Advisory Circular

U.S. Department
of Transportation

Federal Aviation Administration

Subject: GUIDELINES FOR DESIGN APPROVAL OF AIRCRAFT DATA COMMUNICATIONS SYSTEMS	**Date:** 8/16/99 **Initiated by:** AIR-100	**AC No:** 20-140 **Change:**

1. PURPOSE. This advisory circular (AC) is issued to support the introduction of data communications applications for air traffic services (ATS). Ultimately, the International Civil Aviation Organization (ICAO) will use data communications applications to implement the communication, navigation, and surveillance (CNS) concepts that describe the future air navigation system (FANS). This AC provides guidelines for design approval of aircraft data communications systems and applications primarily used for air traffic services (ATS). Like all advisory material, this AC is not, in itself, mandatory and does not constitute a regulation. It is issued to provide guidelines and to outline a method of compliance with airworthiness standards contained in the Title 14, Code of Federal Regulations (CFR), subchapter C. This AC will also ensure standardization among the Aircraft Certification Offices (ACO) in their assessment of aircraft data communications systems and applications for design approval. This AC was developed in consideration of the ICAO standards and recommended practices (SARPs) and in cooperation with foreign civil air authorities (FCAA). A comment form is included in appendix 5 of this AC to allow ACO's and other users to offer comments during the use of this AC.

2. BACKGROUND. Aircraft operators have been using very high frequency (VHF) based aircraft communications addressing and reporting system (ACARS) data communications systems for aircraft operational control (AOC) and aeronautical administrative control (AAC) for more than a decade. Recently, the use of these data communications systems have been approved for limited ATS, such as pre-departure clearance (PDC) at domestic airports, and their use in air traffic management (ATM) operations is continuing to expand. As a supplement to HF voice radio communications, satellite-based data communications, in conjunction with the ACARS network, are being used in oceanic airspace to report aircraft position. Based on this experience, the industry believes that the satellite subnetwork, data communications system, and applications are essential to the success of implementing the ICAO FANS concepts associated with CNS. Aircraft operators are now seeking approval of satellite-based data communications to improve two-way communications and surveillance for ATM in oceanic and remote airspace.

a. Current data communications systems and applications installed on aircraft have been approved as non-essential equipment and shown to not interfere with more critical functions on the aircraft. That is, the applicants have substantiated that the effects of failures and design errors would contribute to only minor failure conditions for the data communications applications. However, when data communications systems are used for ATS applications, failures and design errors of the data communications system and applications may contribute to failure conditions whose classification is more severe than minor.

b. To adequately assess the effects of failures and design errors, this AC describes a means, using the safety assessment, to identify safety requirements for the operational environment in which the aircraft data communications system and applications will operate and the requirements for interoperability with the air/ground subnetwork, ground data communications system, and ground applications. Although these safety and interoperability requirements will be defined to support the design approval of the aircraft data communications system and applications, they will be used to facilitate the operational authorization to use the data communications applications as they evolve.

3. RELATED INFORMATION. Appendix 1 provides a list of sections from Title 14 Code of Federal Regulations (CFR) parts 23, 25, 27, and 29 that should be considered when determining the certification basis for approving aircraft data communications systems and the applications. This appendix also provides references to advisory circulars (AC), technical standard orders (TSO), and industry documents that may be useful in determining the means for showing that the aircraft data communications system and the applications comply with the certification basis. These references are applicable to the means of compliance described herein only when specifically identified in the body of this AC or as negotiated during the certification planning process described in paragraph 6 of this AC. The appendix also lists industry activities, which are producing documents related to data communications systems, the applications, and their use.

