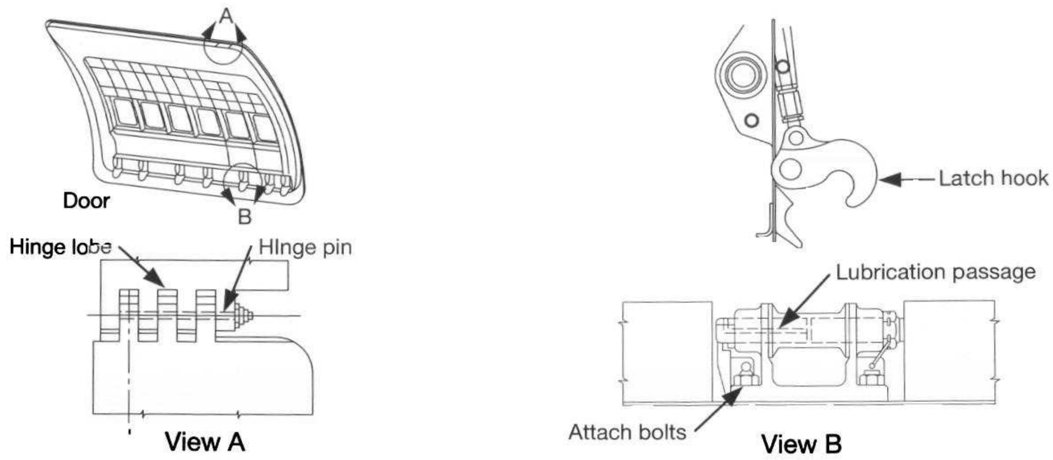
Type and possible location of MSD/MED

- MED—repeated details in overwing fuselage attachments

Service or test experience of factors that influence MSD and/or MED (examples)

- Manufacturing defect—prestress
- Induced deflections

Figure A2-11 ***Over Wing Fuselage Attachments (MED)***



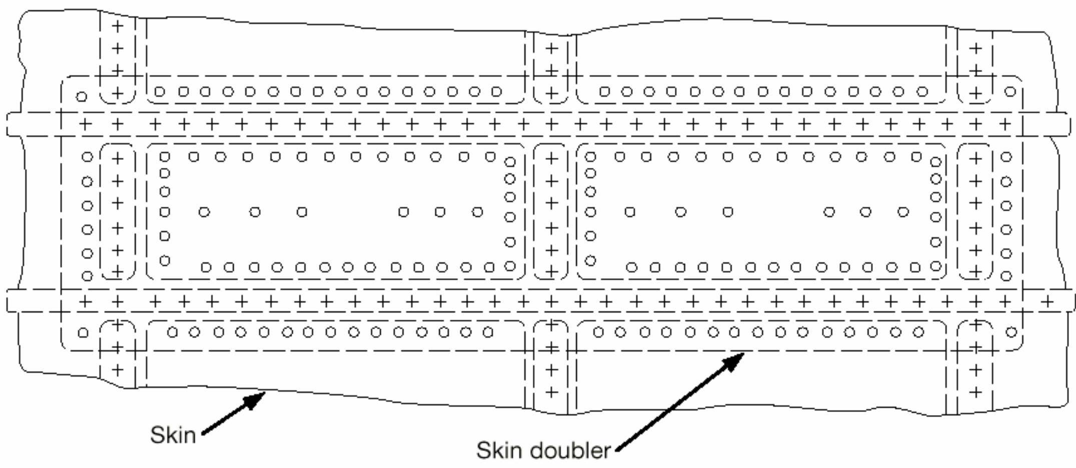
Type and possible location of MSD/MED

- MSD—piano hinge
  - At hinge fastener attachment row
  - In fillet radius
  - Emanating from hole in lobes
- MED—latches
  - In multiple latch hooks
  - At lube channel of latch spool
  - At spool bracket attach bolts (also corrosion)

Service or test experience of factors that influence MSD and/or MED (examples)

- Bending stresses due to fuselage elongation
- High local stress
- Fretting

Figure A2-12 ***Latches and Hinges of Non-plug Doors (MSD/MED)***



Type and possible location of MSD/MED

- MSD—cracks initiated at multiple critical fastener holes in skin at runout of doubler

Service or test experience of factors that influence MSD and/or MED (examples)

- High load transfer—high local stress

Figure A2-13 ***Skin at Runout of Large Doubler (MSD) — Fuselage, Wing or Empennage***

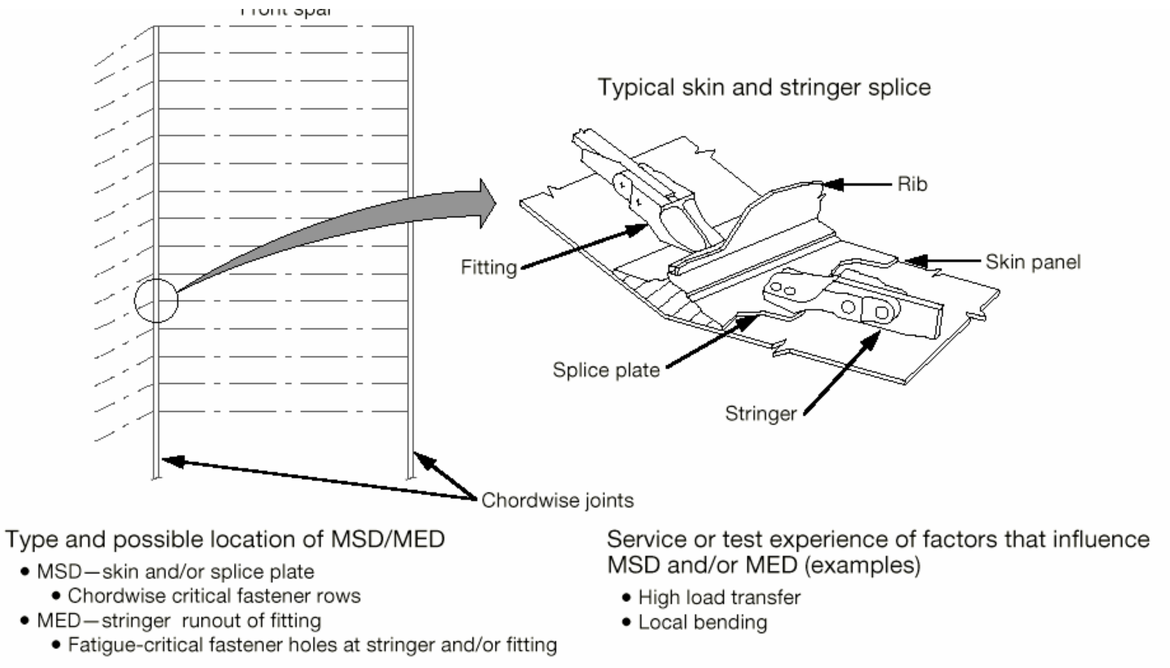


Figure A2-14 ***Wing or Empennage Chordwise Splices (MSD/MED)***

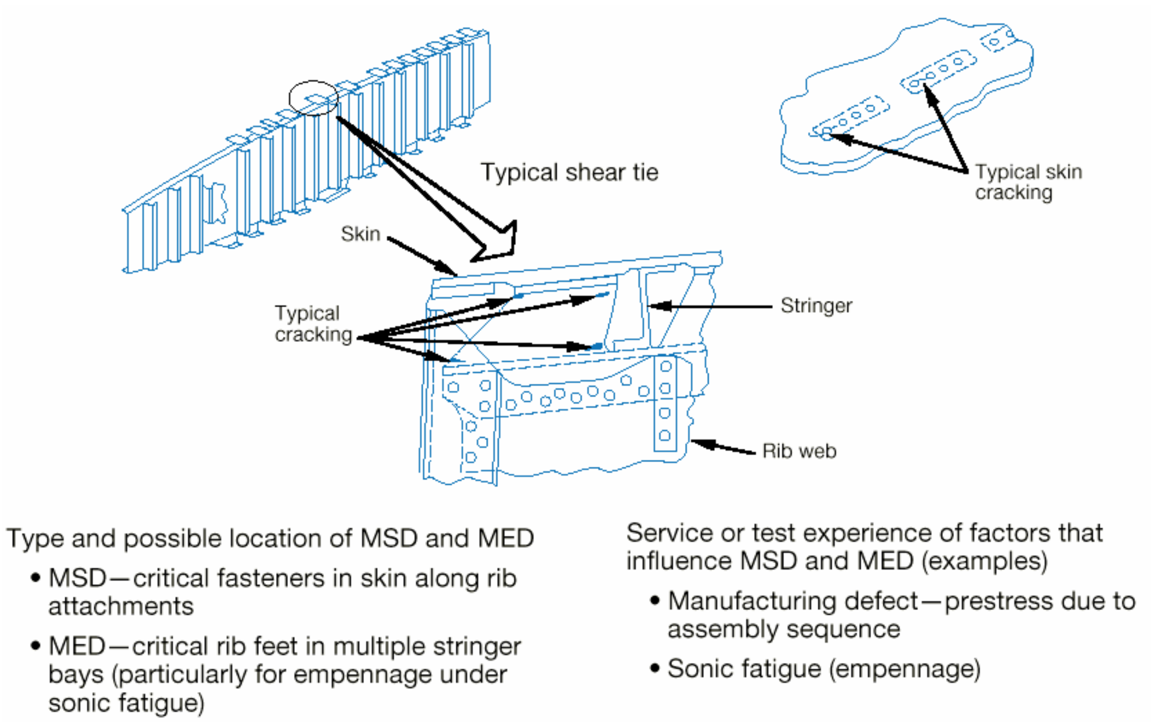


Figure A2-15 ***Rib to Skin Attachments (MSD/MED)***

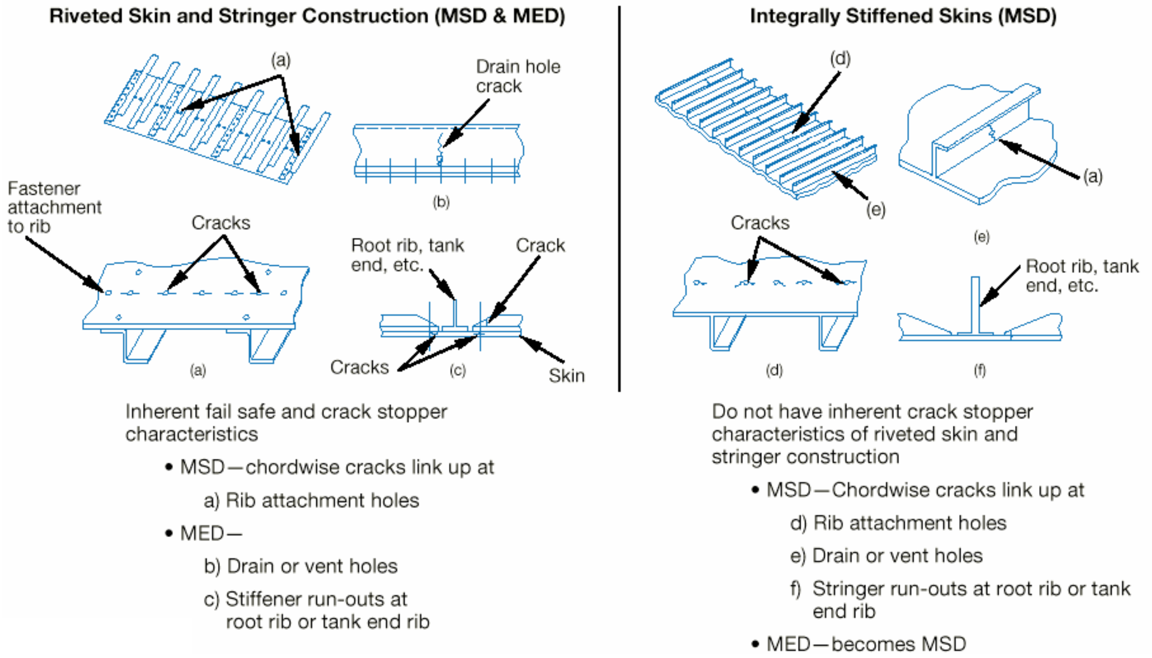


Figure A2-16 ***Typical Wing and Empennage Construction (MSD/MED)***

4.3 WFD Evaluation

By the time the highest-time aircraft of a particular model reaches its DSG, the evaluation for each area susceptible to the development of WFD should be completed. A typical evaluation process is shown in Figure A2-17, below. This evaluation will establish the necessary elements to determine a maintenance programme to preclude WFD in that particular model's aircraft fleet. These elements are developed for each susceptible area and include:

4.3.1 Identification of structure potentially susceptible to WFD

The TCH should identify each part of the aircraft's structure that is potentially susceptible to WFD for further evaluation. A justification should be given that supports selection or rejection of each area of the aircraft structure. DAHs for modified or repaired structure should evaluate their structure and its affect on existing structure.

Typical examples of structure susceptible to WFD are included in paragraph 4.2 of this appendix.

4.3.2 Determination of WFD average behaviour in the fleet:

The time in terms of flight cycles/hours defining the WFD average behaviour in the fleet should be established. The data to be assessed in determining the WFD average behaviour includes:

- a review of the service history of the susceptible areas to identify any occurrences of fatigue cracking,
- evaluation of the operational statistics of the fleet in terms of flight hours and landings,
- significant production variants (material, design, assembly method, and any other change that might affect the fatigue performance of the detail),
- fatigue test evidence including relevant full-scale and component fatigue and damage tolerance test data (see sub-paragraph 4.3.10 for more details),
- teardown inspections, and
- any fractographic analysis available.

The evaluation of the test results for the reliable prediction of the time to when WFD might occur in each susceptible area should include appropriate test-to-structure factors. If full-scale fatigue test evidence is used, Figure A2-18, below, relates how that data might be utilised in determining WFD Average Behaviour. Evaluation may be analytically determined, supported by test and, where available, service evidence.

4.3.3 Initial Crack/Damage Scenario

This is an estimate of the size and extent of multiple cracking expected at MSD/MED initiation. This prediction requires empirical data or an assumption of the crack/damage locations and sequence plus a fatigue evaluation to determine the time to MSD/MED initiation. Alternatively, analysis can be based on either:

- the distribution of equivalent initial flaws, as determined from the analytical assessment of flaws found during fatigue test and/or teardown inspections regressed to zero cycles; or
- a distribution of fatigue damage determined from relevant fatigue testing and/or service experience.

4.3.4 Final Cracking Scenario

This is an estimate of the size and extent of multiple cracking that could cause residual strength to fall to certification levels. Techniques exist for 3-D elastic-plastic analysis of such problems; however, there are several alternative test and analysis approaches available that provide an equivalent level of safety. One such approach is to define the final cracking scenario as a sub-critical condition (e.g., first crack at link-up at limit load). Use of a sub-critical scenario reduces the complexity of the analysis and, in many cases, will not greatly reduce the total crack growth time.

4.3.5 Crack Growth Calculation

Progression of the crack distributions from the initial cracking scenario to the final cracking scenario should be developed. These curves can be developed:

- *analytically*, typically based on linear elastic fracture mechanics, or
- *empirically*, from test or service fractographic data.

4.3.6 Potential for Discrete Source Damage (DSD)

A structure susceptible to MSD/MED may also be affected by DSD due to an uncontained failure of high-energy rotating machinery (i.e., turbine engines). The approach described in this guidance material should ensure the MSD sizes and densities, that normally would be expected to exist at the structural modification point, would not significantly change the risk of catastrophic failure due to DSD.

4.3.7. Analysis Methodology:

The evaluation methods used to determine the WFD average behaviour and associated parameters will vary. The report “Recommendations for Regulatory Action to Prevent Widespread Fatigue Damage in the Commercial Aeroplane Fleet”, Revision A, dated June 29, 1999 (a report of the AAWG for the ARAC’s Transport Aircraft and Engine Issues Group), discusses two Round Robin exercises developed by the TCHs to provide insight into their respective methodologies. One outcome of the exercises was an identification of key assumptions or methods that had the greatest impact on the predicted WFD behaviour. These assumptions were:

- the flaw sizes assumed at initiation of crack growth phase of analysis;
- material properties used (static, fatigue, fracture mechanics);
- ligament failure criteria;
- crack growth equations used;
- statistics used to evaluate the fatigue behaviour of the structure (e.g., time to crack initiation);
- methods of determining the structure modification point (SMP);

- detectable flaw size assumed;
- initial distribution of flaws; and
- factors used to determine bound behaviour as opposed to mean behaviour.

The following parameters are developed from paragraphs 4.3.2 through 4.3.7 above, and are necessary to establish a MSD/MED maintenance programme for the area under investigation.

4.3.8 Inspection Start Point (ISP):

This is the point at which inspection starts if a monitoring period is used. It is determined through a statistical analysis of crack initiation based on fatigue testing, teardown, or service experience of similar structural details. It is assumed that the ISP is equivalent to a lower bound value with a specific probability in the statistical distribution of cracking events. Alternatively, the ISP may be established by applying appropriate factors to the average behaviour.

4.3.9 Considerations:

Due to the redundant nature of semi-monocoque structure, MED can be difficult to manage in a fleet environment. This stems from the fact that most aircraft structures are built-up in nature, and that makes the visual inspection of the various layers difficult. Also, visual inspections for MED typically rely on internal inspections, which may not be practical at the frequency necessary to preclude MED due to the time required to gain access to the structure. However, these issues are dependent on the specific design involved and the amount of damage being considered. In order to implement a viable inspection programme for MED, the following conditions must be met:

a) Static stability must be maintained at all times.

b) Large damage capability should be maintained.

c) There is no concurrent MED with MSD in a given structural area.

4.3.10 Structural Modification Point (SMP)

The applicant should demonstrate that the proposed SMP established during the evaluation has the same confidence level as current regulations require for new certification. In lieu of other acceptable methods, the SMP can be established as a point reduced from the WFD Average Behaviour, based on the viability of inspections in the monitoring period. The SMP can be determined by dividing the WFD Average Behaviour by a factor of 2 if there are viable inspections, or by a factor of 3 if inspections are not viable.

Whichever approach is used to establish the SMP, a study should be made to demonstrate that the approach ensures that the structure with the expected extent of MSD/MED at the SMP maintains a LDC.

An aircraft should not be operated past the SMP unless the structure is modified or replaced, or unless additional approved data is provided that would extend the SMP. However, if during the structural evaluation for WFD, a TCH/DAH finds that the flight cycles and/or flight hours SMP for a particular structural detail have been exceeded by one or more aircraft in the fleet, the TCH/DAH should expeditiously evaluate selected high time aircraft in the fleet to determine their structural condition. From this evaluation, the TCH/DAH should notify the competent authorities and propose appropriate service actions.

