AMC-20 AMENDMENT 2: CHANGE INFORMATION

The Agency publishes amendments to AMC-20 as consolidated text for each constituent AMC individually.

Consequently, except for the header that identifies the amendment status, the consolidated text of each individual AMC does not allow readers to see the detailed changes introduced by the new amendment. To allow readers to also see these detailed changes this document has been created. The same format as for publication of Notices of Proposed Amendments has been used to show the changes.

1. text not affected by the new amendment remains the same: unchanged
2. deleted text is shown with a strike through: ~~deleted~~
3. new text is highlighted with grey shading: new
4. ....
   Indicates that remaining text is unchanged in front of or following the reflected amendment.

AMC 20-1
Certification of Aircraft Propulsion Systems Equipped with Electronic Control Systems
~~**See 2 below for cross references**~~

TABLE OF CONTENTS

1 GENERAL

The existing specific~~regul~~ations 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, ~~the content of this document is not mandatory. It is issued for guidance purposes and to outline a method of compliance with the airworthiness code.~~ it is issued to outline issues to be considered during demonstration of compliance with the certification specifications.
~~In lieu of following this method, an alternative method may be followed, provided that this is agreed by the Agency as an acceptable method of compliance with the airworthiness code. This document addresses the compliance tasks relating to both the Engine/Propeller and the aircraft certification.~~

2 ~~REFERENCE~~ RELEVANT SPECIFICATIONS

~~2.1 *Engine and Propeller Certification*~~

~~Turbine Engines for Aeroplanes and Rotorcraft -~~
~~CS-E~~
~~Book 1, Section A, paragraphs E20, E30, E40, E50, E60, E90, E110, E140 & E150, E190 Section D, paragraphs E500, E510, E130 Section E, as appropriate.~~

~~Propellers -~~
~~CS-P, Paragraph P70~~

~~2.2 A~~For aircraft c~~C~~ertification, the main related certification specifications are:

For ~~A~~aeroplanes: in CS-25 (and, where applicable, CS-23)

- Paragraphs, ~~25.~~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 r~~R~~otorcraft: e~~E~~quivalent specifications in CS-27 and CS-29.

3 SCOPE

This acceptable means of compliance ~~provides guidance for electronic (analogue and digital) Engine and Propeller control systems, on the interpretation and means of compliance with the relevant Engine, Propeller and aircraft certification requirements.~~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 d~~D~~egree of authority of the system, the p~~P~~hase of flight and the a~~, A~~vailability of a B~~b~~ack-up S~~s~~ystem.

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

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

4 PRECAUTIONS

~~4.1~~(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 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 F~~f~~ailures 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 F~~f~~aults 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 ~~must~~should therefore be taken to minimise these risks.

~~4.2~~(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 ~~by~~ Engine and ~~/~~Propellers ~~equipped with~~using hydromechanical control and protection systems.
~~This objective, when defined for the aircraft/Engine for a specific application, will be agreed with the Agency.~~
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.

~~4.3 *Precautions Relating to Engine/Propeller Control, Protection and Monitoring*~~

~~The software associated with Engine/Propeller control, protection and monitoring functions must have a quality level and architecture appropriate to their criticality (see also paragraph 4.5.1).~~

~~The design of the system relating to the control, protection and monitoring functions must be such as to satisfy the requirements of CS-E 50(c).~~

~~4.4 *Precautions Relating to Engine/Propeller Independence From the Aircraft*~~

~~4.4.1~~(c) Precautions relating to electrical power supply and data from the aircraft

When considering the objectives of paragraph 4 (a) or (b)~~2~~, due consideration ~~must~~should be given to the reliability of electrical power and data supplied to the electronic control~~s~~ systems and peripheral components. The~~refore 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 ~~must~~are ~~be~~ 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.

~~The use of either the aircraft electrical power network or electrical power sources specific to the Engine/Propeller, or the combination of both may meet the objectives. Defects of aircraft input data may be overcome by other data references specific to each Engine/Propeller.~~

~~4.4.2~~(d) Local events

~~a. In designing an electronic control system to meet the objectives of paragraph 4.2, special consideration needs to be given to~~For Engine and Propeller certification, effects of local events should be assessed.