4. SCOPE. This AC provides guidelines for design approval of aircraft systems that provide the data communications function and applications on the aircraft. The data communications function and applications on the aircraft communicate digital data with the ground computer systems managed by air traffic, a service provider, or an aircraft operator. Digital data are exchanged between the aircraft and the ground systems and are used to display or print information to the flightcrew or controller or directly interface with other computer applications, such as flight planning and navigation, on the aircraft and surveillance on the ground. The aircraft systems that provide this capability will be referred to throughout this AC as aircraft data communications systems and applications. This AC considers the following:

a. Evolutionary development. The guidelines contained in this AC are applicable to all aircraft data communications systems and applications, even those that may not be compatible with the ICAO aeronautical telecommunication network (ATN). Therefore, this AC provides for the data communications technology to evolve within the national airspace system (NAS) and international airspace during operational service without compromising safety, while at the same time it provides the flexibility to migrate to ATN-compatible data communications systems.

b. Data communications applications. Guidelines provide for the addition and modification of data communications applications and minimize the evaluation of the data communications system. Data communications systems and applications that use protected navigation frequencies, such as for delivery of differential global positioning system (DGPS) information, are beyond the scope of this AC and will be addressed in documents providing guidance for design approval of navigation functions. Examples of data communications applications are controller-pilot data link communications (CPDLC) for pilot-controller communication, automatic dependent surveillance (ADS), pre-departure clearance (PDC), oceanic clearance, automatic terminal information service (ATIS), weather services, ATS facilities notification (AFN) for the ACARS, and context management for ATN.

c. Data communications system subnetworks. Guidelines provide for the data communications system to use a variety of air/ground subnetworks, including satellite, very high frequency (VHF) radio, high frequency (HF) radio, Mode S, and gatelink.

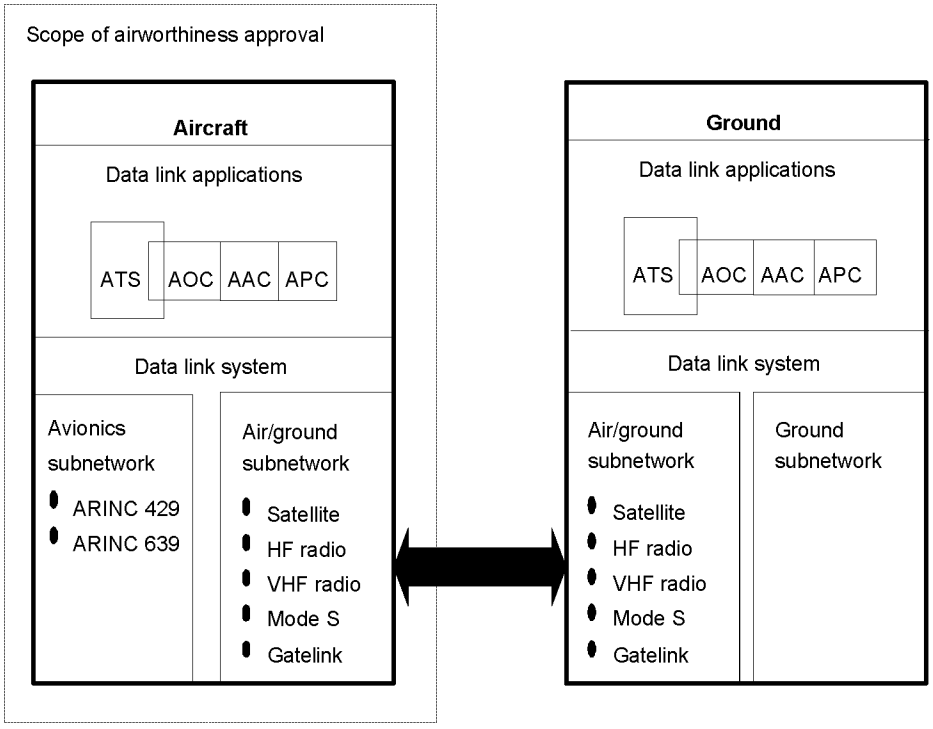
d. Institutional considerations. Different parts of the data communications system and applications are controlled by different organizations. For example, within the FAA, the Aircraft Certification Service is responsible for design approval, whereas the Flight Standards Service is responsible for operational authorization. In some cases, a foreign civil air authority (FCAA) will be responsible for operational authorization. Other organizations, some non-Federal, are responsible for commissioning the air/ground subnetwork, ground data communications system, and ground applications.

e. International implications. The Aircraft Certification Service is coordinating these guidelines for design approval of aircraft data communications systems and applications with FCAA. We intend to harmonize the airworthiness criteria contained within this AC.