The initial SMP may be adjusted based on the following:

(a) In some cases, the SMP may be extended without changing the required reliability of the structure, i.e. projection to that of a two life time full-scale fatigue test. These cases may generally be described under the umbrella of additional fatigue test evidence and include either or a combination of any or all of the following:

- Additional fatigue and/or residual strength tests on a full-scale aircraft structure or a full-scale component followed by detailed inspections and analyses.
- Testing of new or used structure on a smaller scale than full component tests (i.e., sub-component and/or panel tests).
- Teardown inspections (destructive) that could be done on structural components that have been removed from service.
- Local teardown by selected, limited (non-destructive) disassembly and refurbishment of specific areas of high-time aircraft.
- In-service data from a statistically significant number of aircraft close to the original SMP showing no cracking compared with the predictions, taking into account future variability in service usage and loading compared to the surveyed aircraft. This data may be used to support increasing the original SMP by an amount that is agreed by the competent authority.

(b) If cracks are found in the structural detail for which the evaluation was done during either the monitoring period or the modification programme, the SMP should be re-evaluated to ensure that the SMP does in fact provide the required confidence level. If it is shown that the required confidence level is not being met, the SMP should be adjusted and the adjustment reflected in appropriate service bulletins to address the condition of the fleet. Additional regulatory action may be required.

4.3.11 Inspection Interval and Method:

An interval should be chosen to provide a sufficient number of inspections between the ISP and the SMP so that there is a high confidence that no MSD/MED condition will reach the final cracking scenario without detection. The interval is highly dependent on the detectable crack size and the probability of detection associated with the specific inspection method. If the crack cannot be detected, the SMP must be re-evaluated to ensure there is a high confidence level that no aircraft will develop MSD/MED before modification.

4.4 Evaluation of Maintenance Actions

For all areas that have been identified as susceptible to MSD/MED, the current maintenance programme should be evaluated to determine if adequate structural maintenance and inspection programmes exist to safeguard the structure against unanticipated cracking or other structural degradation. The evaluation of the current maintenance programme typically begins with the determination of the SMP for each area.

Each area should then be reviewed to determine the current maintenance actions and compare them to the maintenance needs established in this evaluation. Issues to be considered include the following:

(a) Determine the inspection requirements (method, inspection start point, and repeat interval) of the inspection for each susceptible area (including that structure that is expected to arrest cracks) that is necessary to maintain the required level of safety.

(b) Review the elements of the existing maintenance programmes already in place

(c) Revise and highlight elements of the maintenance programme necessary to maintain safety.

For susceptible areas approaching the SMP, where the SMP will not be increased or for areas that cannot be reliably inspected, a programme should be developed and documented that provides for replacement or modification of the susceptible structural area.

4.4.1 Period of WFD Evaluation Validity:

At whatever point the WFD evaluation is made, it should support the limit of validity (LOV) of the maintenance programme. Consistent with the use of test evidence to support individual SMPs, as described above in paragraph 4.3.10, the LOV of the maintenance programme should be based on fatigue test evidence. The initial WFD evaluation of the complete airframe will typically cover a significant forward estimation of the projected aircraft usage beyond its DSG, also known as the "proposed ESG." An evalution through at least an additional twenty-five percent of the DSG would provide a realistic forecast, with reasonable planning time for necessary maintenance action. However, it may be appropriate to adjust the evaluation validity period depending on issues such as:

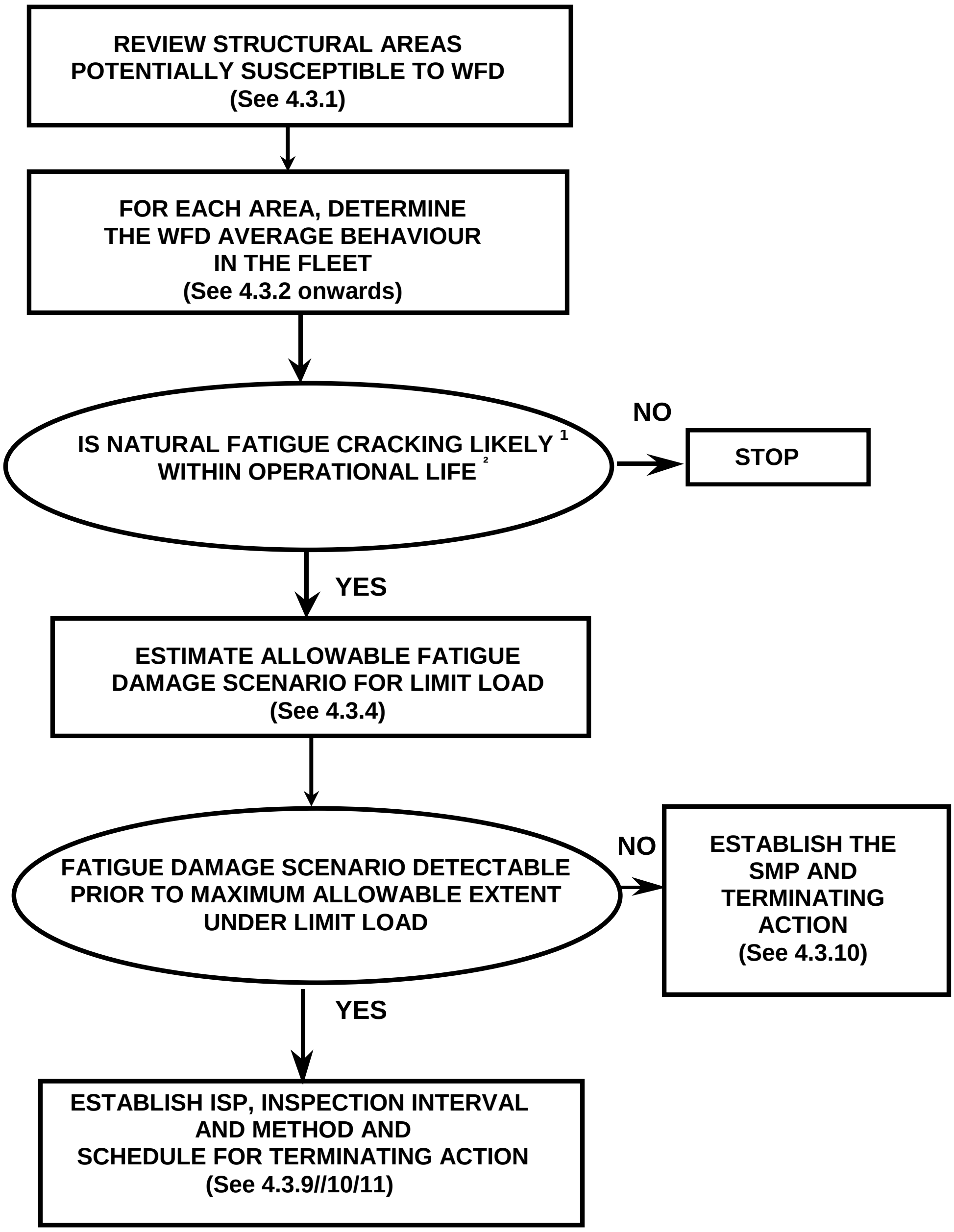
(a) The projected useful life of the aircraft at the time of the initial evaluation;

(b) Current non-destructive inspection (NDI) technology; and

(c) Airline advance planning requirements for introduction of new maintenance and modification programmes, to provide sufficient forward projection to identify all likely maintenance/modification actions essentially as one package.

Upon completion of the evaluation and publication of the revised maintenance requirements, the "proposed ESG" becomes the Limit of Validity (LOV)

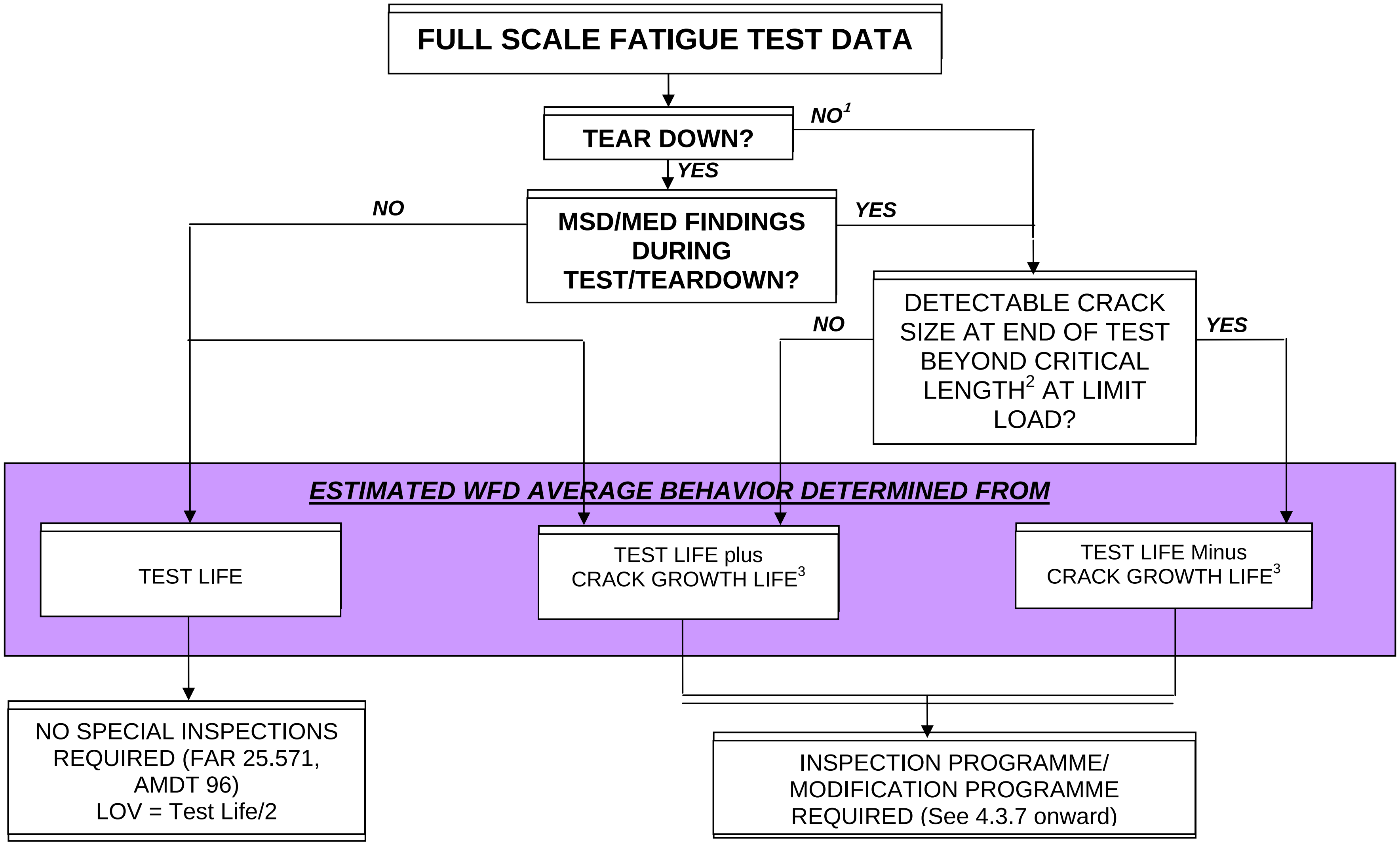
Note: This assumes that all other aspects of the maintenance programme that are required to support the LOV (such as SSID, CPCP, etc.) are in place and have been evaluated to ensure they too remain valid up to the LOV.



NOTES

1. Fatigue cracking is defined as likely if the factored fatigue life is less than the projected ESG of the aircraft at time of WFD evaluation.
2. The operational life is the projected ESG of the aircraft at time of WFD Evaluation. (See 4.4.1).

Figure A2-17: ***Aircraft Evaluation Process***



1 **ASSUMED STATE AT END OF TEST**: Best estimate of non-detected damage from inspection method used at end of test or during teardown.
2 **CRITICAL CRACK LENGTH**: First link-up of adjacent cracks at limit load (locally) or an adequate level of large damage capability.
3 **CRACK GROWTH LIFE**: Difference between assumed or actual state at end of test and critical crack length.

Figure A2-18 ***Use of Fatigue Test and Teardown Information to Determine WFD Average Behaviour***

5. DOCUMENTATION

Any person developing a programme should develop a document containing recommendations for inspection procedures and replacement or modification of parts or components necessary to preclude WFD, and establish the new limit of validity of the operator's maintenance programme. That person also must revise the SSID or ALS as necessary, and/or prepare service bulletins that contain the recommendations for inspection procedures and replacement or modification of parts or components necessary to preclude WFD. Since WFD is a safety concern for all operators of older aircraft, the Agency will make mandatory the identified inspection or modification programmes. In addition, the Agency may consider separate AD action to address any service bulletins or other service information publications revised or issued as a result of in-service MSD/MED findings resulting from implementation of these programmes.

The following items should be contained in the front of the approved document:

(a) Identification of the variants of the basic aircraft type to which the document relates;

(b) Summary of the operational statistics of the fleet in terms of hours and flights;

(c) Description of the typical mission, or missions;

(d) The types of operations for which the inspection programme is considered valid;

(e) Reference to documents giving any existing inspections, or modification of parts or components; and

(f) The LOV of the maintenance programme in terms of flight cycles or flight hours or both as appropriate to accommodate variations in usage.

The approved document should contain at least the following information for each critical part or component:

(a) Description of the Primary Structure susceptible to WFD;

(b) Details of the monitoring period (inspection start point, repeat inspection interval, SMP, inspection method and procedure (including crack size, location and direction) and alternatives) when applicable;

(c) Any optional modification or replacement of the structural element as terminating action to inspection;

(d) Any mandatory modification or replacement of the structural element;

(e) Service bulletins (or other service information publications) revised or issued as a result of in-service findings resulting from the WFD evaluations (added as a revision to the initial WFD document); and

(f) Guidance to the operator on which inspection findings should be reported to the TCH/DAH, and appropriate reporting forms and methods of submittal.

6. REPORTING REQUIREMENTS

Operators, TCHs and STC Holders are required to report in accordance with various regulations, for example Part 21.3, Part 145.60. The regulations to which this AMC relates do not require any reporting requirements in addition to the current ones. Due to the potential threat to structural integrity, the results of inspections must be accurately documented and reported in a timely manner to preclude the occurrence of WFD. The current system of operator and TCH communication has been useful in identifying and resolving a number of issues that can be classified as WFD concerns. MSD/MED has been discovered via fatigue testing and in-service experience. TCHs have been consistent in disseminating related data to operators to solicit additional service experience. However, a more thorough means of surveillance and reporting is essential to preclude WFD.

When damage is found while conducting an approved MSD/MED inspection programme, or at the SMP where replacement or modification of the structure is occurring, the TCHs, STC Holders and the operators need to ensure that greater emphasis is placed on accurately reporting the following items:

(a) A description (with a sketch) of the damage, including crack length, orientation, location, flight cycles/hours, and condition of structure;

(b) Results of follow-up inspections by operators that identify similar problems on other aircraft in the fleet;

(c) Findings where inspections accomplished during the repair or replacement/modification identify additional similar damage sites; and

(d) Adjacent repairs.

Operators must report all cases of MSD/MED to the TCH, STC Holder or the competent authority as appropriate, irrespective of how frequently such cases occur. Cracked areas from in-service aircraft (damaged structure) may be needed for detailed examination. Operators are encouraged to provide fractographic specimens whenever possible. Aeroplanes undergoing heavy maintenance checks are perhaps the most useful sources for such specimens.

Operators should remain diligent in the reporting of potential MSD/MED concerns not identified by the TCH/DAH. Indications of a developing MSD/MED problem may include:

(a) Damage at multiple locations in similar adjacent details;

(b) Repetitive part replacement; or

(c) Adjacent repairs.

Documentation will be provided by the TCH and STC Holder as appropriate to specify the required reporting format and time frame. The data will be reviewed by the TCH or STC Holder, operator(s), and the Agency to evaluate the nature and magnitude of the problem and to determine the appropriate corrective action.

7. STRUCTURAL MODIFICATIONS AND REPAIRS

All major modifications (STCs) and repairs that create, modify, or affect structure that are susceptible to MSD/MED (as identified by the TCH) must be evaluated to demonstrate the same confidence level as the original manufactured structure. The operator is responsible together with the DAH for ensuring the accomplishment of this evaluation for each modified aircraft. The operator may first need to conduct an assessment on each of its aircraft to determine what modifications or repairs exist and would be susceptible to MSD/MED. The following are some examples of types of modifications and repairs that present such concerns:

(a) Passenger-to-freighter conversions (including addition of main deck cargo doors);

(b) Gross weight increases (increased operating weights, increased zero fuel weights, increased landing weights and increased maximum takeoff weights);

(c) Installation of fuselage cutouts (passenger entry doors, emergency exit doors or crew escape hatches, fuselage access doors and cabin window relocations);

(d) Complete re-engine and/or pylon modifications;

(e) Engine hush-kits and nacelle modifications;

(f) Wing modifications, such as the installation of winglets or changes in flight control settings (flap droop), and changes to wing trailing edge structure;

(g) Modified, repaired, or replaced skin splice;

(h) Any modification or repair that affects several frame bays; and

(i) Multiple adjacent repairs.

Other potential areas that must be considered include:

(a) A modification that covers structure requiring periodic inspection by the operator's maintenance programme (Modifications must be reviewed to account for the differences with TCH baseline maintenance programme requirements.);

(b) A modification that results in operational mission change that significantly changes manufacturers load/stress spectrum (for example, a passenger-to-freighter conversion); and

(c) A modification that changes areas of the fuselage from being externally inspectable using visual means to being uninspectable (for example, a large external fuselage doubler that resulted in hidden details, rendering them visually uninspectable).

8. RESPONSIBILITY

While the primary responsibility is with the DAH to perform the analyses and supporting tests, it is expected that the evaluation will be conducted in a cooperative effort between the operators and TCHs/DAHs, with participation by the Agency.

APPENDIX 3

Guidelines for establishing instructions for continued airworthiness of structural repairs and modifications.

