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ELECTRONIC PROPULSION CONTROL/AIRCRAFT INTERFACE CONTROL DOCUMENTS

FOREWORD

Electronic Propulsion Control systems have become established for a number of applications in the commercial field.

Frequently, a given aircraft can have engines from different engine manufacturers, and also a given engine type may be used in different aircraft. Without an accepted standard this multiplicity can lead to large resource expenditure in documenting the interfaces between the engine and the aircraft.

As electronic propulsion control systems become more complex, with increased data and functional integration, this problem will be aggravated in the future and significant benefit will result from an accepted standard which can apply to all applications.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) provides guidelines for the format and content of documents defining the interface between electronic propulsion control systems and aircraft systems.

The scope includes civilian aircraft powered by turbofan, turboprop, and turboshaft engines equipped with electronic engine controls.

2. REFERENCES:

2.1 Applicable Documents:

Joint Airworthiness Authority Document AMJ-20X, "Certification of Aircraft Propulsion Systems Equipped with Electronic Controls"

2.2 Acronyms/Abbreviations:

EEC Electronic Engine Control
EECS Electronic Engine Control System
EPCS Electronic Propulsion Control System
FADEC Full Authority Digital Engine Control
ICD Interface Control Document
LRU Line Replaceable Unit

3. INTERFACE DEFINITION OVERVIEW:

3.1 Purpose:

The purpose of defining interfaces between powerplant controls and other airplane and powerplant systems is to ensure the powerplant controls, and the airplane as a whole, perform safely, effectively and reliably.

In addition, identification of these interfaces is a necessary part of certifying an aircraft propulsion system equipped with electronic controls (reference 2.1).

The definition of the interfaces between a powerplant control system and related aircraft systems is the physical and functional relationship of one system to the other (i.e., how they fit and function together).

3.2 Interface Definition Requirements:

Considerations which must be addressed when determining and documenting interfaces include:

a. Physical Interface Characteristics: These include electrical, mechanical, optical and environmental characteristics.

3.2 (Continued):

b. Functional Interface Characteristics: The functions performed and data exchanged between the aircraft and the electronic propulsion control system that allow the engine and aircraft to operate as an integrated system.

4. INTERFACE CONTROL DOCUMENT (ICD):

4.1 Purpose:

The purpose of the ICD is to define the interface between a given electronic propulsion control system and a given aircraft. For any powerplant-aircraft combination, the document will define physical and functional interfaces.

The definition of physical and functional interface characteristics should embrace both normal and abnormal operating conditions together with appropriate fault detection, accommodation, and annunciation requirements.

NOTE: This is not intended to make the ICD a failure modes and effects analysis report, but instead to describe and define specific functional characteristics related to failures of aircraft and control system interfaces which are to be used as FADEC system design requirements.

The functional definition will cover all operating modes including for example reversionary and get-you-home modes (if required).

The intended audience of the ICD will include the responsible design engineering organizations at both the engine manufacturer and at the aircraft manufacturer. In addition, experience has shown that the completed ICD is a useful resource document for certification test procedure development, for engine and aircraft manufacturer's maintenance training organizations, for airline maintenance engineering organizations, and for manufacturers of flight and maintenance crew training simulators. Distribution of the ICD is sometimes constrained by proprietary data concerns or by government export license restrictions. These factors and the intended audience should be discussed before preparation of the document to ensure it fulfills its intended purpose.

4.2 ICD Preparation and Approval:

The ICD is one of several sources of engineering data which define the installation of the engine control system in the aircraft. The complete definition of the installation generally includes, but may not be limited to:

a. Engine installation drawing
b. Engine Installation Manual
c. Propulsion control system interface control document

The aircraft manufacturer and engine manufacturer will typically jointly define the development plan for the ICD as a part of the engine specification and engine integration plan negotiation process, and complete it during the subsequent design phases for the powerplant and engine.

4.2 (Continued):

The means for controlling the configuration of the document needs to be agreed upon at the beginning of the program, because this may affect the structure of the document (see 4.3).

The plan for development of the ICD should be designed to recognize the existence of all sources of engineering data, including the previous drawings and manual, and avoid duplication of information.

In a mature program, periodic revisions of the ICD are essential as product improvements or new features that affect aircraft/engine interfaces are defined and introduced into service.

The document and its revisions will be approved by both engine and airframe parties.