NOTE: This AC discusses the operational concepts of data communications applications and the NAS only to describe the relationship of the design approval of aircraft data communications systems and applications with the commissioning of ATS facilities and operational authorizations. This information should not be misinterpreted as guidance for obtaining an operational authorization to use ATS data communications applications or for commissioning ground and space segments of the data communications system and applications. This AC only provides guidance for obtaining design approval of the aircraft data communications system and applications.

5. OVERVIEW OF THE DATA COMMUNICATIONS SYSTEM AND APPLICATIONS. This paragraph provides an overview of the data communications system and applications as shown in figure 1.

Figure 1: OVERVIEW OF THE DATA COMMUNICATIONS SYSTEM AND APPLICATIONS



The overview provides the framework and terminology necessary to provide guidelines for design approval of the aircraft functions and associated systems, which follow in subsequent paragraphs. The definitions of terms and acronyms used in this AC are contained in appendix 2.

a. General. The aircraft data communications system and applications are shown separate from the ground data communications system and applications to provide for the different approval processes and organizations associated with each part of the overall data communications system and applications. The distinction between the data communications system and applications provides for integrating new or modified applications into an existing data communications system.

b. Data communications system. The data communications system comprises the data communications system on the aircraft, at least one of the air/ground subnetworks, and the ground data communications system. The data communications system supports the data communications applications.

c. Data communications applications. The data communications applications rely on the data communications system and provide functions comprising the aircraft and ground elements. Examples of these functions include CPDLC communications between the flightcrew and the air traffic controller and ADS, which RTCA defines as separate ATS applications. Figure 1 depicts ATS applications and AOC applications as overlapping boxes to indicate that some ATS applications, such as PDC, may be supported by an operator's AOC facility. Otherwise, ATS applications are provided by an air traffic facility and are referred to as air traffic control (ATC) applications. ATC applications, AOC applications, AAC applications, and aeronautical public correspondence (APC) applications are mutually exclusive.

d. Relationship to industry, federal, and international standards. The overview is consistent with industry, federal, and international standards. For example, RTCA, Inc. is developing a family of minimum operational performance standards (MOPS) for aircraft data communications applications, a family of MOPS's for the air/ground data communications subnetworks, and a MOPS for the interface between the aircraft data communications applications and the air/ground subnetworks.