1. INTRODUCTION

With an SSID, CPCP and LOV in place an individual aircraft may still not meet the intended level of airworthiness for ageing aircraft structures. Repairs and modifications to aircraft structure also require investigation. For large transport aeroplanes, all repairs and modifications that affect FCS should be assessed using some form of damage-tolerance based evaluation. A regulatory requirement for damage-tolerance was not applied to aeroplane designs type certificated before 1978, and even after this time, implementation of DTE on repairs and modifications was not consistent. Therefore the damage-tolerance characteristics of repairs and modifications may vary widely and are largely unknown. In view of these concerns it is necessary to perform an assessment of repairs and modifications on existing aircraft to establish their damage-tolerance characteristics.

2. DEFINITIONS

For the purposes of this Appendix, the following definitions apply:

- **Damage Tolerance Data** are damage tolerance evaluation (DTE) documentation and the damage tolerance inspections (DTIs).

- **Damage Tolerance Evaluation (DTE)** is a process that leads to a determination of maintenance actions necessary to detect or preclude fatigue cracking that could contribute to a catastrophic failure. As applied to repairs and modifications, a DTE includes the evaluation of the repair or modification and the fatigue critical structure affected by the repair or modification. The process utilises the damage tolerance procedures as described in CS-25 AMC 25.571.

- **Damage Tolerance Inspections (DTIs)** are the inspections developed as a result of a DTE. A DTI includes the areas to be inspected, the inspection method, the inspection procedures, including acceptance and rejection criteria, the threshold, and any repetitive intervals associated with those inspections. The DTIs may specify a time limit when a repair or modification needs to be replaced or modified. If the DTE concludes that DT-based supplemental structural inspections are not necessary, the DTI documentation should include a statement that the normal zonal inspection programme is sufficient.

- **Fatigue Critical Baseline Structure (FCBS)** is the baseline structure of the aircraft that is classified as fatigue critical structure.

3. ESTABLISHMENT OF A DAMAGE-TOLERANT BASED INSPECTION PROGRAMME FOR REPAIRS AFFECTING FCS

Repairs are a concern on older aircraft 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 unique and tailored in design to correct particular damage to the original structure. Whereas the performance of the original structure may be predicted from tests and from experience on other aircraft in service, the behaviour of a repair and its effect on the fatigue characteristics of the original structure are generally known to a lesser extent than for the basic un-repaired structure.

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

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

The practice of repair justification has evolved gradually over the last 20 plus years. Some repairs described in the aircraft manufacturers' SRMs were not designed to fatigue and damage-tolerance principles. (Ref. AAWG Report: Recommendations concerning ARAC taskings FR Doc.04-10816 Re: Aging Aircraft Safety Final Rule. 14 CFR 121.370a and 129.16.) Repairs accomplished in accordance with the information contained in the early versions of the SRMs may require additional inspections if evaluated using the fatigue and damage-tolerance methodology.

Damage-tolerance is a structural design and inspection methodology used to maintain safety considering the possibility of metal fatigue or other structural damage (i.e., safety is maintained by adequate structural inspection until the damage is repaired). One prerequisite for the successful application of the damage tolerance approach for managing fatigue is that crack growth and residual strength can be anticipated with sufficient precision to allow inspections to be established that will detect cracking before it reaches a size that will degrade the strength below a specified level. A damage-tolerance evaluation entails the prediction of sites where fatigue cracks are most likely to initiate in the aircraft structure, the prediction of the crack path and rates of growth under repeated aircraft structural loading, the prediction of the size of the damage at which strength limits are exceeded, and an analysis of the potential opportunities for inspection of the damage as it progresses. This information is used to establish an inspection programme for the structure that will be able to detect cracking that may develop before it precipitates a major structural failure.

The evidence to date is that when all critical structure is included, damage-tolerant based inspections and procedures, including modification and replacement, provide the best assurance of continued structural integrity that is currently available. In order to apply this concept to existing transport aeroplanes, the competent authorities issued a series of ADs requiring compliance with the first supplemental inspection programmes resulting from application of this concept to existing aeroplanes. Generally, these ADs require that operators incorporate SSIDs into their maintenance programmes for the affected aeroplanes. These documents were derived from damage-tolerance assessments of the originally certificated type designs for these aeroplanes. For this reason, the majority of ADs written for the SSIP did not attempt to address issues relating to the damage-tolerance of repairs that had been made to the aeroplanes. The objective of this programme is to provide the same level of assurance for areas of the structure that have been repaired as that achieved by the SSIP for the baseline structure as originally certificated.

The fatigue and damage-tolerance evaluation of a repair would be used in an assessment programme to establish an appropriate inspection programme, or a replacement schedule if the necessary inspection programme is too demanding or not possible. The objective of the repair assessment is to assure the continued structural integrity of the repaired and adjacent structure based on damage-tolerance principles. Any identified supplemental inspections are intended to detect damage which may develop in a repaired area, before that damage degrades the load carrying capability of the structure below the levels required by the applicable airworthiness standards.

The following guidance is intended to help TCHs and operators establish and implement a damage-tolerant based maintenance programme for repairs affecting FCBS. Additional guidance for repairs to modified structure is provided in paragraph 4.

3.1 Overview of the TCH tasks for repairs that may affect FCBS

(a) Identify the affected aircraft model, models, aircraft serial numbers, and DSG stated as a number of flight cycles, flight hours, or both.

(b) Identify the certification level.

(c) Submit the list of FCBS to EASA for approval, and make it available to operators and STC holders.

(d) Review and update published repair data as necessary.

(e) Submit any new or updated published repair data to EASA for approval, and make it available to operators.

(f) Develop Repair Evaluation Guidelines (REGs) and submit them to EASA for approval, and make the approved REGs available to operators.

3.2. Certification Level

In order to understand what data is required, the TCH should identify the amendment level of the original aircraft certification relative to CS 25.571. The amendment level is useful in identifying what DT Data may be available and what standard should be used for developing new DT Data. The two relevant aircraft groups are:

Group A - Aircraft certified to CAR 4b or § 25.571, prior to Amendment 25-45 or equivalent. These aircraft were not evaluated for damage tolerance as part of the original type certification. Unless previously accomplished, existing and future repairs to FCBS will need DT Data developed.

Group B - Aircraft certified to § 25.571, Amendment 25-45 or later. These aircraft were evaluated for damage tolerance as part of the original type certification. As noted in the introduction, some of these repairs may not have repair data that includes appropriate DTI and the TCH and operators may need to identify and perform a DTE of these repairs and develop DTI.

3.3. Identifying Fatigue Critical Baseline Structure (FCBS)

TC Holders should identify and make available to operators a list of baseline structure that is susceptible to fatigue cracking that could contribute to a catastrophic failure. The term “baseline” refers to the structure that is designed under the original type certificate or amended type certificate for that aircraft model (that is, the as delivered aircraft model configuration). Guidance for identifying this structure can be found in CS-25 AMC 25.571. This structure is referred to in this AMC as “fatigue critical baseline structure.” The purpose of requiring identification and listing of fatigue critical structure (FCS) is to provide operators with a tool that will help in the evaluating existing and future repairs or modifications. In this context, fatigue critical structure is any structure that is susceptible to fatigue that could contribute to a catastrophic failure, and should be subject to a damage-tolerance evaluation (DTE). The DTE would determine if DTIs need to be established for the repaired or modified structure. For the purpose of this AMC, structure that is modified after aircraft delivery from the TCH is not considered to be “baseline” structure.

CS 25.571(a) states “An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue…will be avoided throughout the operational life of the aircraft. This evaluation must be conducted…for each part of the structure which could contribute to a catastrophic failure (such as wing, empennage, control surfaces, fuselage, engine mounts, and their related primary attachments)….” When identifying FCBS, it is not sufficient to consider only that structure identified in the supplemental structural inspection document (SSID) or airworthiness limitation section (ALS). Some SSIDs or ALSs might only include supplemental inspections of the most highly stressed elements of the FCBS. A SSID and ALS often refer to this structure as a Principal Structural Element (PSE). If repaired, other areas of structure not identified as a PSE in the SSID or ALS may require supplemental inspections. The term PSE has, at times, been applied narrowly by industry. The narrow application of the term PSE could incorrectly limit the scope of the structure that would be considered relative to fatigue if repairs or modifications exist or are subsequently made. The relationship between PSE and FCS could vary significantly depending on the TCH’s working definition of PSE. In addition, there may be structure whose failure would be catastrophic, but due to low operational loads on the part, the part will not experience fatigue cracking. However, if the subject part is repaired or modified, the stresses in the part may be increased to a level where it is now susceptible to fatigue cracking. These types of parts should be considered as fatigue critical structure.

TC Holders should develop the list of FCBS and include the locations of FCS and a diagram showing the extent of FCS. TC Holders should make the list available to STC Holders and to operators.

3.4. Certification Standard Applied When Performing a DTE

For Group A aircraft, the TC Holder should use the requirements of § 25.571, at Amendment 25-45, as a minimum standard. For Group B aircraft, the TC Holder should use the requirements that correspond to the original certification basis as a minimum standard. For each repair requiring a DTE, the DAH should apply not less than the minimum standard when developing new or revised DT Data. The certification standard applied by the TC Holder in performing a DTE for repairs should be included with the relevant approved documentation to the operator.

3.5. Performing a DTE on a Repair That Affects FCBS

When performing a DTE on a repair that affects FCBS, the DTE would apply to the affected FCBS and repair. This may consist of an individual analysis or the application of a DT-based process such as RAGs that would be used by an operator. The result of the DTE should lead to developing DTI that address any adverse effects the repair may have on the FCBS. If the DTE results determine that DTIs are not required to ensure the continued airworthiness of the affected FCBS, the TC Holder should note that in the DTE documentation.

The term ''adverse effects'' refers to a degradation in the fatigue life or inspectability of the affected FCBS. Degradation in fatigue life (earlier occurrence of critical fatigue cracking) may result from an increase in internal loading, while degradation of inspectability may result from physical changes made to the structure. The DTE should be performed within a time frame that ensures the continued airworthiness of affected FCBS.

3.6. Review of Published Repair Data

Published repair data are generally applicable instructions for accomplishing repairs, such as those contained in SRMs and SBs. TCHs should review their existing repair data and identify each repair that affects FCBS. For each such repair, unless previously accomplished, the TCH must perform a DTE and develop any necessary DTI for the affected FCBS and repair data. For some repairs, the results of the DTE will conclude that no new DTI will be required for the affected FCBS or repair. For these cases, the TCH should provide a means that informs the operator a DTE was performed for the subject repair. This may be accomplished, for example, by providing a statement in a document, such as an SRM, stating that all repairs contained in this manual have had a DTE performed. This should preclude operators from questioning those repairs that do not have DTIs. TCHs should provide a list of its published repair data to operators and a statement that a DTE has been performed on this data. The following examples of published repair data developed by the TCH should be reviewed and included in this list:

(a) SRMs,

(b) SBs,

(c) Documents containing AD mandated repairs, and

(d) Other documents available to operators (for example, aircraft maintenance manuals and component maintenance manuals) containing approved repair data.

3.7. Developing DT Data for Existing Published Repair Data

3.7.1. SRMs

The TCH should review the repair data contained in each SRM and identify repairs that affect FCBS. For these repairs, the TCH will need to determine if the SRM needs revising to provide adequate DTI. In determining the extent to which an SRM may need to be revised for compliance, consider the following:

(a) Whether the existing SRM contains an adequate description of DTIs for the specific model.

(b) Whether normal maintenance procedures (for example, the inspection threshold and/or existing normal maintenance inspections) are adequate to ensure the continued airworthiness (inspectability) equal to the unrepaired surrounding structure.

(c) Whether SRM Chapter 51 standard repairs have a DT evaluation.

(d) Whether all SRM specific repairs affecting FCBS have had a DTE performed.

(e) Whether there is any guidance on proximity of repairs.

(f) Whether superseded repairs are addressed and how a DTE is performed for future superseded repairs and how any DTI will be made available.

3.7.2. SBs

The TCH should review the repair data contained in its SBs and identify those repairs that affect FCBS. For those repairs, the TCH should then determine if a new DTE will need to be performed. This review may be done in conjunction with the review of SBs for modifications that affect FCBS.

3.7.3. ADs

The TCH should review ADs that provide maintenance instructions to repair FCBS and determine if the instructions include any necessary DT Data. While the maintenance instructions supporting ADs are typically contained in SBs, other means of documentation may be used.

3.7.4. Other Forms of Data Transmittal

In addition to SRMs, SBs, and documentation for ADs, the TCH should review any other documents (for example, aircraft maintenance manuals and component maintenance manuals) that contain repair data. Individual repair data not contained in the above documents will be identified and DT Data obtained through the Repair Evaluation Guidelines process.

3.8. Developing DT Data for Future Published Repair Data

Following the completion of the review and revision of existing published data any subsequent repair data proposed for publication should also be subject to DTE and DTI provided.

3.9. Approval of DT Data Developed For Published Repair Data

For existing published repair data that requires new DT Data for repairs affecting FCBS, the TCH should submit the revised documentation to EASA for approval unless otherwise agreed. The DT Data for future published repair data may be approved according to existing processes.

3.10. Documentation of DT Data Developed for Published Repair Data

TCH should include the means used to document any new DTI developed for published repair data. For example, in lieu of revising individual SBs, the TCH may choose to establish a collector document that would contain new DTI developed and approved for specific repairs contained in various SBs.

3.11. Existing Repairs

TCHs should develop processes that will enable operators to identify and obtain DTI for existing repairs on their aircraft that affect FCBS. Collectively, these processes are referred to as the REGs and are addressed below.

3.12. Future Repairs

Repairs to FCBS conducted after the operator has incorporated the REGs into his maintenance programme must have a DTE performed. This includes blendouts, trim-outs, etc. that are beyond published TCH limits. For new repairs, the TCH may, in conjunction with an operator, use the three stage approval process provided in Annex 1 of this Appendix. This process involves incremental approval of certain engineering data to allow an operator to return its aircraft to service before all the DT Data are developed and approved. The TCH should document this process for the operator's reference in their maintenance programme if it intends to apply it.

3.13. Repair Evaluation Guidelines

The REG provides instructions to the operator on how to survey aircraft, how to obtain DTI, and an implementation schedule that provides timelines for these actions. An effective REG may require that certain DT Data be developed by the TCH and made available to operators. Updated SRMs and SBs, together with the existing, expanded, or new RAG documents, form the core of the information that will need to be made available to the operator to support this process. In developing the REG the TCH will need to determine what DT Data are currently available for repairs and what new DT Data will need to be developed to support operator compliance. The REG should include:

(a) A process for conducting surveys of affected aircraft that will enable identification and documentation of all existing repairs that affect fatigue critical baseline structure;

(b) A process for obtaining DTI for repairs affecting FCBS that are identified during an aircraft survey; and

(c) An implementation schedule that provides timelines for:

  (1) Conducting aircraft surveys,

  (2) Obtaining DTI, and

  (3) Incorporating DTI into the operator's maintenance programme.

3.13.1. Implementation Schedule

The TCH should propose a schedule for Approval by EASA based on the guidance given in paragraph 12 of the main body of this AMC that takes into account the distribution of the fleet relative to ¾ DSG, the extent of the work involved and the airworthiness risk. The Agency notes that many fleets are currently approaching or beyond DSG and these should be given priority in the implementation schedule.

3.13.2. Developing a Process for Conducting Surveys of Affected Aircraft

The TCH should develop a process for use by operators to conduct aircraft surveys. These aircraft surveys are conducted by operators to identify and document repairs and repairs to modifications that may be installed on their aircraft. The survey is intended to help the operators determine which repairs may need a DTE in order to establish the need for DTI. Identification of repairs that need DTI should encompass only existing repairs that reinforce (for example, restore strength) the FCBS. This typically excludes maintenance actions such as blend-outs, plug rivets, trim-outs, etc. unless there are known specific risks associated with these actions in specific locations. The process the TCH developes to conduct surveys should include:

(a) A survey schedule.

(b) Areas and access provisions for the survey.

(c) A procedure for repair data collection that includes:

(1) Repair Dimensions,
(2) Repair Material,
(3) Repair Fastener Type,
(4) Repair Location,
(5) Repair Proximity to other repairs,
(6) Repairs covered by Published Repair Data, and
(7) Repairs requiring DTI.

(d) A means to determine whether or not a repair affects FCBS.

3.13.3. Developing a Process to Obtain DT Data for Repairs.

(a) The TCH must develop a process that operators can use to obtain DTIs that address the adverse effects repairs may have on FCBS. In developing this process, TCHs will need to identify all applicable DTIs they have developed that are available to operators. This may include updated SRMs and SBs, existing RAGs, expanded or new RAGs, and other sources of DTIs developed by the TCH. For certain repairs, the process may instruct the operators to obtain direct support from the TCH. In this case, the TCH evaluates the operator's request and makes available DTI for a specific repair or group of repairs, as needed. These may include operator or third-party developed/approved repairs, and repairs that deviate from approved published repair data.

(b) The process should state that existing repairs that already have DTIs developed and in place in the maintenance programme require no further action. For existing repairs identified during an individual aircraft survey that need DTIs established, the process may direct the operators to obtain the required DTIs from the following sources:

(1) TCH published service information such as DT-based SRMs, SBs, or other documents containing applicable DT Data for repairs.

(2) Existing approved RAG documents (developed for compliance with § 121.107).

(3) Expanded or newly developed RAG documents. In order to expedite the process for an operator to obtain DTI necessary to address the adverse affects repairs may have on FCBS, the TCH may determine that the existing RAG document should be expanded to address other FCBS of the aircraft pressure boundary. In addition, for aircraft that do not currently have a RAG, the TCH may determine that in order to fully support operators in obtaining DTI, a new RAG document may need to be developed. General guidance for developing this material can be found in Annex 2 below, which is similar to AC 120-73, *Damage Tolerance Assessment of Repairs to Pressurised Fuselages*. The RAGs or any other streamlined process developed to enable operators to obtain DTI without having to go directly to the TCH.

(4) Procedures developed to enable operators to establish DTIs without having to contact the TCH for direct support. These procedures may be similar in concept to the RAG documents.

(5) Direct support from the TCH for certain repairs. The operator directly solicits DTIs from a TCH for certain individual repairs as those repairs are identified during the survey.

3.14 Repairs to Removable Structural Components

Fatigue critical structure may include structure on removable structural parts or assemblies that can be exchanged from one aircraft to another, such as door assemblies and flight control surfaces. In principle, the DT Data development and implementation process also applies to repairs to FCS on removable components. During their life history, however, these parts may not have had their flight times recorded on an individual component level because of removal and reinstallation on different aircraft multiple times. These actions may make it impossible to determine the component's age or total flight hours or total flight cycles. In these situations, guidance for developing and implementing DT Data for existing and new repairs is provided in Annex 3 of this Appendix.