4.3 ICD Format and Content:

A recommended outline for the ICD is shown in Figure 1. The outline provides a recommended structure for the document. However, design specific sections, such as paragraphs discussing system description and functional interface requirements, must be expanded as necessary for a given application.

In some applications, it may be of use to configure each section as a stand-alone item. For projects which require large documents, this approach allows the ICD to be divided into smaller, more manageable sections which may be configured and released separately as the design progresses. In this arrangement, each section would contain a detailed change history, table of contents, signature sheets, etc.

The document will define the application, hardware configuration and software version so that there is a clear understanding for configuration control purposes.

The document will include a brief description of the overall system providing top level information on all aircraft and propulsion system LRU's to which the electronic propulsion control system components interface.

The detailed definition will cover both physical and functional characteristics of all data, signals and power associated with the aircraft to propulsion system interface.

Appendix A presents additional details for recommended ICD content. Note that the suggested format incorporates all discussion of functional interface requirements in Section 8.0. Alternatively, individual functional requirements may be included in separate paragraphs, e.g. Section 8.1. Aircraft Data Management, Section 8.2 Thrust/Power Management, etc. Aspects such as fault detection, accommodation, annunciation and dispatch criteria for each function may be included as subsections within the paragraph that discusses that function.

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8.n Engine Health Monitoring

Appendices (as required)

NOTE: This outline is provided as a guideline. See section 4.3 for discussion of other options.

FIGURE 1 - Standard Interface Control Document Outline

4.4 Electronic Transfer of Documents:

Consideration should be given in preparing the plan for delopment of the ICD for transfer of the document electronically between the engine manufacturer and the aircraft manufacturer.

5. KEY WORDS:

Electronic engine controls, interfaces, FADEC, interface control document

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APPENDIX A
RECOMMENDED CONTENT FOR INTERFACE CONTROL DOCUMENT

A.1 TABLE OF CONTENTS:

The table of contents should include items such as:

a. Text
b. List of figures
c. List of tables
d. Appendices

A.2 DOCUMENT REVISION HISTORY:

The revision history should allow document changes to be easily identified and traceable. In addition, the revision history will provide the ability to identify all active pages of the document.

A.3 SCOPE:

The scope section of the ICD should:

a. Define airframe-engine application
b. Define hardware configuration and software version for the electronic propulsion control system and interfacing aircraft systems

A.4 REFERENCE DOCUMENTS:

The reference section of the ICD should include references, such as:

a. Applicable government regulations
b. Applicable industry standards
c. Aircraft manufacturer specifications
d. Engine and/or component specifications
e. Engine and/or component installation drawings

Where appropriate, a precedence statement may be included for resolution of conflicting requirements. Agreed-upon deviations from reference documents may also be listed.

A.5 SUPPLEMENTAL INFORMATION:

Supplemental information may include:

A.5.1 Definitions:

A.5.2 Acronyms, Abbreviations:

A.5.3 Mnemonic Name Cross-Reference:

This list will define mnemonics used in the ICD, including identifying where the mnemonic is defined and where it is used in other functions.

A.5.4 Traceability:

A traceability section which describes the source of requirements in the ICD may be found useful for documenting the history of design decisions for later use when product improvements or future requirements changes are considered.

Traceability may be documented in the ICD by including a reference to another report, in cases where a separate document is prepared on this subject.

A.6 SYSTEM OVERVIEW:

A.6.1 Aircraft Systems Description:

The aircraft systems description should contain:

A.6.1.1 System Overview: The overview should include a block diagram of the system showing the aircraft subsystems and units comprising the system.

A.6.1.2 Aircraft System Components: A list of aircraft units or subsystems which perform functions related to the electronic propulsion control system.

A.6.1.3 System Functions: A description of aircraft system functions related to the electronic propulsion control system.

A.6.1.4 Allocation of Functions: For each aircraft function related to the engine control system, a description of which aircraft units are involved in implementing the function.

A.6.1.5 Operating Modes: This section should include:

a. A list and description of operating modes, e.g., automatic versus manual flight control, normal versus reversionary engine control modes.

b. Definition of configurations (e.g., with faults present in the system) for which aircraft dispatch is to be allowed.

c. Description of any significant differences in operating and performance characteristics for all dispatchable configurations, in comparison to a normal or fully-operational system dispatch.

A.6.2 Electronic Propulsion Control System Description:

The system description should contain:

A.6.2.1 System Overview: The overview should include a block diagram of the system showing the subsystems and units comprising the system.