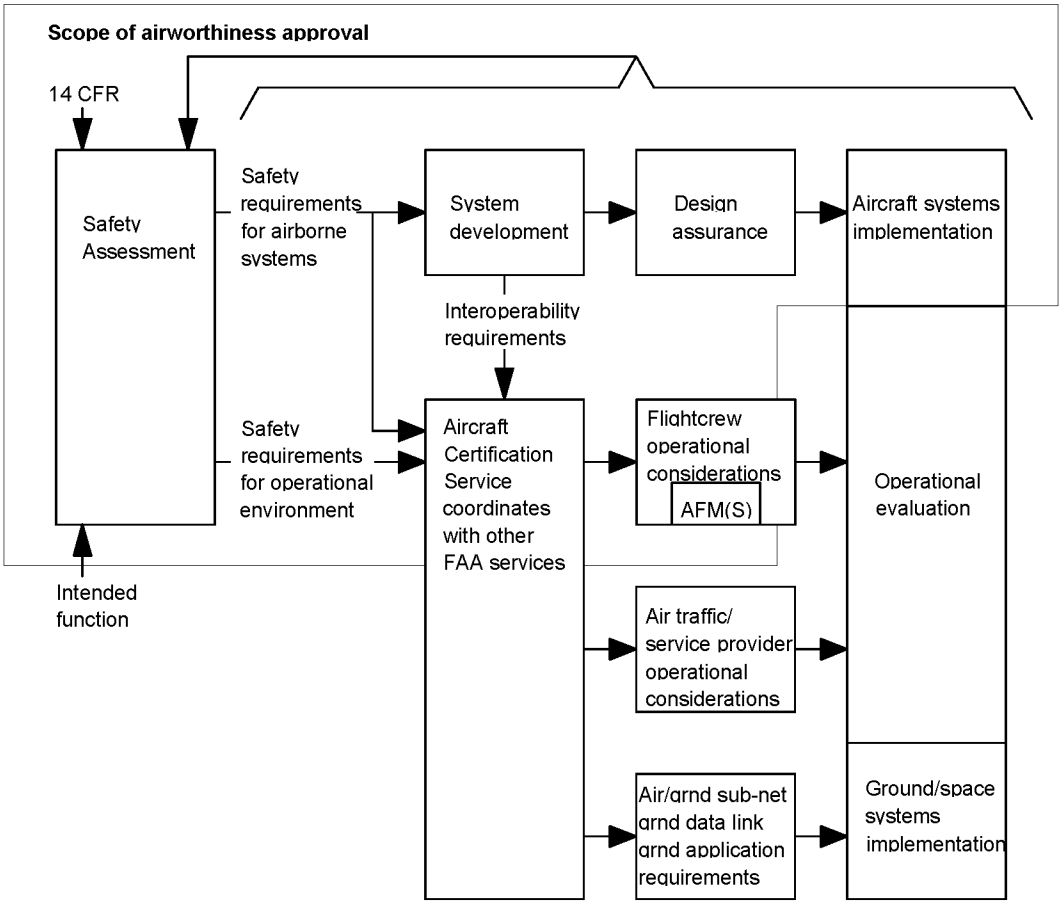
6. PLANNING FOR DESIGN APPROVAL. Planning for design approval is an interactive process between the FAA and the applicant. As such, applicants should conduct technical specialists' meetings and submit drafts of the certification plan to the ACO throughout the planning process to minimize the risk of certification issues at the end of the planning process. The applicant should obtain agreement with the certification authority on the certification plan, which defines the means by which the applicant will show that the aircraft data communications system and applications comply with airworthiness requirements.

a. Overview. Figure 2 is intended to emphasize the activities of the design approval process as they relate to data communications systems and applications and shows the inter-relationships among the activities. These activities consist of:

(1) Conducting a safety assessment.

(2) Validating the safety requirements established by the safety assessment.

Figure 2: OVERVIEW OF THE DESIGN APPROVAL PROCESS



(3) Validating the requirements for the aircraft data communications system and applications.

(4) Validating the interoperability requirements.

(5) Ensuring that the implementations provided by the aircraft systems meet the requirements for the aircraft data communications system and applications.

(6) Evaluating flightcrew operations and flight manual provisions.

b. Safety assessment. The applicant conducts a safety assessment to examine aircraft level functions, identify potential hazards, and classify related failure conditions considering the operational environment. The operational environment includes the air/ground subnetwork, the ground data communications, the ground applications, and operational aspects. The safety assessment determines the safety requirements for the aircraft data communications system and the applications in the context of the safety requirements established for the operational environment. Therefore, the safety assessment may allocate requirements to the operational environment to substantiate the classification of failure conditions and to substantiate that the failure conditions are adequately precluded. For the aircraft systems, the safety assessment interacts with the development processes to validate the safety requirements allocated to aircraft systems and to ensure that the aircraft implementation satisfies its requirements.

c. Interoperability. The interoperability requirements define the operational environment which ensures the aircraft data communications applications, the data communications system, and the ground applications are compatible. For the aircraft systems, the validation and verification activities performed during system development need to validate the interoperability requirements allocated to the aircraft systems and ensure that the aircraft implementation satisfies its requirements.