~~Examples of local events include fluid leaks, mechanical disruptions, electrical problems, fires or overheat conditions. An overheat condition results when the temperature of the electronic control unit is greater than the maximum safe design operating temperature declared during the Engine/Propeller certification. This situation can increase the failure rate of the electronic control system.~~

~~b.~~ Whatever the local event, the behaviour of the electronic control system ~~must~~should not cause a hazard to the aircraft. This will require consideration of effects such as the control of the thrust reverser deployment, the over-speed of the Engine, transients 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 ~~must~~should be shown that this function is not rendered inoperative by the same local event (including destruction of wires, ducts, power supplies).

~~c. Specific design features or analysis methods may be used to show compliance with respect to hazardous effects. Where this is not possible, for example due to the variability or the complexity of the failure sequence, then testing may be required. These tests must be agreed with the Agency.~~ Such assessment should be reviewed during aircraft certification.

~~4.5 *Precautions Relating to Failure Modes Common to More Than One Engine/Propeller*~~

~~4.5.1~~(e) ~~*System* design~~ Software and Programmable Logic Devices

~~For digital systems, any residual errors not activated during the software development and certification process could cause a failure common to more than one Engine/Propeller. RTCA DO178B (or the equivalent~~

~~EUROCAE ED-12B) constitutes an acceptable means of compliance for software development and certification. It should be noted however that the DO178A states in paragraph 3.3 - 'It is appreciated that, with the current state of knowledge, the software disciplines described in this document may not, in themselves, be sufficient to ensure that the overall system safety and reliability targets have been achieved. This is particularly true for certain critical systems, such as full authority fly-by-wire systems, In such cases it is accepted that other measures, usually within the system, in addition to a high level of software discipline may be necessary to achieve these safety objectives and demonstrate that they have been met.~~ 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.

~~It is outside the scope of this document to suggest or specify these measures, but in accepting that they may be necessary, it is also the intention to encourage the development of software techniques which could support meeting the overall system safety objectives.'~~

~~4.5.2~~(f) Environmental effects

~~Special attention should be given to any condition which could affect more than one Engine/Propeller control system. For example, incorrect operation under hot ambient conditions.~~

~~4.5.3 *Lightning and other electromagnetic effects*~~

~~Electronic control systems are sensitive to lightning and other electromagnetic interference. Moreover, these conditions can be common to more than one Engine/Propeller. The system design must incorporate sufficient protection in order to ensure the functional integrity of the control system when subjected to designated levels of electric or electromagnetic inductions, including external radiation effects.~~

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

~~4.5.4 *Aircraft electrical power supply*~~

~~If the aircraft electrical system supplies power to the Engine/Propeller control system at any time, the power supply quality, including transients or failures, must not lead to a situation identified during the Engine certification, which is considered during the aircraft certification to be a hazard to the aircraft.~~

~~4.5.5 *Data exchanged with the aircraft*~~

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

- ~~i. 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~~
- ~~ii. Control system operating faults propagating via data links between Engine/Propellers (e.g. maintenance recording, common bus, cross-talk, autofeathering, automatic reserve power system).~~

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

~~4.6 *Other Functions Integrated into the Electronic Control System*~~

~~If functions other than those directly associated with the control of the Engine/Propeller, such as thrust reverser control or automatic starting, are integrated into the electronic control system, the Engine/Propeller certification should take into account the applicable aircraft requirements.~~

5 INTER-RELATION BETWEEN ENGINE, ~~/~~PROPELLER AND AIRCRAFT CERTIFICATION

~~5.1~~(a) Objective

To satisfy the ~~CS~~ aircraft ~~requirements~~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.

~~5.2~~(b) Interface Definition

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

~~b.~~ The Engine/Propeller/aircraft documents should cover in particular:

- The software quality level (per function if necessary),
- The reliability objectives for ~~Engine shut-down in flight, Loss~~ loss of Engine/Propeller control or significant change in thrust, (including IFSD due to control system malfunction),~~Transmission~~ 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).

~~5.3~~(c) Distribution of Compliance Demonstration

The certification tasks of the aircraft propulsion system equipped with electronic control~~s~~ systems may be shared between the Engine, Propeller and aircraft certification. The distribution between the different certification activities ~~must~~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 ~~must~~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 or 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