3.15 Training

The complexity of the repair assessment and evaluation may require adequate training for proper implementation. In that case, it is necessary that each TCH considers providing training for all operators of the aircraft considered by this AMC

4. <u>MODIFICATIONS AND REPAIRS TO MODIFICATIONS</u>

4.1. TCH and STC Holder Tasks – Modifications and Repairs to Modifications

The following is an overview of the TCH and STC Holder tasks necessary for modifications that affect FCBS. This overview also includes TCH and STC Holder tasks necessary for repairs that may affect any FCS of the subject modifications. These tasks are applicable to those modifications that have been developed by the TCH or STC Holder.

(a) Establish a list of modifications that may affect FCBS. From that list establish a list of modifications that may contain FCS.

(b) In consultation with operators, determine which aircraft have the modification(s) installed.

(c) STC Holders should obtain a list of FCBS from the TCH for the aircraft models identified above.

(d) STC Holders should identify:

- Modifications that affect FCBS, or
- Modifications that contain FCS.

(e) Determine if DT Data exist for the identified modifications.

(f) Develop additional DT Data, if necessary.

(g) Establish an implementation schedule for modifications.

(h) Review existing DT Data for repairs made to modifications that affect FCBS.

(i) Develop additional DT Data for repairs made to modifications that affect FCBS.

(j) Establish an implementation schedule for repairs made to modifications.

(k) Prepare documentation, submit it to EASA for approval, and make it available to operators.

4.2. Specific Modifications to be Considered

The TCH should consider modifications and any STCs it owns for modifications that fall into any of the categories listed in Annex 5 of this Appendix. STC Holders should do the same for their STC modifications. For modifications that are not developed by a TCH or STC Holder the operator should consider whether the modification falls into any of the categories listed in Annex 5 of this Appendix.

4.3. Modifications that need DT data

Using the guidance provided in AMC 25.571 and the detailed knowledge of the modification and its affect on the FCBS, the TCH and STC Holder, and in certain cases the operator, should consider the following situations in determining what DT data need to be developed

4.3.1. Modifications that affect FCBS

Any modification identified in Annex 5 that is installed on FCBS should be evaluated regardless of the size or complexity of the modification. In addition, any modification which indirectly affects FCBS (for example, modifications which change the fatigue loads environment, or affect the inspectability of the structure, etc.) must also have a DT evaluation performed to assess its impact.

4.3.2. Modifications that contain new FCS

For any modification identified in Annex 5 of this appendix that affects FCBS, the TCH or STC Holder should identify any FCS of the modification. Any modification that contains new FCS should be evaluated regardless of the size or complexity of the modification. Examples of this type of modification may be a modification that adds new structural splices, or increases the operational loads causing existing structure to become fatigue critical. If a modification does not affect FCBS, then it can be assumed that this modification does not contain FCS.

4.4. Reviewing Existing DT Data for Modifications that Affect FCBS

Based on the CS 25.571 certification amendment level and other existing rules, the modification's approval documentation may already provide appropriate DT data.

The TCH or STC Holder should identify modifications that have existing approved DT data. Acceptable DT data contain a statement of DTE accomplishment and are approved. Confirmation that approved DT data exists should be provided to the operators.

Modifications that have been developed by a TCH may affect FCBS. These include ATCs and in some cases STCs. These changes to type design also require review for appropriate DT data.

4.5. Developing Additional DT Data for Modifications that Affect FCBS

The DT data may be published as follows:

(a) **STC modifications** – The additional DT data for existing modifications may be published in the form of an amended STC, a supplemental compliance document, or an individual approval.

(b) **TC Holder modifications** – The additional DT data for existing modifications may be published in the form of an amended TC, TCH service information, etc.

(c) **Modifications not developed by a TCH or STC Holder** – For modifications identified in Annex 5 of this appendix that affect FCBS and were not developed by a TCH or STC Holder, the operator is responsible for obtaining DT data for those modifications. For those existing individual modifications that do not have DT data or other procedures implemented, establish the DT data according to an implementation plan approved by the Competent Authority.

NOTE: The TCH and STC Holder should submit data that describes and supports the means used to determine if an modification affects FCBS, and the means used for establishing FCS of an modification.

4.6. DT Data Implementation Schedule then the TCH or STC Holder is no longer in business or a TC or STC is surrendered

For those modifications where the TCH or STC Holder is no longer in business or the TC or STC is surrendered, this paragraph provides guidance for an operator to produce a DT data implementation schedule for that modification. The operator's DT Data Implementation Schedule should contain the following information:

(a) A description of the modification;

(b) The affected aircraft and the affected FCS

(c) The DSG of the affected aircraft;

(d) A list of the modification FCS (if it exists);

(e) The 25.571 certification level for determining the DT data;

(f) A plan for obtaining the DT data for the modification; and

(g) A DT Data Implementation Schedule for incorporating the DT data once they are received.

5. DEVELOPMENT OF TCH AND STC HOLDER DOCUMENTATION AND EASA APPROVAL

TCH, STC Holders, operators and the airworthiness authorities should work together to develop model-specific documentation with oversight provided by those authorities and assistance from the ARAC AAWG. It is anticipated that TCHs will utilise structural task groups (STG) to support their development of model-specific documents. EASA will approve the TCH or STC Holder submissions of the REGs and any other associated documentation required by the operator to provide appropriate DTI to all repairs and modifications to FCS whether submitted as separate documents or in a consolidated document.

6. OPERATOR TASKS – REPAIRS, MODIFICATIONS AND REPAIRS TO MODIFICATIONS.

(a) Review the applicable Documents supplied by TCH and STC Holders.

(b) Identify modifications that exist in the operators' fleet that affect FCBS.

(c) Obtain or develop additional DT data for modifications not addressed by the TCH or STC Holder's documents.

NOTE: If the TCH or STC Holder no longer exists or is unwilling to comply with this request it becomes the responsibility of the operator to develop or obtain approved DT data. The data should be provided by a Design Organisation with an appropriate DOA.

(d) Incorporate the neccessary actions into the Maintenance programme for Approval by the Competent Authority.

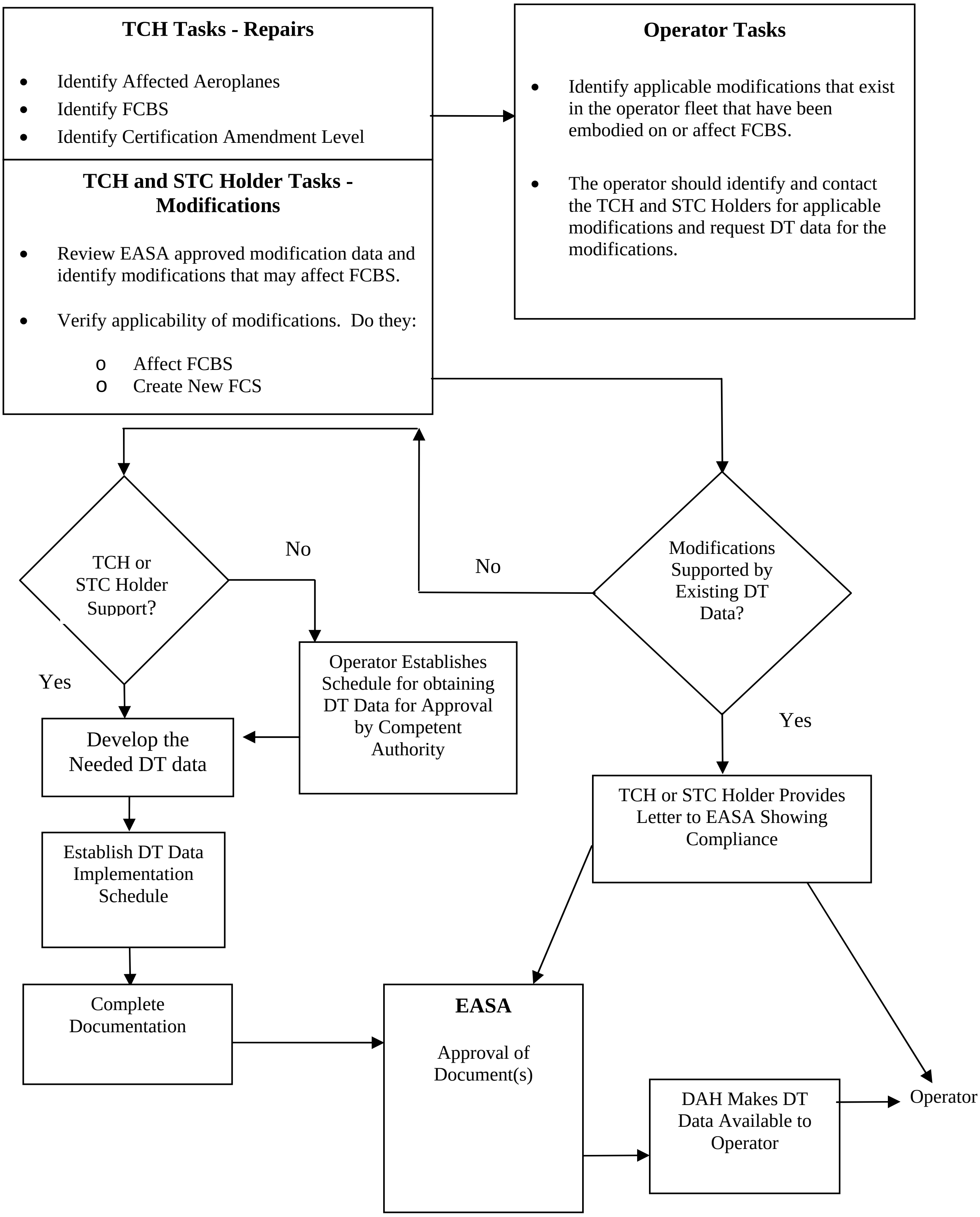


Figure A3-1 – Developing a Means of Compliance for Modifications

6.1. Contents of the Maintenance Programme

(a) The operator should include the following in their Maintenance Programme:

(1) A process to ensure that all new repairs and modifications that affect FCBS will have DT data and DTI or other procedures implemented.

(2) A process to ensure that all existing repairs and modifications to FCBS are evaluated for damage tolerance and have DTI or other procedures implemented. This process includes:

(i) A review of operator processes to determine if DT data for repairs and modifications affecting FCBS have been developed and incorporated into the operator's maintenance programme for the operational life of the aircraft. If an operator is able to demonstrate that these processes ensure that DT data are developed for all repairs and modifications affecting FCBS, then no further action is required for existing repairs and modifications.

(ii) A process to identify or survey existing repairs (using the survey parameters from Annex 3 of this Appendix) and modifications that affect FCBS and determine DTI for those repairs and modifications. This should include an implementation schedule that provides timing for incorporation of the DT data into the operator's maintenance programme, within the timeframe given in the applicable TCH or STC Holder's approved documentation.

(b) Figure A3-2, below, outlines one possible means an operator can use to develop an implementation plan for aircraft in its fleet.

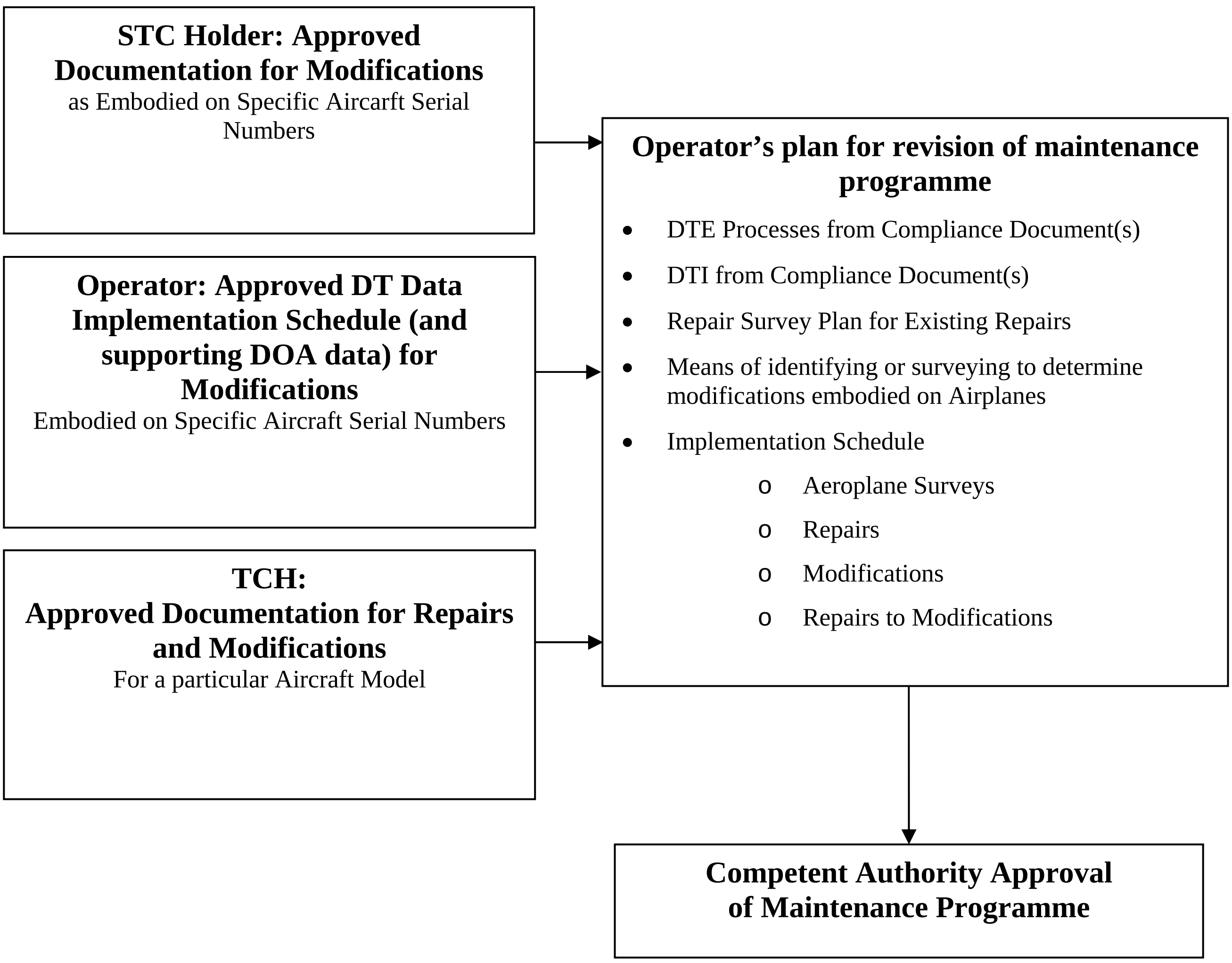


Figure A3-2 - Operator's Maintenance Programme Approval Process

6.1.1. Implementation Plan for Repairs

Repair Survey Plan. The maintenance programme should include a repair survey schedule to identify repairs that may need DT data developed. The TCH's REG may be used as a basis for this plan. (See Paragraph 3 above and Annex 2 for further information)

6.1.2. Implementation Plan for Modifications:

(a) The plan should include a process for producing a list of modifications that affect FCBS on an operator's aircraft. The list may be developed by obtaining data through a review of aircraft records and by a survey of the aircraft. If the means for identifying the subject modifications is by a records review, the operator will need to show its competent authority that the aircraft records are a reliable means for identifying modifications that affect the FCBS. Per the guidance in paragraph (3), below, the operator may identify modifications developed by TCH and STC Holders by performing a records review. A records review, however, may not be adequate to identify modifications not developed by a TCH or STC Holder. An aircraft survey may need to be conducted to identify such modifications. For each modification that affects FCBS, the process should document the means of compliance for incorporating DT data associated with that modification, whether through a TCH or STC Holder Compliance Document, an operator's DT data implementation schedule, or existing DT-based ICA.

(b) The plan should:

(1) Include the process for when and how to obtain DT data for those modifications included in a DT data implementation schedule,

(2) Include a means of ensuring that the aircraft will not be operated past the time limit established for obtaining DT data,

(3) Include DT data associated with an modification that is provided in a Compliance Document, and

(4) Identify how DT data will be incorporated into the operator's maintenance programme.

(c) To support identification of modifications that TCH and STC Holders need to address the operators should, concurrent with the TC and STC Holders' tasks, identify the TCH or STC Holder-developed modifications that exist in its fleet of aircraft. This may be done by reviewing the operator's aircraft configuration records, if record keeping is complete. During the review the TCH and STC Holder of each specific modification should be identified. The operator should then establish which modifications have been installed on or are likely to affect FCBS and prepare a list of modifications by aircraft. Modifications not developed by a TCH or STC Holder that affect FCBS should be identified at the time the operator conducts its aircraft survey for repairs.

(1) Compile a listing of all TCH and STC Holder developed modifications that are currently installed on its active fleet;

(2) Delete from the listing those modifications that do not affect FCBS. Documents from the TCH may be used to identify the FCBS.

(3) The remaining modifications that affect FCBS on this list require a DTE and DT data, unless previously accomplished.

(4) The operator must review each modification to determine whether:

(i) The DT data already exist; or

(ii) The DT data need to be developed.

(5) Notify both the STC Holder and the Competent Authority and EASA when STCs owned by the STC Holder are identified on the operator's fleet and that DT data are required.

NOTE: The operator should begin developing this modifications list as soon as the TCHs make their FCBS listing available.

(d) The operator should consider the list of modifications contained in Annex 5 of this AMC in determining which modifications may affect FCBS on a model-specific basis.

(e) The operator should submit a letter that provides a list of modifications it has on its active fleet to the Competent Authority and a status on the TCH or STC Holders' support for developing required DT data.

(f) The operator should also contact the TCH or STC Holder for the applicable modification to determine if DT data are available for that modification. If the data do not exist, and the TCH or STC Holder intends to support the development of DT data, and this modification is likely to exist on other operators' fleets, the group of affected operators may wish to collectively meet with the TCH or STC Holder. If the TCH or STC Holder no longer exists, or is unwilling to support the modification, or if an modification affecting FCBS has not been approved under a TC or STC, it is the responsibility of the operator(s) to develop the data, either internally, or by using an third party with the appropriate design approval.

(g) Some individual modifications may not be easily identified through a review of aircraft maintenance records. In these situations, the means of compliance is a plan to survey the aircraft for modifications in the similar manner as repairs and repairs to modifications as given in paragraph 3 of this Appendix. The DT data for those modifications identified in the survey should be developed and implemented into an operator's maintenance programme. It is anticipated that most aircraft will need to be surveyed in order to ensure all modifications are identified. This survey can be conducted at the same time the survey for repairs is performed.