d. Validation of safety and interoperability. The applicant seeking design approval needs to identify the safety and interoperability requirements because the applicant cannot ensure that the operational environment satisfies its requirements, which is beyond the scope of the design approval. The Aircraft Certification Service will coordinate the safety and interoperability requirements provided by the applicant with the appropriate FAA organizations to validate the requirements allocated to the operational environment and to ensure that the operational environment satisfies its requirements.

e. Certification plan. When planning for design approval, the applicant should provide the following:

(1) Description. Describe the aircraft data communications system, the applications, and their interface with other systems and functions on the aircraft. Describe the operation (e.g., human/machine interface) and the flight deck arrangement. See also the guidelines contained in paragraph 9 of this AC.

(2) Safety assessment. Define the safety assessment activities and their interrelationships with other activities within the design approval process. See also the guidelines contained in paragraph 7 of this AC.

(3) Safety and interoperability requirements. Define the means to identify safety requirements for the aircraft systems and for the operational environment and the interoperability requirements. In addition to the following, see also the guidelines contained in paragraph 8 of this AC.

(a) To facilitate the coordination process within the FAA, the applicant is encouraged to submit the safety and interoperability requirements in electronic media format acceptable to the ACO. The ACO will need to coordinate the safety and interoperability requirements with the Aircraft Engineering Division of the Aircraft Certification Service prior to design approval of the aircraft data communications system and the applications. The Aircraft Engineering Division will coordinate with other organizations responsible for approval of different parts of the data communications system, the applications, and the authorization to use those applications, as necessary, to substantiate the validity of safety requirements and to ensure the feasibility of interoperability requirements.

(b) The users of the data communications applications will use the safety and interoperability requirements to facilitate operational authorization. The safety and interoperability requirements will also determine the level necessary to substantiate subsequent changes to the air/ground subnetwork, ground data communications system, and ground applications, including networks and applications provided by non-FAA service providers and other certification authorities. Additional substantiation may be necessary to support operational authorization to ensure the design approval of the aircraft data communications system and the applications is not compromised.

(4) Validation of requirements. Describe the means for validating the requirements for the aircraft data communications system and the applications and the safety and interoperability requirements for the operational environment.

(5) Design assurance for aircraft systems. Describe the means for ensuring that the implementations provided by the aircraft systems satisfy the requirements for the aircraft data communications system and the applications.

(a) Development processes. Define the development processes, including the supporting processes, how the applicant will coordinate with the certification authority throughout certification, and the interrelationships among processes.

(b) System development environment. Define the system development environment, including the methods and tools to be used during the system design, development, and safety assessment processes. If tools are used to replace verification and validation activities, define the means by which the tools will be qualified.

(c) Standards and guidelines. Specify international, national, corporate, or project standards that will be used to support the selection of valid functional requirements and verifiable design implementations.

(d) Consideration of design errors. Define the methods used for considering errors in the aircraft system design (for example, architectural means, safety directed life cycle, systematic approach to systems development, exhaustive input testing, service experience). Also, define the acceptance criteria for each of the techniques used. Define the means that will protect the more critical functions from the malfunction or failure of less critical functions.

(e) Consideration of random failures. Define the methods used to allocate the reliability requirements to the various parts of the aircraft systems. The methods used for meeting those requirements should also be defined (for example, probability analysis of failure rates).

(f) User-modifiable, option-selectable functions. If the aircraft data communications system or its applications are designed to be modified (e.g., user-selectable options or partitioned user-modifiable software) without a re-evaluation for airworthiness, then define the means (for example, processes, design features, environment, tools, certification data) by which the safety requirements, as determined by the safety assessment, will be ensured throughout the service life of the system and means by which the configuration of these features will be managed.

(g) Certification data. Define the means for providing evidence showing that the aircraft data communications system and applications comply with airworthiness requirements. Describe how certification data will be packaged, in what form, and how certification data are made available to the certification authority. For example, the certification plan may provide an overview of the processes and refer to other documents that define the processes.