A.6.2.2 System Components: A list of units or subsystems comprising the system.

A.6.2.3 System Functions: A list of EPCS functions, for example:

a. Thrust control
b. Control of fuel flow
c. Overspeed protection
d. Control of compressor variable geometry and bleeds
e. Starting functions
f. Heat management, etc.

A.6.2.4 Allocation of Functions: For each function, a description of which units are involved in implementing the function.

A.6.2.5 Operating Modes: This section should include:

a. A list and description of operating modes, e.g., initialization, ground tests, engine running, etc.

b. State transition diagram or equivalent describing transition between operating modes.

A.6.3 Aircraft Interfaces with EPCS: This section should include a summary description of the interfaces between the aircraft and the electronic propulsion control system.

A.7 PHYSICAL INTERFACE CHARACTERISTICS:

Physical characteristics including electrical, mechanical, optical, and environmental interface characteristics must be defined.

A.7.1 Electrical Interface Characteristics:

A.7.1.1 General Requirements: This section would address such issues as:

a. Channel-to-channel isolation
b. Response to fault conditions
c. Aircraft to propulsion system isolation

A.7.1.2 Analog Signal Interfaces: Items that typically must be defined for each signal path into and out of a system or component include:

a. Shielding requirements

b. Impedance requirements or limits

c. Connector designation and contact number (or the equivalent for other types of disconnects such as terminal strips)

d. Form of the aggregate interconnection (twisted-pair, twisted-triplet, coaxial, etc.)

The signal must be defined in sufficient detail so that the interface can be designed to function correctly in all conceivable operating conditions. No important characteristic of the signal can be left to chance. Factors such as the maximum operating temperature or worst-case signal characteristics must be defined.

Characteristics of each signal that may be specified, depending on the specific type and application of the interconnection, include:

a. Name, source, and purpose of the signal

b. Electrical voltage, current, impedance, or power ranges for all operating modes and conditions (i.e., with equipment powered and depowered, and for all temperatures expected), at both sides of the interface disconnect

c. Electrical parameter relationship to the sensed quantity (for sensor inputs), including accuracy, linearity, and resolution specifications for the signal

d. Frequency, wave shape, duty cycle, and other pertinent data for alternating current signals

A.7.1.3 Discrete Signal Interface Characteristics: Important characteristics of discrete signal interfaces include:

a. Signal name, source, and purpose
b. Signal type (e.g. contact closure or voltage)
c. Minimum open circuit resistance
d. Maximum closed circuit resistance
e. Maximum voltage
f. Minimum, maximum, and typical current levels

A.7.1.4 Digital Data Bus Signals: Characteristics of each data bus crossing the interface need to be specified. These include:

a. The specification used (ARINC 429, RS232, etc.)

b. Bus specification options, such as operating mode (voltage or current, clock speed, etc.)

c. Bus terminal identifier and terminal bus interface characteristics (if appropriate)

Digital data must be defined in detail. Table A1 lists typical parameters that must be included in the definition.

A.7.1.5 Power Supply: Electrical power requirements must be defined including type and quality of electrical power, maximum power or current, maximum in-rush current (if appropriate), etc.

A.7.2 Mechanical Interface Characteristics:

Physical details of electrical (or optical) interconnections across system or component boundaries must be specified. These details include:

a. The part number of each connector on both sides of the interface (including any special information not inherently specified by the part number alone)

b. The keyway orientation for each interface connector pair

c. The connector contact arrangement and contact signal assignments

If physical limits such as the maximum length, maximum thickness, or maximum permitted bend radius of an interconnection are pertinent, they must also be included in the ICD and observed in the design. In some installations, pneumatic pressure sense line may also cross the interface between the aircraft and the electronic engine control system, and this is another type of mechanical interface which must be specified. This interface occurs, for example, when aircraft-provided pneumatic lines are connected to the electronic engine control system for measurement of freestream total or static pressure.

A.7.3 Optical Interface Characteristics:

Important aspects of optical interfaces may include interconnecting fiber characteristics, optic connector(s), signal format, power budget and wavelength.

A.7.4 Environmental Characteristics:

Environmental characteristics which may be considered as part of the interface include specification of thermal, vibration, and electromagnetic characteristics to which components of the system are exposed. Where these subjects are treated outside the scope of the ICD, it is appropriate for the ICD to reference other documents rather than duplicating requirements identified elsewhere.