6.1.3. DT Data Implementation Process

(a) Use the regular maintenance or inspection programme for repairs where the inspection requirements utilise the chosen inspection method and interval. Repairs or modifications added between the predetermined maintenance visits, including Category B and C repairs (see Annex 2 of this Appendix) installed at remote locations, should have a threshold greater than the predetermined maintenance visit. Repairs may also be individually tracked to account for their unique inspection method and interval requirements. This ensures the airworthiness of the structure until the next predetermined maintenance visit, when the repair or modification will be evaluated as part of the repair maintenance programme.

(b) Where inspection requirements are not fulfilled by the chosen inspection method and interval, Category B or C repairs will need additional attention. These repairs will either require upgrading to allow utilising the chosen inspection method and interval, or individual tracking to account for the repair's unique inspection method and interval requirements.

6.2 Maintenance programme changes

When a maintenance or inspection programme interval is revised, the operator should evaluate the impact of the change on the repair assessment programme. If the revised maintenance or inspection programme intervals are greater than those in the BZI, the previous classification of Category A repairs may become invalid. The operator may need to obtain approval of an alternative inspection method, upgrade the repair to allow utilisation of the chosen inspection method and interval, or re-categorise some repairs and establish unique supplemental inspection methods and intervals for specific repairs. Operators using the "second technique" of conducting repetitive repair assessments at predetermined maintenance visits would evaluate whether the change to the predetermined maintenance visit continues to fulfil the repair inspection requirements in accordance with the guidance provided in Annex 2 of this AMC.

7. THE COMPETENT AUTHORITY

The competent authority is responsible for approving the means for incorporating the Agency Approved DT data for repairs and modifications into the operator's maintenance programmeme.

ANNEX 1: APPROVAL PROCESS FOR NEW REPAIRS

In the past, FAA AC 25.1529-1, *Instructions for Continued Airworthiness of Structural Repairs on Transport Aircraft*, August 1, 1991, described a two-stage approach for approving repairs to principal structural elements. The two-stage approach consisted of:

- Evaluating type design strength requirements per CS 25.305 before return to service.
- Performing a damage tolerance evaluation and developing DT Data to demonstrate compliance with CS 25.571 within 12 months of return to service.

The FAA guidance material in AC 25.1529-1 is now embodied in this AMC, and is modified to describe a three-stage approach now commonly used in the aviation industry. The three-stage approach is in lieu of the two-stage approach discussed above.

The DT Data include inspection requirements, such as inspection threshold, inspection method, and inspection repetitive interval, or may specify a time limit when a repair or modification needs to be replaced or modified. The required data may be submitted all at once, prior to the aircraft return to service, or it may be submitted in stages. The following three-stage approval process is available, which involves incremental approval of engineering data to allow an aircraft to return to service before all the engineering data previously described are submitted. The three stages are described as follows:

(a) The first stage is approval of the static strength data and the schedule for submittal of the DT Data. This approval is required prior to returning an aircraft to service.

(b) The second stage is approval of the DT Data. This should be submitted no later then 12 months after the aircraft was returned to service. At this stage the DT Data need only contain the threshold when inspections are required to begin as long as a process is in place to develop the required inspection method and repetitive intervals before the threshold is reached. In this case, the submittal and approval of the remaining DT Data may be deferred to the third stage.

(c) The third stage is approval of the inspection method and the repetitive intervals. This final element of the repair certification data in compliance with CS 25.571 must be submitted and approved prior to the inspection threshold being reached.

ANNEX 2: ASSESSMENT OF EXISTING REPAIRS

A DTI assessment process consists of an aircraft repair survey, identification and disposition of repairs requiring immediate action and development of damage tolerance based inspections, as described below:

1. AIRCRAFT REPAIR SURVEY

A survey will be used to identify existing repairs and repair configurations on FCBS and provide a means to categorise those repairs. The survey would apply to all affected aircraft in an operator's fleet, as defined in the maintenance programme, using the process contained in the REG or similar document. The procedure to identify repairs that require DTE should be developed and documented using CS 25.571 and AMC 25.571 (dependent on aircraft certification level), together with additional guidance specific to repairs, such as:

(a) Size of the repair,

(b) Repair configuration,

 (1) SRM standards

 (2) Other

(c) Proximity to other repairs, and

(d) Potential affect on FCBS

 (1) Inspectability (access and method)

 (2) Load distribution.

See Paragraph 4 of this Annex for more details.

2. IDENTIFICATION AND DISPOSITION OF REPAIRS REQUIRING IMMEDIATE ACTION

Certain repairs may not meet minimum requirements because of cracking, corrosion, dents, or inadequate design. The operator should use the guidance provided in the Compliance Document to identify these repairs and, once identified, take appropriate corrective action. In some cases, modifications may need to be made before further flight. The operator should consider establishing a fleet campaign if similar repairs may have been installed on other aircraft.

3. DAMAGE TOLERANCE INSPECTION DEVELOPMENT

This includes the development of the appropriate maintenance plan for the repair under consideration. During this step determine the inspection method, threshold, and repetitive interval. Determine this information from existing guidance information as documented in the RAG (see Paragraph 4), or from the results of an individual damage tolerance evaluation performed using the guidance in AMC 25.571. Then determine the feasibility of an inspection programme to maintain continued airworthiness. If the inspection programme is practical, incorporate the DTI into the individual aircraft maintenance programme. If the inspection is either impractical or impossible, incorporate a replacement time for the repair into the individual aircraft maintenance programme. The three-stage approach discussed in Annex 1 of this AMC may be used, if appropriate.

4. REPAIR ASSESSMENT GUIDELINES

4.1. Criteria to assist in developing the repair assessment guidelines

The following criteria are those developed for the fuselage pressure boundary, similar to those found in FAA AC 120-73 and previous JAA and EASA documentation. DAHs may find it appropriate to develop similar practices for other types of aircraft and areas of the structure.

The purpose is to develop repair assessment guidelines requiring specific maintenance programmes, if necessary, to maintain the damage-tolerance integrity of the repaired airframe. The following criteria have been developed to assist in the development of that guidance material:

(a) Specific repair size limits for which no assessment is necessary may be selected for each model of aircraft and structural location. This will enable the burden on the operator to be minimised while ensuring that the aircraft's baseline inspection programme remains valid.

(b) Repairs that are not in accordance with SRM must be reviewed and may require further action.

(c) Repairs must be reviewed where the repair has been installed in accordance with SRM data that have been superseded or rendered inactive by new damage-tolerant designs.

(d) Repairs in close proximity to other repairs or modifications require review to determine their impact on the continued airworthiness of the aircraft.

(e) Repairs that exhibit structural distress should be replaced before further flight.

4.2. Repair assessment methodology.

The next step is to develop a repair assessment methodology that is effective in evaluating the continued airworthiness of existing repairs for the fuselage pressure boundary. Older aircraft models may have many structural repairs, so the efficiency of the assessment procedure is an important consideration. In the past, evaluation of repairs for damage-tolerance would require direct assistance from the DAH. Considering that each repair design is different, that each aircraft model is different, that each area of the aircraft is subjected to a different loading environment, and that the number of engineers qualified to perform a damage-tolerance assessment is small, the size of an assessment task conducted in that way would be unmanageable. Therefore, a new approach has been developed as an alternative.

Since repair assessment results will depend on the model specific structure and loading environment, the DAHs should create an assessment methodology for the types of repairs expected to be found on each affected aircraft model. Since the records on most of these repairs are not readily available, locating the repairs will necessitate surveying the structure of each aircraft. A survey form is created by DAH that may be used to record key repair design features needed to accomplish a repair assessment. Airline personnel not trained as damage-tolerance specialists can use this form to document the configuration of each observed repair.

Some DAH have developed simplified methods using the information from the survey form as input data, to determine the damage-tolerance characteristics of the surveyed repairs. Although the repair assessments should be performed by well trained personnel familiar with the model specific repair assessment guidelines, these methods enable appropriate staff, not trained as a damage-tolerance specialist, to perform the repair assessment without the assistance of the TCH. This methodology should be generated by the aircraft TCH. Model specific repair assessment guidelines will be prepared by the TCHs.

From the information on the survey form, it is also possible to classify repairs into one of three categories:

Category A: A permanent repair for which the baseline zonal inspection (BZI), (typical maintenance inspection intervals assumed to be performed by most operators), is adequate 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.

When the LOV of the maintenance programme is extended the initial Categorisation of Repairs may need review by the TCH and operator to ensure these remain valid up until the new LOV.

4.3. Repair assessment process

There are two principal techniques that can be used to accomplish the repair assessment. The first technique involves a three-stage procedure. This technique could be well suited for operators of small fleets. The second technique involves the incorporation of the repair assessment guidelines as part of an operator's routine maintenance programme. This approach could be well suited for operators of large fleets and would evaluate repairs at predetermined planned maintenance visits as part of the maintenance programme. DAHs and operators may develop other techniques, which would be acceptable as long as they fulfil the objectives of this proposed rule, and are approved by the Agency.

The first technique generally involves the execution of the following three stages. (See Figure.A3(2)-1):

Stage 1 Data Collection

This stage specifies what structure should be assessed for repairs and collects data for further analysis. If a repair is on a structure in an area of concern, the analysis continues, otherwise the repair does not require classification per this programme.

Repair assessment guidelines for each model will provide a list of structure for which repair assessments are required. Some DAHs have reduced this list by determining the inspection requirements for critical details. If the requirements are equal to normal maintenance checks (e.g., BZI checks), those details were excluded from this list.

Repair details are collected for further analysis in Stage 2. Repairs that do not meet the minimum design requirements or are significantly degraded are immediately identified, and corrective actions must be taken before further flight.

Stage 2 Repair Categorisation

The repair categorisation is accomplished by using the data gathered in Stage 1 to answer simple questions regarding structural characteristics.

If the maintenance programme is at least as rigorous as the BZI identified in the
TCH's model specific repair assessment guidelines, well designed repairs in good condition meeting size and proximity requirements are Category A. Simple condition and design criteria questions are provided in Stage 2 to define the lower bounds of Category B and Category C repairs. The process continues for Category B and C repairs.

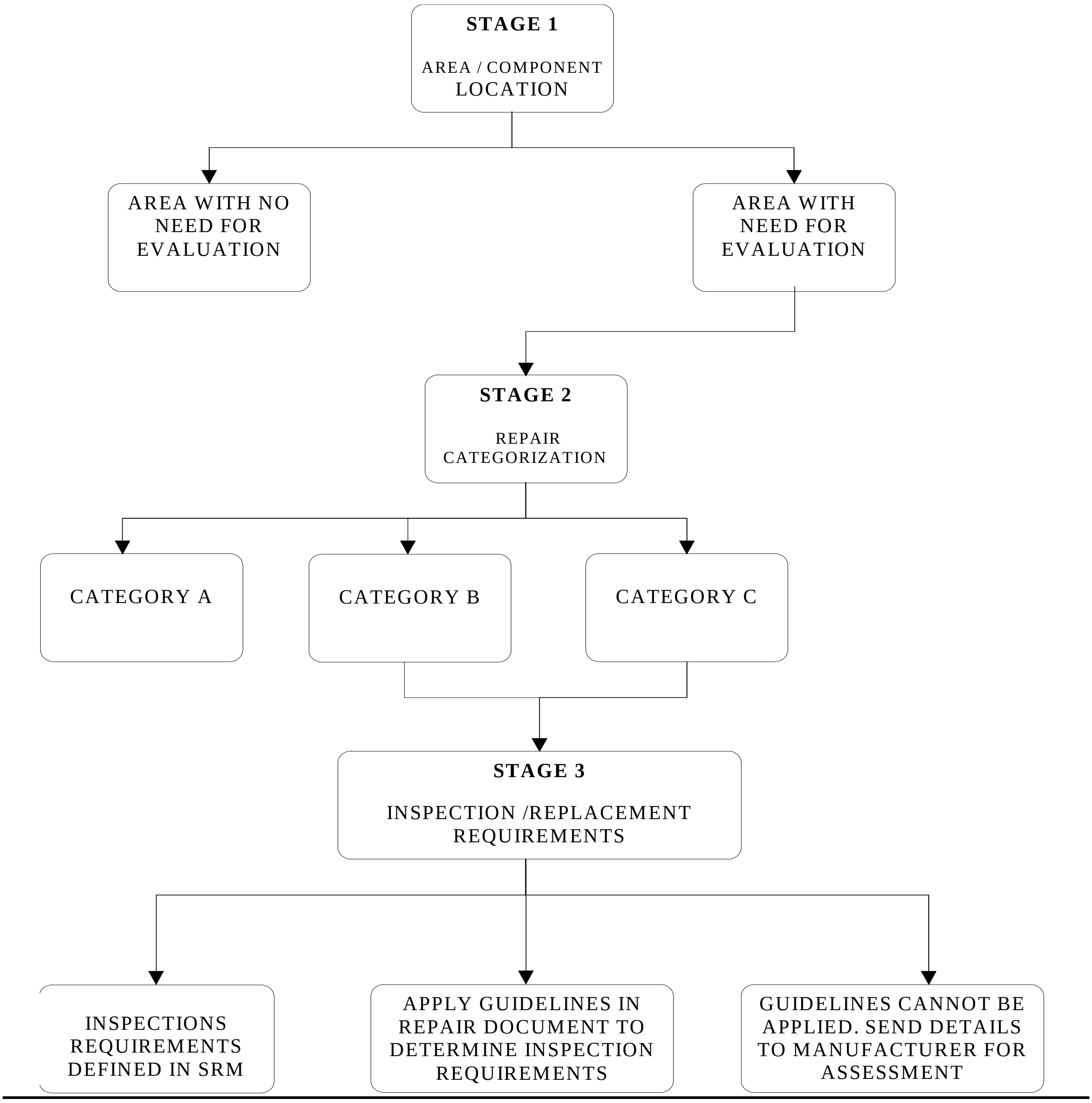


Figure A3(2)-1. Repair Assessment Stages

Stage 3 Determination of Structural Maintenance Requirements

The specific supplemental inspection and/or replacement requirements for Category B and C repairs are determined in this stage. Inspection requirements for the repair are determined by calculation or by using predetermined values provided by the DAH, or other values obtained using an Agency approved method.

In evaluating the first supplemental inspection, Stage 3 will define the inspection threshold in flight cycles measured from the time of repair installation. If the time of installation of the repair is unknown and the aircraft has exceeded the assessment implementation times or has exceeded the time for first inspection, the first inspection should occur by the next "C-check" interval, or equivalent cycle limit after the repair data is gathered (Stage 1).

An operator may choose to accomplish all three stages at once, or just Stage 1. In the latter case, the operator would be required to adhere to the schedule specified in the Agency approved model specific repair assessment guidelines for completion of Stages 2 and 3. Incorporating the maintenance requirements for Category B and C repairs into an operator's individual aircraft maintenance or inspection programme completes the repair assessment process for the first technique.

The second technique would involve setting up a repair maintenance programme to evaluate all applicable structure as detailed in paragraph 2.6 at each predetermined maintenance visit to confirm that they are permanent. This technique would require the operator to choose an inspection method and interval in accordance with the Agency approved repair assessment guidelines. The repairs whose inspection requirements are fulfilled by the chosen inspection method and interval would be inspected in accordance with the approved maintenance programme. Any repair that is not permanent, or whose inspection requirements are not fulfilled by the chosen inspection method and interval, would either be:

(a) Upgraded to allow utilisation of the chosen inspection method and interval, or

(b) Individually tracked to account for the repair's unique inspection method and interval requirements.

This process is then repeated at the chosen inspection interval.

Repairs added between the predetermined maintenance visits, including interim repairs installed at remote locations, would be required either to have a threshold greater than the length of the predetermined maintenance visit or to be tracked individually to account for the repair's unique inspection method and interval requirements. This would ensure the airworthiness of the structure until the next predetermined maintenance visit, at which time the repair would be evaluated as part of the repair maintenance programme.

5. MAINTENANCE PROGRAMME CHANGES

When a maintenance or inspection programme interval is revised, the operator should evaluate the impact of the change on the repair assessment programme. If the revised maintenance or inspection programme intervals are greater than those in the BZI, the previous classification of Category A repairs may become invalid. The operator may need to obtain approval of an alternative inspection method, upgrade the repair to allow utilisation of the chosen inspection method and interval, or re-categorise some repairs and establish unique supplemental inspection methods and intervals for specific repairs. Operators using the "second technique" of conducting repetitive repair assessments at predetermined maintenance visits would evaluate whether the change to the predetermined maintenance visit continues to fulfil the repair inspection requirements.

6. SRM UPDATE

The general section of each SRM will contain brief descriptions of damage-tolerance considerations, categories of repairs, description of baseline zonal inspections, and the repair assessment logic diagram. In updating each SRM, existing location specific repairs should be labelled with appropriate repair category identification (A, B, or C), and specific inspection requirements for B and C repairs should also be provided as applicable. SRM descriptions of generic repairs will also contain repair category considerations regarding size, zone, and proximity. Detailed information for determination of inspection requirements will have to be provide in for each model. Repairs which were installed in accordance with a previous revision of the SRM, but which have now been superseded by a new damage-tolerant design, will require review. Such repairs may be reclassified to Category B or C, requiring additional inspections and/or rework.

7. STRUCTURE MODIFIED BY A STC

The current repair assessment guidelines provided by the TCH do not generally apply to structure modified by a STC. Nonetheless it is expected that all structure modified by STC should be evaluated by the operator in conjunction with the STC holder. The STC holder should develop, submit, and gain Agency approval of guidelines to evaluate repairs to such structure or conduct specific damage-tolerance assessments of known repairs and provide appropriate instructions to the operator.

It is expected that the STC holder will assist the operators by preparing the required documents. If the STC holder is out of business, or is otherwise unable to provide assistance, the operator would have to acquire the Agency approved guidelines independently. To keep the aircraft in service, it is always possible for operators, individually or as a group, to hire the necessary expertise to develop and gain approval of repair assessment guidelines and the associated DSG. Ultimately, the operator remains responsible for the continued safe operation of the aircraft.

ANNEX 3: REPAIRS AND MODIFICATIONS TO REMOVABLE STRUCTURAL COMPONENTS

1. DETERMINING THE AGE OF A REMOVABLE STRUCTURAL COMPONENT

Determining an actual component age or assigning a conservative age provides flexibility and reduces operator burden when implementing DT data for repairs and modifications to structural components. In some cases, the actual component age may be determined from records. If the actual age cannot be determined this way, the component age may be conservatively assigned using one of the following fleet leader concepts, depending upon the origin of the component:

(a) If component times are not available, but records indicate that no part changes have occurred, aircraft flight cycles or flight hours can be used.