(h) Process assurance. Describe the involvement of the designated engineering representative (DER) and the FAA certification engineer that is necessary throughout the certification process to ensure that the certification plan complies with the guidelines contained herein and that the actual processes comply with the certification plan or its references.

(6) Flight and ground tests and flight manual provisions. Define the objectives and acceptance criteria for flight and ground tests. The flight and ground tests should include tests to validate the aircraft data communications system and applications in the context of the safety and interoperability requirements and to check for adverse effects on other aircraft systems and functions.

Provide a proposed flight manual or flight manual supplement. See also the guidelines contained in paragraphs 10 and 11 of this AC.

7. SAFETY ASSESSMENT CONSIDERATIONS. The applicant should consider the following guidelines for conducting safety assessments for design approval of aircraft data communications systems and applications. Appendix 3 contains an example of a partial safety assessment.

a. General. The safety assessment should consider the effects of failures and design errors introduced by the aircraft systems and external sources. Assumptions made about the operational environment to substantiate the effects of failures and design errors introduced by external sources should be identified as safety requirements (See paragraph 8 of this AC). AC 25.1309-1A, System Design Analysis, for transport category airplanes; AC 23.1309-1A, Equipment, Systems, and Installations in Part 23 Airplanes, for normal, utility, acrobatic, and commuter category airplanes; AC 27-1, Certification of Normal Category Rotorcraft, for normal category rotorcraft; and AC 29-2A, Certification of Transport Category Rotorcraft, for transport category rotorcraft, provide acceptable means for showing that hardware complies with § xx.1309 of 14 CFR parts 23, 25, 27, and 29, respectively. AC 20-115B, Software Design Considerations (RTCA DO-178B), provides an acceptable means for showing that the software complies with §§ xx.1301 and xx.1309 of 14 CFR parts 23, 25, 27, and 29. These ACs provide criteria for determining, classifying, and evaluating failure conditions of aircraft level functions (e.g., ATS applications) which result from malfunction or loss of function. They also provide criteria for evaluating failures or design errors of the data communications system which could contribute to failure conditions of other functions.

b. Loss of aircraft data communications applications. The safety assessment should determine the impact of loss of each aircraft data communications application. In general, the loss of aircraft data communications applications produces minor failure conditions provided the safety requirements have been properly allocated to the aircraft systems and/or operational environment. For example, loss of two-way data communications used for ATM may have minor effects provided the operational authorizations continue to require alternative communications systems that meet current operating rules. For example, 14 CFR part 121 requires HF transceivers in oceanic and remote areas and VHF transceivers in domestic airspace for pilot-controller voice communications.

c. Effects of undetected errors in aircraft data communications applications. The safety assessment should identify and classify failure conditions for the data communications applications. In general, undetected errors in ATS applications produce major failure conditions, unless otherwise substantiated by the safety assessment. The safety assessment should consider ATS messages received out of sequence, errors in the ATS message address, and errors in ATS messages. The safety assessment should allocate safety requirements to the aircraft systems and/or operational environment to ensure adequate protection from undetected errors in aircraft data communications applications caused by the effects of hardware or software design errors, hardware failures, and environmental conditions, such as electromagnetic interference. See also the guidelines contained in sub-paragraphs 8c(1), 8c(4), and 9f of this AC.

(1) For example, the applicant conducts an analysis using message length and bit error rate of the data communications system to determine the safety requirements for the data communications system and applications. Based on the analysis, the applicant determines that the end systems require an integrity check on ATS messages to show that a message with an undetected error is improbable (e.g., $< 10^{-6}$ per message).