(b) If no records are available, and the parts could have been switched from one or more older aircraft under the same maintenance programme, it should be assumed that the time on any component is equal to the oldest aircraft in the programme. If this is unknown, the time should be assumed equal to the same model aircraft that is the oldest or has the most flight cycles or flight hours in the world fleet.

(c) A manufacturing date marked on a component may also be used to help establish the component's age in flight cycles or flight hours. This can be done by using the above reasoning and comparing it to aircraft in the affected fleet with the same or older manufacturing date.

If none of these options can be used to determine or assign a component age or total number of flight cycles or flight hours, a conservative implementation schedule can be established by using the guidelines applied in paragraph 3. of this appendix, for the initial inspection, if required by the DT data.

2. TRACKING

An effective, formal, control or tracking system should be established for removable structural components that are identified as FCBS or that contain FCS. This will help ensure compliance with maintenance programme requirements specific to repairs and modifications installed on an affected removable structural component. Paragraph 4 of this appendix, provides options that could be used to alleviate some of the burdens associated with tracking all repairs to affected removable structural components.

3. DEVELOPING AND IMPLEMENTING DT DATA

(a) Repairs

Accomplish the initial repair assessment of the affected structural component at the same time as the aircraft level repair survey for the aircraft on which the component is installed. Develop the DT data per the process given in Step 3 of Appendix 6 and incorporate the DTI into the maintenance programmeme.

(b) Modifications

Accomplish the initial modification assessment of the affected structural component at the same time as the aircraft level modification assessment for the aircraft on which the component is installed. Develop the DT data and incorporate the DTI into the maintenance programmeme.

If the actual age of the repairs or modifications installation, or the total number of flight cycles or flight hours is known, use that information to establish when the initial inspection of the component should be performed. Repeat the inspection at the intervals provided by the TCH or STC Holder for the repair or modification installed on the component.

If the actual age of the repairs or modifications installation, or the total number of flight cycles or flight hours is unknown, but the component age or total number of flight cycles or flight hours is known, or can be assigned conservatively, use the component age, or total number of flight cycles or flight hours to establish when the initial inspection of the component should be performed. Repeat the inspection at the intervals provided by the TCH or STC Holder for the repairs and modifications against the component.

As an option, accomplish the initial inspection on the affected component at the next C-check (or equivalent interval) following the repair assessment. Repeat the inspection at the intervals provided by the TCH or STC Holder for the repairs and modifications against the component.

4. EXISTING REPAIRS AND MODIFICATIONS – COMPONENTS RETRIEVED FROM STORAGE.

(a) If the time on the component (in flight cycles or flight hours) is known, or can be conservatively assigned, perform the following:

(1) Survey the component,

(2) Disposition the repairs and modifications,

(3) Implement any DTI in accordance with the approved schedule,

(4) Accomplish the initial inspection using the actual age of the repairs or modifications, or total number of flight cycles or flight hours, if known. If the age of the repairs or modifications is not known, use the component age. Repeat the inspection at the intervals given for the repairs or modifications against the component.

(b) If the time on the component (in flight cycles or flight hours) is unknown and cannot be conservatively assigned, perform the initial repair or modification assessment of the affected component prior to installation, perform the following actions:

(1) Develop the DT data per the process given in paragraph 3 or 4 of Appendix 3 of this AMC as applicable.

(2) Incorporate any DTI into the maintenance programme.

(3) Accomplish the first inspection on the affected component at the next C-check (or equivalent interval) following the repair or modification assessment.

(4) Repeat the inspection at the intervals given for the repair or modification against the component.

5. IMPLEMENTATION OPTIONS TO HELP REDUCE TRACKING BURDEN

The following implementation techniques could be used to alleviate some of the burdens associated with tracking repairs to affected removable structural components. These techniques, if used, would need to be included in the Maintenance Programmeme and may require additional EASA approval and TCH or STC Holder input for DTI.

(a) Upgrading Existing Repairs

As an option, existing repairs may be removed and replaced to zero time the DTI requirements of the repair and establish an initial tracking point for the repair. Normally, this would be done at or before the survey for maximum benefit. The initial and repetitive inspections for the upgraded repair would then be accomplished at the intervals given for the repair against the component.

A repair could also be upgraded to one whose inspection requirements and methods are already fulfilled by an operator's maintenance or inspection programmeme. That repair would then be repetitively inspected at each routine inspection interval applicable to the repair. Specific tracking would not be required because that area of the aircraft would already be normally inspected on each aircraft in the fleet as part of the existing approved maintenance programme. If the operator's programme intervals were changed, the affect on requirements for specific tracking would have to be re-evaluated.

(b) Special Initial and/or Routine Inspections

As an option, existing repairs may have special initial inspections accomplished during the component survey. This initial inspection establishes an initial tracking point for the repair. Following this initial inspection, the DTI requirements (e.g., repetitive inspections) of the repair would be implemented.

In addition, special routine inspections could be defined for typical repairs that could be applied at a normal interval. In this case, an operator could check the affected components on each aircraft for this type of a repair at the defined interval. If the repair were found, the special inspection would be applied to ensure its airworthiness until the next scheduled check. This alleviates the need to specifically track affected components for every repair, especially typical ones.

The development of inspection processes, methods, applicability and intervals will probably require the assistance of the TCH or STC Holder for the FCS in question.

ANNEX 4. SERVICE BULLETIN REVIEW PROCESS

Guidelines for Following the Service Bulletin (SB) Flow Chart

NOTE: While it is believed that this guidance is fairly comprehensive, it may not address every possible situation. It is therefore incumbent on the user to use good judgment and rationale when making any determination.

Screening SBs to determine which ones require DT data is primarily a TCH responsibility.

The result of this screening is a list of SBs which require special directed inspections to ensure continued airworthiness. The SBs included on the list will be grouped into Type I and Type II SBs. Type I SBs have existing DT data and Type II SBs require developing DT data. The list is not comprehensive and will not include all of the SBs associated with an aircraft. Specifically, the list will not include those SBs where a BZI programme developed for the Repair Assessment Programme has been determined to be sufficient to meet the damage tolerance requirements for the FCBS that is affected by the SB. A note should be prominently placed somewhere in the Compliance Document stating that SBs not included in the list satisfy the DT data requirement.

> **"ALL SBs HAVE BEEN EVALUATED FOR DAMAGE TOLERANCE INSPECTION REQUIREMENTS; SERVICE BULLETINS NOT INCLUDED IN THIS LIST HAVE BEEN DETERMINED TO SATISFY THE DAMAGE- TOLERANCE REQUIREMENT BY INSPECTIONS COVERED IN THE BZI. THE BZI IS DOCUMENTED IN SECTION X.XXX.XX.X OF THE MAINTENANCE PLANNING DOCUMENT."**

Query 1 – Does the SB address a structural repair or a modification to FCS?

Historically, any SB, service letter or other document that lists ATA chapters 51 through 57 could provide repair or modification instructions that may require DT data. In addition, certain repairs or modifications accomplished under other ATA chapters may affect FCS. The first step in the screening process is to identify all such service instructions and develop a list of candidates for review (Q2).

Query 2 – Does the service instruction specify either a repair or modification that creates or affects FCS?

If it does, then the service instruction requires further review (Q3). If it does not, then the service instruction does not require further review.

Query 3 – Is the service instruction mandated?

Service bulletins and other service instructions that are mandated by an AD have requirements to ensure inspection findings (e.g., detected cracks or other structural damage/degradation) are addressed in an approved manner. If the TCH can demonstrate that it applies a process for developing inspection programmes for mandated SBs using DT data and/or service-based inspection results, and for continuously reviewing the SBs for their adequacy to detect cracks in a timely manner, the mandated SBs should then be considered as compliant with the intent of this process. Otherwise, the TCH will need to demonstrate the inspection programme in the mandated SB has been developed using DT data and/or appropriate service-based inspection results. The outcomes of Query 3 branch to two unrelated boxes (Q4 – if mandated by an AD) or (Q7- if not mandated by an AD).

Query 4 – Does the SB or service instruction contain terminating action?

Query 3 established that the inspection programme for the baseline configuration is acceptable.

Query 5 – Does the terminating action have DT data?

If the terminating action has a documented continuing airworthiness inspection programme based on damage tolerance principals, then no further review is required. The SB should be documented in the list. If the terminating action does not have DT data, or the status of the inspection programme cannot be verified, then further review is necessary (Q6).

<u>Query 6</u> – Does the SB address a safe-life part?

If it does no further action is required. Otherwise, damage-tolerance based inspections will need to be developed and provided to the operators. The SB should be included in the list along with where to find the required continued airworthiness inspection programme.

<u>Query 7</u> – In Query 3 a structural SB that was mandated by AD was identified.

Query 7 asks if a one-time inspection is required to satisfy the intent of the requirement. If it does, it is deemed that this is being done to verify that a condition does not exist and, on finding that condition, correct that condition to baseline configuration. As such, normal SSID programmes would then be expected to cover any required continued airworthiness inspections. If a repair is necessary, it is further assumed that this was done by reference to the SRM or other suitable means. No further action is required if this is the case and, if a repair was necessary, other means exist to determine the required DT data. If no inspections or multiple inspections are required, additional evaluation is required (Q8).

<u>Query 8</u> – Is this a major structural design change (e.g., modification)?

This is a TCH decision that is part of the original certification process and is not a major/minor repair decision. If it is not a major design change then proceed to Q10, if not, proceed to Q9.

<u>Query 9</u> – Does the change require non-destructive inspections to verify the integrity of the structure or are normal routine maintenance inspections (as delineated in the BZI) sufficient?

This is a subjective question and may require re-evaluating the change and determining where specific fatigue cracking might be expected. If normal maintenance inspections are adequate, no further action is required. Otherwise, proceed to Q10.

<u>Query 10</u> – Does the SB contain DT data for both the baseline and modified aircraft configurations?

If so, the SB is satisfactory. Otherwise, damage tolerance-based inspections will need to be developed and provided to the operators. The SB should be documented in the list along with where to find the required continued airworthiness inspection programme.

<u>Service Bulletin Screening Procedure</u>

1. The TCH will perform the screening and the Structures Task Group will validate the results.

2. A list of all SBs requiring action will be included in the TCH Compliance Document. Those not requiring action will <u>not</u> be in the list.

3. Service Bulletins included on the list will fall into one of two general types:

Type I - SBs which have existing DT data.

Type II - Service Bulletins that require developing DT data.

4. TCH actions:

Type I – No action required.

Type II – Develop DT data and make it available to operators.

5. Operator actions (apply to both SB Types):

- Review SB incorporation on a tail number basis.

- For incorporated SBs that rely on BZI (i.e., no special inspections required based on DTE performed), reconcile any maintenance planning document structural inspection escalations.

- For incorporated SBs that require DTI, verify that DTI has been included in the operations specification and include it if it is missing.

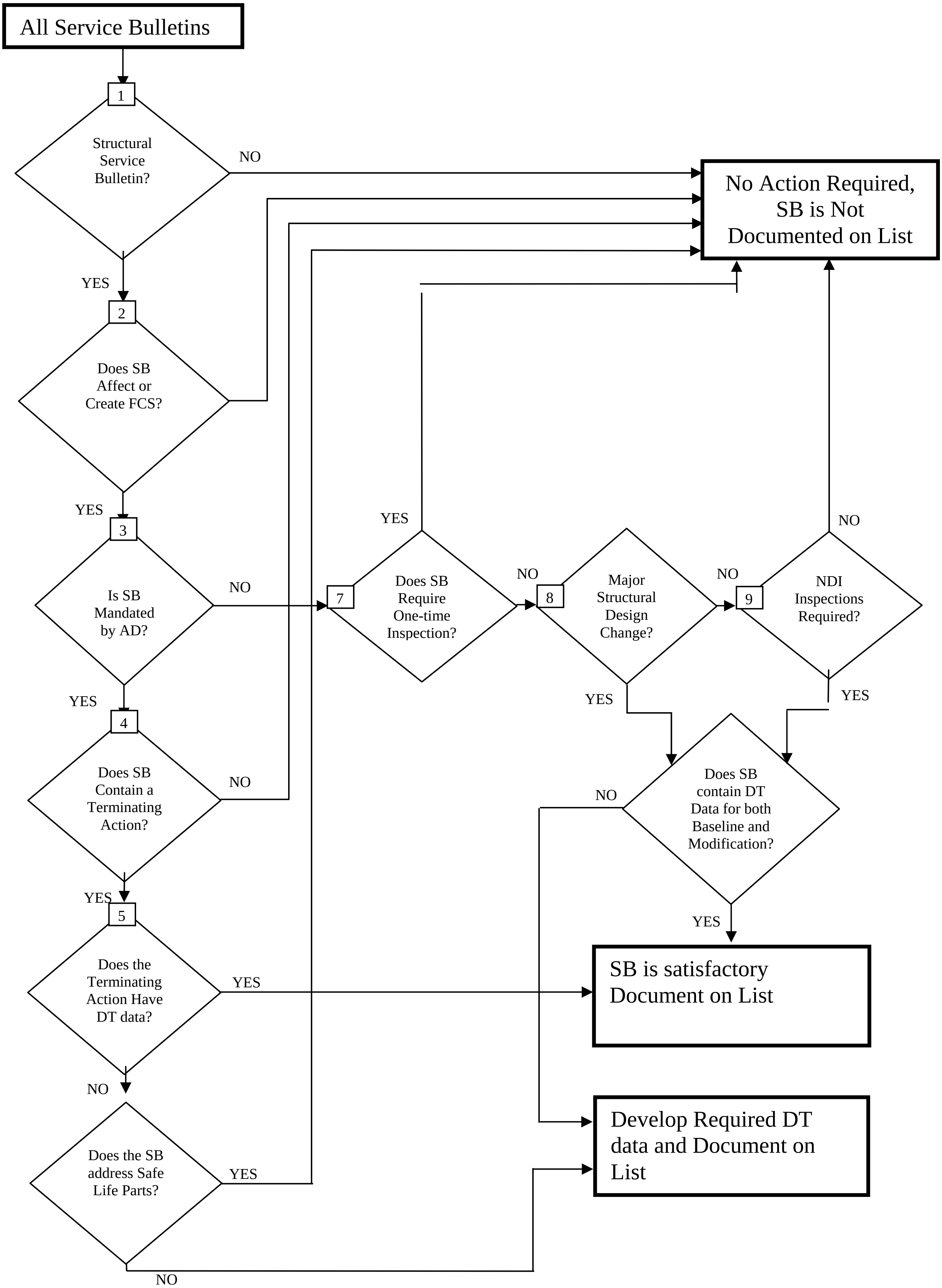


Figure A3(4)-1. Service Bulletin (SB) Flow Chart

ANNEX 5. LIST OF SIGNIFICANT STCs THAT MAY ADVERSELY AFFECT FATIGUE CRITICAL STRUCTURE

1. Passenger-to-freighter conversions (including addition of main deck cargo doors).

2. Gross weight increases (increased operating weights, increased zero fuel weights, increased landing weights, and increased maximum takeoff weights).

3. Installation of fuselage cutouts (passenger entry doors, emergency exit doors or crew escape hatches, fuselage access doors, and cabin window relocations).

4. Complete re-engine or pylon modifications.

5. Engine hush-kits.

6. Wing modifications such as installing winglets or changes in flight control settings (flap droop), and modification of wing trailing edge structure.

7. Modified skin splices.

8. Antenna Installations.

9. Any modification that affects several stringer or frame bays.

10. An modification that covers structure requiring periodic inspection by the operator's maintenance programme.

11. An modification that results in operational mission change that significantly changes the manufacturer's load or stress spectrum (e.g., passenger-to-freighter conversion).

12. An modification that changes areas of the fuselage that prevents external visual inspection (e.g., installation of a large external fuselage doubler that results in hiding details beneath it).

13. In general, attachment of interior monuments to FCS. Interior monuments include large items of mass such as galleys, closets, and lavatories.

APPENDIX 4

Guidelines for the development of a corrosion control programme

1. GENERAL

Before an operator may include a CPCP in its maintenance or inspection programme, the Agency should review and approve that CPCP. The Agency review is intended to ensure that the CPCP is comprehensive and systematic. The operator should show that the CPCP is comprehensive in that it addresses all corrosion likely to affect Primary Structure and is systematic in that if it provides:

(a) Step-by-step procedures that are applied on a regular basis to each identified task area or zone, and

(b) These procedures are adjusted when they result in evidence that corrosion is not being controlled to an established acceptable level (Level 1 or better).

1.1 Purpose

This appendix gives guidance to operators and DAHs who are developing and implementing a Corrosion Prevention and Control Programme (CPCP) for aeroplanes maintained in accordance with a maintenance programme developed in compliance with Part M M.A.302.

CPCPs have been developed by the DAH with the assistance of aircraft operators and competent authorities. They relied heavily on service experience to establish CPCP implementation thresholds and repeat intervals. Since that time a logical evaluation process has been developed to ensure environmental damage is considered in the evaluation of aircraft structure. This process is identified in ATA MSG-3 Scheduled Maintenance Development document, which introduced the CPCP concept in revision 2, circa 1993. The Agency will accept a CPCP based on this document and the information in this advisory circular. The Agency will also accept any other process that follows the guidelines in this AMC.

2. DEFINITIONS

- **Allowable Limit**. The *allowable limit* is the amount of material (usually expressed in material thickness) that may be removed or blended out without affecting the ultimate design strength capability of the structural member. *Allowable limits* may be established by the TCH/DAH. The Agency may, also, establish *allowable limits*. The DAH normally publishes allowable limits in the SRM or in SBs.

- **Baseline Programme**. A *baseline programme* is a CPCP developed for a specific model aeroplane. The TCH typically, develops the *baseline programme*. (See TCH Developed Baseline Programme, below) However, it may be developed by a group of operators who intend to use it in developing their individual CPCP (See Operator Developed Programme, below). It contains the corrosion inspection tasks, an implementation threshold, and a repeat interval for task accomplishment in each area or zone. Development of a systematic and comprehensive CPCP for inclusion in the operator's maintenance programme.

- **Basic Task(s)**. The *basic task* is a specific and fundamental set of work elements that should be performed repetitively in all task areas or zones to successfully control corrosion. The contents of the *basic task* may vary depending upon the specific requirements in an aeroplane area or zone. The *basic task* is developed to protect the Primary Structure of the aeroplane.

- **Corrosion Prevention and Control Programme (CPCP)**. A *Corrosion Prevention and Control Programme (CPCP)* is a comprehensive and systematic approach to controlling corrosion such that the load carrying capability of an aircraft structure is not degraded below a level necessary to maintain airworthiness. It contains the basic corrosion inspection task, a definition of corrosion levels, an implementation threshold and a repeat interval for task accomplishment in each area or zone, and specific procedures if corrosion damage exceeds

Level 1 in any area or zone. A CPCP consists of a basic corrosion inspection task, task areas, defined corrosion levels, and compliance times (implementation thresholds and repeat intervals). The CPCP also includes procedures to notify the competent authority of the findings and data associated with Level 2 and Level 3 corrosion and the actions taken to reduce future findings to Level 1.

- **Implementation Threshold (IT)**. The *implementation threshold* is the aircraft age associated with the first time the basic corrosion inspection task should be accomplished in an area or zone.

- **Level 1 Corrosion**. *Level 1 corrosion* is:

  (1) Corrosion, occurring between successive corrosion inspection tasks that is local and can be reworked or blended out within the allowable limit; or

  (2) Corrosion damage that is local and exceeds the allowable limit, but can be attributed to an event not typical of operator's usage of other aircraft in the same fleet (e.g. mercury spill); or

  (3) Operator experience has demonstrated only light corrosion between each successive corrosion inspection task inspection; and, the latest corrosion inspection task results in rework or blend out that exceeds the allowable limit.

- **Level 2 Corrosion**. *Level 2 corrosion* is that corrosion occurring between any two successive corrosion inspections task that requires a single rework or blend out which exceeds the allowable limit.

  <u>OR,</u>

  <u>Corrosion occurring between successive inspections that is widespread and requires a single blend-out approaching allowable rework limits. i.e. it is not light corrosion as provided for in Level 1, definition (3).</u>

  A finding of *Level 2 corrosion* requires repair, reinforcement, or complete or partial replacement of the applicable structure.

  Note: A statement of fact in previously mandated CPCPs states: corrosion findings that were discovered during the corrosion inspection task accomplished at the implementation threshold, and which require repair, reinforcement, or complete or partial replacement of the applicable structure, should not be used as an indicator of the effectiveness of the operators CPCP. The argument is that an operator's corrosion programme effectiveness can only be determined after a repeat inspection has been performed in a given inspection task area. This argument is valid for aircraft with mandated corrosion prevention and control programmes introduced after the aircraft has been in service for a number of years without a CPCP. This argument, however, may not be valid for aircraft that have been maintained using a design approval holders CPCP. Consequently, corrosion findings exceeding level 1 found on the corrosion inspection task implementation threshold may have been set too high by the design approval holder and action should be taken to readjust the implementation threshold.

- **Level 3 Corrosion**. *Level 3 corrosion* is that corrosion occurring during the first or subsequent accomplishments of a corrosion inspection task that the operator determines to be an urgent airworthiness concern.

  Note: If level 3 corrosion is determined at the implementation threshold or any repeat inspection then it should be reported. Any corrosion that is more than the maximum acceptable to the design approval holder or the Agency must be reported in accordance with current regulations. This determination should be conducted jointly with the DAH.

- **Light Corrosion**. *Light corrosion* is corrosion damage so slight that removal and blend-out over multiple repeat intervals (RI) may be accomplished before material loss exceeds the allowable limit.

- **Local Corrosion**. Generally, *local corrosion* is corrosion of a skin or web (wing, fuselage, empennage or strut) that does not exceed one frame, stringer, or stiffener bay. *Local corrosion* is typically limited to a single frame, chord, stringer or stiffener, or corrosion of more than one frame, chord, stringer or stiffener where no corrosion exists on two adjacent members on each side of the corroded member.

- **Operator Developed Programme.** In order to operate an aeroplane in compliance with the maintenance programme of Part-M an operator should include in its maintenance or inspection programme an approved CPCP. An operator may adopt the baseline programme provided by the DAH or it may choose to develop its own CPCP, or may be required to if none is available from the DAH. In developing its own CPCP an operator may join with other operators and develop a baseline programme similar to a TCH developed baseline programme for use by all operators in the group. The advantages of an operator developed baseline programme are that it provides a common basis for all operators in the group to develop their CPCP and it provides a broader experience base for development of the corrosion inspection tasks and identification of the task areas.

- **Repeat Interval (RI)**. The *repeat interval* is the calendar time between the accomplishment of successive corrosion inspection tasks for a task area or zone.

- **Task Area.** The *task area* is a region of aircraft structure to which one or more corrosion inspection tasks are assigned. The *task area* may also be referred to as a zone.

- **TCH Developed Baseline Programme.** As part of the ICA, the TCH should provide an inspection programme that includes the frequency and extent of inspections necessary to provide the continued airworthiness of the aircraft. Furthermore, the ICA should include the information needed to apply protective treatments to the structure after inspection. In order for the inspections to be effectively accomplished, the TCH should include, in the ICA, corrosion removal and cleaning procedures and reference allowable limits. The TCH should include all of these corrosion-related activities in a manual, referred to as the Baseline Programme. The Baseline Programme manual is intended to facilitate operator.

- **Urgent Airworthiness Concern**. An *urgent airworthiness concern* is damage that could jeopardises continued safe operation of any aircraft. An urgent airworthiness concern typically requires correction before the next flight and expeditious action to inspect the other aircraft in the operator's fleet.

- **Widespread Corrosion**. *Widespread corrosion* is corrosion of two or more adjacent skin or web bays (a web bay is defined by frame, stringer or stiffener spacing). Or, *widespread corrosion* is corrosion of two or more adjacent frames, chords, stringers, or stiffeners. Or, *widespread corrosion* is corrosion of a frame, chord, stringer, or stiffener and an adjacent skin or web bay.

- **Zone**. (See *task area)*

3. <u>DEVELOPMENT OF A BASELINE PROGRAMME</u>

3.1. Baseline Programme.

The objective of a baseline programme is to establish requirements for control of corrosion of aircraft structure to Level 1 or better for the operational life of the aircraft. The baseline programme should include the basic task, implementation thresholds, and repeat intervals. The baseline programme should also include procedures to notify the competent authority of the findings and data associated with Level 2 and Level 3 corrosion and the actions taken to reduce future findings to Level 1.

3.1.1. Baseline Programme considerations.

To establish an effective baseline programme consideration of the following is necessary:

(a) The flight and maintenance history of the aircraft model and perhaps similar models;

(b) The corrosion properties of the materials used in the aircraft structure;

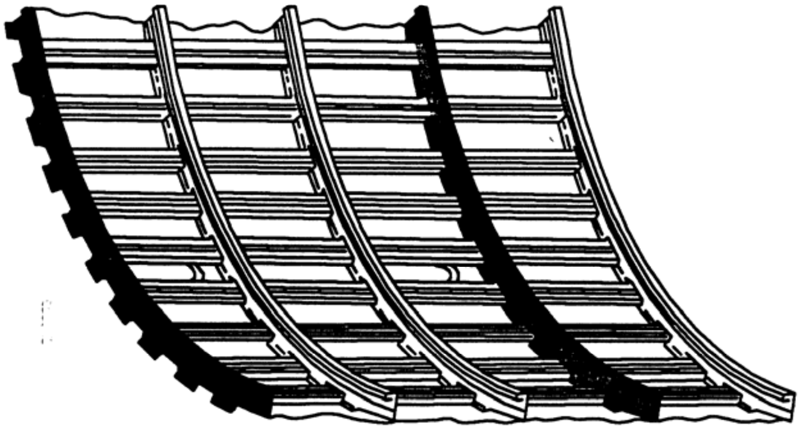
(c) The protective treatments used;

(d) The general practices applied during construction and maintenance; and

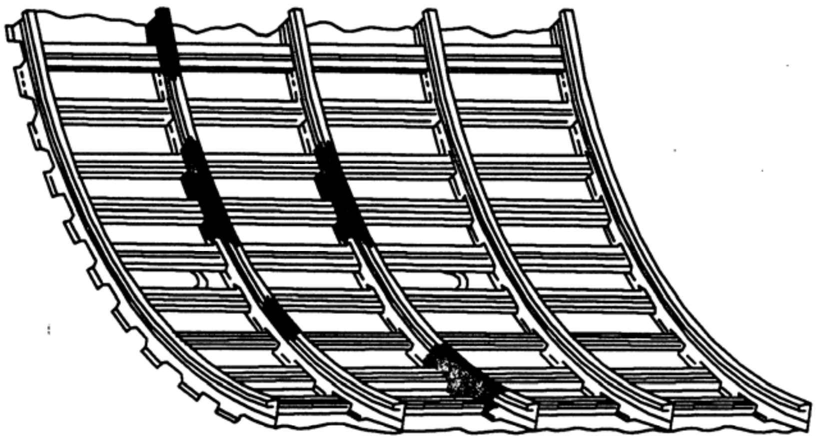
(e) Local and widespread corrosion (See Figure A4-1).

When determining the detail of the corrosion inspection tasks, the implementation threshold, and the repeat interval, a realistic operational environment should be considered. Technical representatives of both the TCH and the operators should participate in evaluating the service history and operational environment for the aircraft model. For new aircraft models and for aircraft models that have been in operation for only a short time, technical representatives of operators of similar aircraft models should be invited to participate.

EXAMPLES OF LOCAL AND WIDESPREAD CORROSION IN FUSELAGE FRAMES



LOCAL CORROSION
(Corrosion occurring in non-adjacent frames)



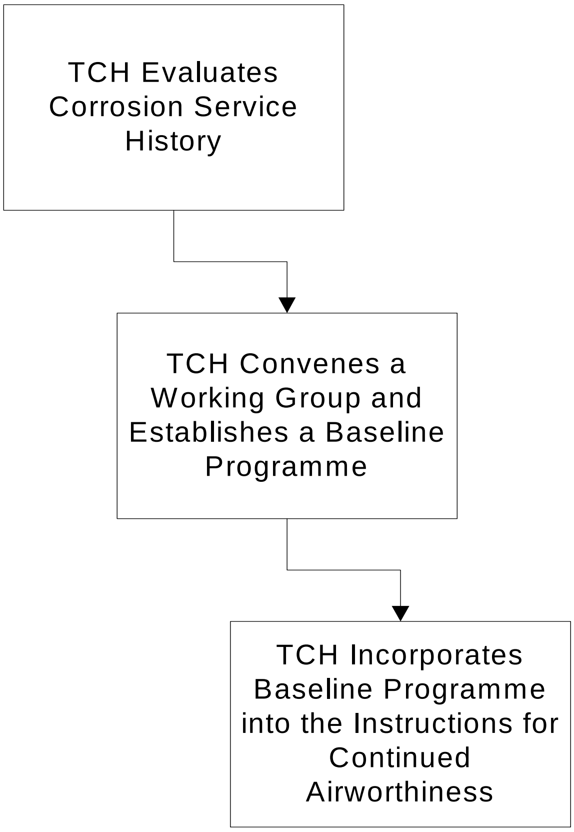
WIDESPREAD CORROSION
(Corrosion occurring in adjacent frames)

Figure A4-1

3.1.2. TCH developed Baseline Programme

During the design development process, the TCH should provide a baseline programme as a part of the instructions for continued airworthiness. The TCH initially evaluates service history of corrosion available for aircraft of similar design used in the same operational environment. Where no similar design with service experience exists those structural features concerned should be assessed using the environmental damage approach of ATA MSG-3. The TCH develops a preliminary baseline programme based on this evaluation. The TCH then convenes a working group consisting of operator technical representatives and representatives of the participating competent authorities. The working group reviews the preliminary baseline programme to assure that the tasks, implementation thresholds, and repeat intervals are practical and assure the continued airworthiness of the aircraft. Once the working group review is complete, the TCH incorporates the baseline programme into the instructions for continued airworthiness. (See Figure A4-2)

Figure A4-2: Type-Certificate Holder Developed Baseline Programme



3.1.3 Operator Developed Programme.

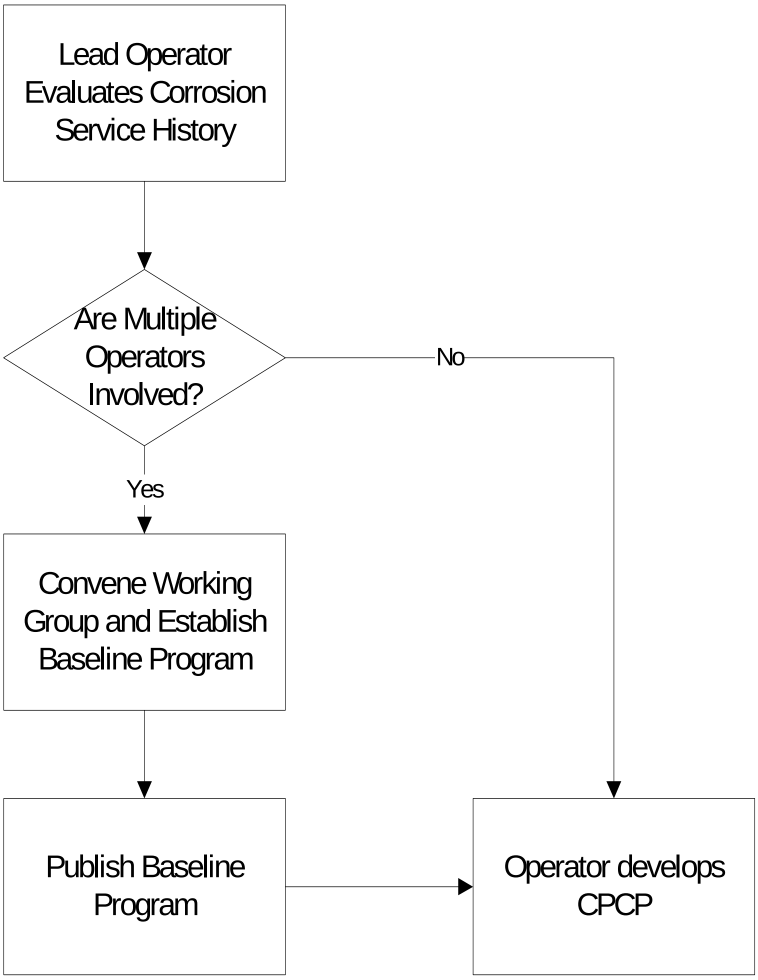
There may be instances where the TCH does not provide a baseline programme. In such instances, an operator may develop its CPCP without using a baseline programme, as long as the operator developed CPCP is consistent with the requirements.. It would be beneficial for an operator developing its own CPCP to consult other operators of the same or similar aircraft models in order to broaden the service experience available for use in preparing its programme. When a TCH prepared baseline programme is unavailable, a group of operators may prepare a baseline programme from which each operator in the group will develop its CPCP.

(a) Operator Developed Baseline Programme

An operator-developed baseline programme should pay particular attention to corrosion prone areas of the aircraft such as:

(i) Exhaust trail areas,
(ii) Battery compartments and battery vent openings,
(iii) Areas surrounding lavatories, buffets, and galleys,
(iv) Bilges,
(v) Fuselage internal lower structure,
(vi) Wheel wells and landing gear,
(vii) External skin areas,
(viii) Water entrapment areas,
(ix) Engine frontal areas and cooling air vents,
(x) Electronic or avionics compartments, and
(xi) Flight control cavities open during takeoff and landing.

Note: Corrosion Prevention and Control Programmes for large transports were developed based on a triad amongst the Airworthiness Authorities, design approval holders, and the operators for the particular model aeroplane. If operator(s) were to develop a CPCP they may want to follow the example of the large transports.



(b) **Individual Operator Developed CPCP**.

An operator may develop its CPCP without reference to a baseline programme; so long as the CPCP is consistent with the requirements of the applicable operating rules. Any operator who develops its own CPCP without a baseline programme, should review all available corrosion related service data on the individual aircraft model and on like design details in similar aircraft models when the operator's data and the Service Difficulty Report data shows no entries.

3.1.4. Continuous Analysis and Surveillance.

The operator's continuous analysis and surveillance system should contain procedures to review corrosion inspection task findings and establish corrosion levels. These procedures should provide criteria for determining if findings that exceed allowable limits are an isolated incident not typical of the operator's fleet. The operator's programme should also provide for notifying the competent authority whenever a determination of Level 2 or Level 3 corrosion is made. Due to the potential urgent airworthiness concern associated with a Level 3 finding, the operator's procedures should provide for notification as soon as possible but not later than 3 calendar days after the Level 3 determination has been made.

3.2. Baseline Programme Manual.

The baseline programme manual should include instructions to implement the baseline CPCP. It may be in a printed form or other form acceptable to the competent authority. It should, also, be in a form that is easy to revise. The date of the last revision should be entered on each page. The baseline programme manual should clearly be identified as a baseline CPCP programme. The aircraft make, model and the person who prepared the manual should also be identified.

3.2.1. Purpose and Background.

This section of the manual should state the purpose of the baseline programme which is, to establish minimum requirements for preventing and controlling corrosion that may jeopardise continuing airworthiness of the aircraft model fleet. The section should further state that an operator should include an effective CPCP in its maintenance or inspection programme.

3.2.2. Introduction.

The introduction should include a general statement that corrosion becomes more widespread as aircraft age and that it is more likely to occur in conjunction with other damage such as fatigue cracking. The introduction should also indicate that it is not the intent of a CPCP to establish rigid requirements to eliminate all corrosion in the fleet, but to control corrosion at or below levels that do not jeopardise continued airworthiness. However, due to the unpredictability of corrosion it must be removed and the structure repaired and corrosion prevention treatment reapplied.

3.2.3. Programme Application.

For a programme to be fully effective, it is essential that a corrosion inspection task be applied to all areas where corrosion may affect Primary Structure. This section should recommend that priority for implementing the CPCP be given to older aeroplanes and to areas requiring significant changes to previous maintenance procedures in order to meet corrosion prevention and control requirements. This section should allow an operator to continue its current corrosion control procedures in a given task area or zone where there is documentation to show that corrosion is being consistently controlled to level 1.

3.2.4. Baseline Programme.

This section should fully describe the baseline programme. It should include the basic task, corrosion inspection task areas, implementation thresholds, and repeat intervals.

3.2.5. Reporting System.

Procedures to report findings of Level 2 and 3 corrosion to the competent authority should be clearly established in this section. All Level 2 and Level 3 findings should be reported in accordance with the applicable AD, operator's service difficulty reporting procedures or reporting required by other competent authorities. Additional procedures for alerting the competent authority of level 3 findings should be established that expedite such reporting. This report to the competent authority shall be made after the determination of the corrosion level.

3.2.6 Periodic Review.

This section should establish a period for the TCH (or lead operator) and participating operators to meet with the competent authority and review the reported Level 2 and 3 findings. The purpose of this review is to assess the baseline programme and make adjustments if necessary.

3.2.7. Corrosion Related Airworthiness Directives.

This section should include a list of all ADs that contain requirements related to known corrosion related problems. This section should state that these ADs are in addition to and take precedence over the operator's CPCP.

3.2.8. Development of the Baseline Programme.

This section should identify the actions taken in preparing the baseline programme. It should include a description of the participants, the documents (e.g., SBs, service letters, ADs, service difficulty reports, accident and incident reports) reviewed, and the methodology for selecting and categorising the corrosion prone areas to be included in the baseline programme. Selection criteria for corrosion prone areas should be based on areas having similar corrosion exposure characteristics and inspection access requirements. Some corrosion prone areas that should be considered are the main wing box, the fuselage crown, the bilge, areas under lavatories and galleys, etc. This section should state that the implementation threshold was selected to represent the typical aircraft age beyond which an effective corrosion inspection task should be implemented for a given task area.

3.2.9. Procedures for Recording Corrosion Inspection Findings.

The Agency has not imposed a requirement for additional record keeping for an operator's CPCP. However, the operator should maintain adequate records to substantiate any proposed programme adjustments. For example, an operator should maintain records to enable the operator to determine the amount of damage that has occurred during the repeat interval for each corrosion inspection task. Such data should be maintained for multiple repeat intervals in order to determine whether the damage remains constant or is increasing or decreasing. Such records are necessary when an operator is seeking approval for Interval extension or task reduction.

3.2.10. Glossary.

This section should define all terms specifically used in the baseline manual.

3.2.11. Application of the Basic Task.

This section should describe in detail the basic task. It should provide procedures describing how to accomplish the following actions:

- (a) Removal of all systems equipment and interior furnishings to allow access to the area.
- (b) Cleaning of the area as required.
- (c) Visual inspection of all task areas and zones listed in the baseline programme.
- (d) Removal of all corrosion, damage evaluation, and repair of structure as necessary.
- (e) Unblocking holes and gaps that may hinder drainage.
- (f) Application of corrosion protective compounds.
- (g) Reinstallation of dry insulation blankets, if applicable.

3.2.12. Determination of Corrosion Levels Based on Findings.

This section should describe how the corrosion level definitions are used in evaluating the corrosion findings and assigning a corrosion level. This section should also instruct the operator to consult the DAH or the competent authority for advice in determining corrosion levels.

3.2.13. Typical Actions Following Determination of Corrosion Levels.

This section should establish criteria for evaluating whether or not the Level 2 or 3 corrosion is occurring on other aircraft in the operator's fleet. Criteria to be considered include: cause of the corrosion problem, past maintenance history, operating environment, production build standard, years in service, and inspectability of the corroded area. These and any other identified criteria should be used in identifying those aircraft that should be included in a fleet campaign. The results of the fleet campaign should be used to determine necessary adjustments in the operator's CPCP. The following instructions should also be included in this section:

(a) If corrosion exceeding the allowable limit is found during accomplishment of the corrosion inspection task implementation threshold for a task area, it may be necessary to adjust the CPCP. (see NOTE under level 2 corrosion definition)

(b) A single isolated occurrence of corrosion between successive inspections that exceeds Level 1 does not necessarily warrant a change in the operators CPCP. If the operator experiences multiple occurrences of Level 2 or Level 3 corrosion for a specific task area, then the operator should implement a change to the CPCP.

(c) The operator should not defer maintenance actions for Level 2 and Level 3 corrosion. These maintenance actions should be accomplished in accordance with the operator's maintenance manual.

(d) The operator may implement changes such as the following to improve the programme effectiveness:

(i) Reduction of the repeat interval,
(ii) Multiple applications of corrosion treatments, or
(iii) Additional drainage provisions.
(iv) Incorporation of design approval holders service information, such as service bulletins and service letters.

3.2.14. Programme Implementation.

This section should state that each task is to be implemented on each aircraft when the aircraft reaches the age represented by the implementation threshold for the task. It should, also, describe procedures to be used for establishing a schedule for implementation where the aircraft age exceeds the implementation threshold for individual tasks. It should state that once a task is implemented in an area, subsequent tasks are to be accomplished at the repeat interval in that task area.

4. <u>DEVELOPMENT OF OPERATORS PROGRAMME</u>

4.1. Baseline Programme available

If a baseline programme is available, the operator should use that baseline programme as a basis for developing its CPCP. In addition to adopting the basic task, task areas, implementation thresholds and repeat intervals of the baseline programme, the operator should make provisions for:

(a) Aeroplanes that have exceeded the implementation threshold for certain tasks,
(b) Aeroplanes being removed from storage,
(c) Unanticipated scheduling adjustments,
(d) Corrosion findings made during non CPCP inspections,
(e) Adding newly acquired aircraft, and
(f) Modifications, configuration changes, and operating environment,

4.1.1. Provisions for aircraft that have exceeded the implementation threshold

The operator's CPCP must establish a schedule for accomplishing all corrosion inspection tasks in task areas where the aircraft age has exceeded the implementation threshold (see main text of AMC paragraph 12). Repeat paragraph 12 text on implementation.

4.1.2. Aeroplanes being removed from storage

Corrosion inspection task intervals are established based on elapsed calendar time. Elapsed calendar time includes time out of service. The operators CPCP should provide procedures for establishing a schedule for accomplishment of corrosion inspection tasks that have accrued during the storage period.

The schedule should result in accomplishment of all accrued corrosion inspection tasks before the aircraft is placed in service.

4.1.3. Unanticipated scheduling adjustments

The operators CPCP should include provisions for adjustment of the repeat interval for unanticipated schedule changes. Such provisions should not exceed 10% of the repeat interval. The CPCP should include provisions for notifying the competent authority when an unanticipated scheduling adjustment is made.

4.1.4. Corrosion findings made during non-CPCP inspections

Corrosion findings that exceed allowable limits may be found during any scheduled or unscheduled maintenance or inspection activities. These findings may be indicative of an ineffective CPCP. The operator should make provision in its CPCP to evaluate these findings and adjust its CPCP accordingly.

4.1.5. Adding newly acquired aircraft

Before adding any aircraft to the fleet, the operator should establish a schedule for accomplishing all corrosion inspection tasks in all task areas that are due. This schedule should be established as follows:

(a) For aircraft that have previously operated under an approved maintenance programme, the initial corrosion inspection task for the new operator must be accomplished in accordance with the previous operator's schedule or in accordance with the new operator's schedule, whichever would result in the earliest accomplishment of the corrosion inspection task.

(b) For aircraft that have not previously been operated under an approved maintenance programme, each initial corrosion task inspection must be accomplished either before the aircraft is added to the operator's fleet, or in accordance with schedule approved by the competent authority. After each corrosion inspection task has been performed once, the subsequent corrosion task inspections should be accomplished in accordance with the new operator's schedule.

4.1.6. Modifications, configuration changes and operating environment

The operator must ensure that their CPCP takes account of any modifications, configurations changes and the operating environment applicable to them, that were not addressed in the Baseline Programme Manual.

4.2. Baseline Programme not available.

If there is no baseline programme available for the operator to use in developing its CPCP, the operator should develop its CPCP using the provisions listed in Paragraph 3 of this appendix for a baseline programme as well as the provisions listed in sub-paragraphs 4.1.1 through 4.1.6 of this paragraph.

APPENDIX 5

Guidelines for the development of a SB review and mandatory modification programme

1. GENERAL

This appendix provides interpretation, guideline and Agency accepted means of compliance for the review of Structural Service Bulletins including a procedure for selection, assessment and related recommended corrective action for ageing aircraft structures.

2. SB SELECTION PROCESS

The SB selection, review, assessment and recommendation process within the Structural Task group (STG) is summarised in Figure A5-1. For the first SB review within STG meeting, all inspection SB should be selected. Afterwards, the TCH should update periodically a list of SB which were already selected for a review with all decisions made, and add to this list all new and revised SB. Moreover, some specific modification SB not linked to an inspection SB may also be selected for review.

Operators information input should address the points as detailed in Figure A5-2. This information should be collected and analysed by the TCH for the STG meeting.

If for a given selected SB there is not sufficient in-service data available before the STG meeting that would enable a recommendation to be made, its review may be deferred until enough data are available. The TCH should then check periodically until these data become available.

The operators and the Agency should be advised by the TCH of the SB selection list and provided the opportunity to submit additional SB. For this purpose, the TCH should give the operators enough information in advance (e.g. 2 months), for them to be able to properly consider the proposed selection and to gather data.

When an SB is selected, it is recommended to select also, in the same package, inspection SB that interact with it and all related modification SB. The main criteria for selecting SBs are defined in the following sub-paragraphs.

2.1 High probability that structural cracking exists

Related to the number and type of finding in service and from fatigue testing.

A “no finding” result should be associated to the number of performed inspections.

The type of finding should include an analysis of its criticality.

2.2 Potential structural airworthiness concern

Structural airworthiness of the aircraft is dependent on repeat inspections to verify structural condition and therefore on inspection reliability.

A short repeat inspection interval (e.g. short time to grow from detectable crack to a critical length divided by a factor*)* will lead to increased work load for inspectors and possible increased risk of missing damage.

Special attention should be paid to any single inspection tasks involving multiple repeat actions needed to verify the structural condition that may increase the risk of missing damage (e.g. lap splice inspections).

2.3 Damage is difficult to detect during regular maintenance

The areas to inspect are difficult to access;

NDI methods are unsuitable;

Human factors associated with the inspection technique are so adverse that crack detection may not be sufficiently dependable to assure safety.

2.4 There is adjacent structural damage or the potential for it

Particular attention should be paid to areas susceptible to Widespread Fatigue Damage (WFD) and also to potential interaction between corrosion and fatigue cracking e.g. between fastener damage (due to stress corrosion or other factors) and fatigue cracking.

It is recommended to consider the potential interaction of modifications or repairs usually implemented in the concerned areas to check whether the inspections are still reliable or not (operators input)

3. STG MEETING, SB REVIEW AND RECOMMENDATIONS

It is recommended to review at the same time all the SBs that can interact, the so-called SB package in the selection process. The meeting should start with an STG agreement on the selected SB list and on those deferred. At the meeting the TCH should present its analysis of each SB utilising the collection of operator input data. The STG should then collectively review the ratings (Figure A5-2) against each criteria to come to a consensus recommendation. Such a STG recommendation for a selected SB shall consider the following options:

(a) To mandate a structural modification at a given threshold

(b) To mandate selected inspection SB

(c) To revise modification or repair actions

(d) To revise other SB in the same area concerned by damages

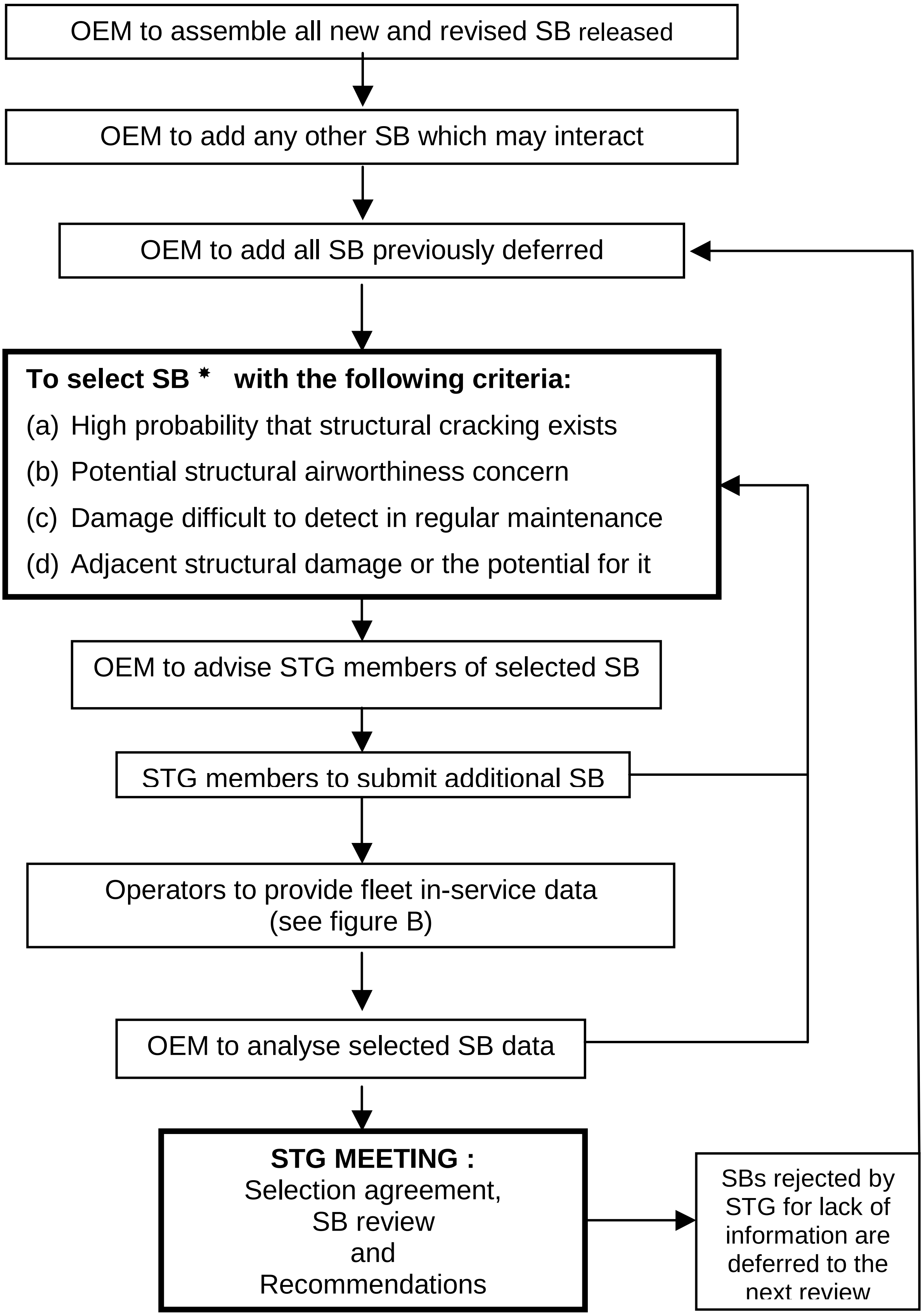
(e) To review inspection method and related inspection intervals

(f) To review ALI/MRB or other maintenance instructions

(g) To defer the review to the next STG and request operators reports on findings for a specific SB or request an inspection sampling on the oldest aircraft

STG recommendations for mandatory action are the responsibility of the TCH to forward to the Agency for appropriate action. Other STG recommendations are information provided to the STG members. It is their own responsibility to carry them out within the appropriate framework.

FIGURE A5-1: SB SELECTION PROCESS AND SB REVIEW



* This may be done by the TCH alone or in conjunction with the operators as a preliminary STG meeting

FIGURE A5-2: OPERATORS FLEET EXPERIENCE

IN-SERVICE DATA / SECTION 1

NAME OF THE OPERATOR
____

AIRCRAFT MODEL/SERIES
____

SERVICE BULLETIN (SB) NUMBER ______________________________

TITLE
____

RELATED INSPECTION/MODIFICATION SB :
1/____

2/____

3/____

SB MANDATED ? ☐ YES ☐ NO
IF NOT, SB IMPLEMENTED IN MAINTENANCE PROGRAMME ? ☐ YES ☐ NO

NUMBER OF AIRCRAFT TO WHICH SB APPLIES (INCLUDING ALL A/C IN THE SB EFFECTIVITY)____________________

NUMBER OF AIRCRAFT EXCEEDING SB INSPECTION THRESHOLD (IF APPLICABLE)
____

NUMBER OF AIRCRAFT INSPECTED PER SB (IF APPLICABLE) ?
____

SPECIFY TYPE OF INSPECTION USED
____

NUMBER OF AIRCRAFT WITH REPORTED FINDINGS
____

TYPE OF FINDINGS
____

____
NUMBER OF FINDINGS DUE TO OTHER INSPECTIONS THAN THE ONE PRESCRIBED IN SB (IF APLICABLE) ______________
SPECIFY TYPE OF INSPECTION USED
____

NUMBER OF AIRCRAFT EXCEEDING SB TERMINATING MODIFICATION THRESHOLD (IF APPLICABLE) ________________
NUMBER OF AIRCRAFT IN WHICH TERMINATING MODIFICATION HAS BEEN ACCOMPLISHED (IF APPLICABLE) ________

NEED THIS SB (OR RELATED SB) BE IMPROVED ? ☐ YES ☐ NO

COMMENTS:____
____

IN-SERVICE DATA / SECTION 2

	(A)	(B)	(C)	(D)	(E)
CRITERIA	INSPECT-ABILITY ACCESS	FREQUENCY REPETITIVE INSPECTION	FREQUENCY OF DEFECTS	SEVERITY RATING	ADJACENT STRUCTURE DAMAGE
RATING					

(A) INSPECTABILITY/ACCESS RATING

OK ◆ Inspection carried out with little or no difficulty.

Acceptable ◆ Inspection carried out with some difficulty.

Difficulty ◆ Inspection carried out with significant difficulty.

Note: Rating should consider difficulty of access as well as inspection technique and size of inspection area.

(B) FREQUENCY OF REPETITIVE INSPECTIONS RATING

OK ◆ Greater than 6 years.

Acceptable ◆ Between 2 and 6 years.

Difficulty ◆ Less than 2 years.

(C) FREQUENCY OF DEFECTS NOTED RATING = % OF THOSE AEROPLANES BEYOND THRESHOLD ON WHICH DEFECTS HAVE BEEN FOUND

OK ◆ No defect noted.

Acceptable ◆ Defects noted but not of a significant amount (less than 10%).

Difficulty ◆ Substantial defects noted (greater than 10%).

(D) FINDING SEVERITY RATING

OK ◆ Airworthiness not affected.

Acceptable ◆ Damage not of immediate concern, but could progress or cause secondary damage.

Difficulty ◆ Airworthiness affected. Damage requires immediate repair.

(E) ADJACENT STRUCTURE DAMAGE RATING (MULTIPLE SITE DAMAGE, MULTIPLE ELEMENT DAMAGE, CORROSION, ETC.)

OK ◆ Low rate of adjacent structural damage.

Acceptable ◆ Medium rate of adjacent structural damage.

Difficulty ◆ High rate of adjacent structural damage/Multiple service actions in area.