(2) The end systems refer to the system that host the ATS application that originates the message and the system that hosts the associated ATS application that uses the ATS message. Additionally, the intermediate systems must not interfere with the integrity check performed by the end systems.

d. Human/machine interface on the flight deck. When assessing the failure conditions for aircraft data communications applications, the safety assessment should take into account the adequacy of the human/machine interface, including accessibility and viewing of controls, annunciations, displays, and printers and the effect on crew workload and head-down time. The safety assessment should consider the effects of flightcrew (procedural) errors determined by the pilot community.

e. Aircraft integration aspects. The following guidelines apply to integrating the data communications application into the data communications system and into the aircraft:

(1) As data communications applications are integrated into the aircraft, the safety assessment should identify and substantiate the areas affected by the introduction of the new data communications application. This may be achieved by conducting an analysis on the interaction of the aircraft data communications application with the aircraft data communications system and with other functions on the aircraft.

(2) The safety assessment should determine that the data communications system is capable of satisfying the safety requirements allocated to each data communications application.

(3) If the aircraft data communications system and applications are integrated with other systems on the aircraft, such as a flight management system, flight guidance system, navigation display, or radar display, then the safety assessment should consider failure conditions of other functions. For example, if an aircraft ATS application interfaces with the flight management system to automatically load a flight plan received from a ground application, then the applicant should consider in the safety assessment the effects of an incorrect flight plan caused by the effects of hardware or software design errors, hardware failures, and environmental conditions, such as electromagnetic interference.

(4) Failures of the aircraft data communications system and applications should not adversely affect other installed aircraft equipment. For example, other aircraft systems which interface with the data communications system should not be disrupted by excessive numbers of messages, messages with improper format, or erroneous data, all of which could be generated by the data communications system. The validity of this protection can be established by test and/or analysis of worst case conditions.

8. SAFETY AND INTEROPERABILITY REQUIREMENTS. Safety and interoperability requirements are necessary to ensure continued safety and interoperability for aircraft data communications systems and applications in accordance with the respective § xx.1529 of 14 CFR parts 23, 25, 27, and 29. The safety and interoperability requirements are used to define the operational environment in which the aircraft data communications system and applications are intended to operate. The applicant should specify the safety and interoperability requirements in terms of performance, integrity, and availability requirements allocated to each part of the data communications system and applications and minimize the specification of requirements in terms of operational uses. This will provide flexibility to authorize the use of the data communications system and applications for different purposes without the need to revise the safety and interoperability requirements, which are part of the design approval. Instead, safety and interoperability requirements should provide information to determine the level necessary to substantiate different uses of the data communications system and applications within the defined operational environment as part of the operational authorization. However, in cases where the proposed use is outside the operational environment as defined by the safety and interoperability requirements, the original design approval should be amended. The applicant should consider the guidelines contained in

this paragraph when developing the safety and interoperability requirements. Appendix 4 contains an example of safety and interoperability requirements.

a. Distribution. Include a list of the types of organizations expected to consider the safety and interoperability requirements. Since the list may change after initial design approval, this list may be maintained separate from the safety and interoperability requirements. The list should include:

(1) Certification authority(ies) responsible for operational authorization to use the data communications system and applications.

(2) Certification authority(ies) responsible for design approval of the data communications system and applications.

(3) Air traffic service(s) responsible for developing operational and system requirements for ground/space data communications systems and the ground applications and ensuring their implementation.

(4) Airway facilities service(s) responsible for ground/space system commissioning.

(5) Service provider(s) responsible for providing ground-ground and air/ground communications services.

(6) Operators intending to use data communications application(s).

b. Revision history. Include a list of changes to the safety and interoperability requirements. A revision history is not applicable to the initial safety and interoperability requirements.

c. Safety requirements. Include safety requirements that were established by the safety assessment.

(1) Aircraft systems. Include safety requirements allocated to each of the parts of the aircraft systems.

(2) Flightcrew, service provider, and air traffic operational considerations. Include operational assumptions that were used to substantiate the classification of the effects of errors in ATS applications during the safety assessment process. These assumptions include safety requirements for procedures for the flightcrew, air traffic controller, or other ground operators. For example, include operational requirements (i.e., safety requirements) that check message integrity, as determined by the safety assessment, and include operational requirements (i.e., interoperability requirements) to control the configuration of user modifiable systems and option selectable functions.

(3) Airspace assumptions. Include assumptions about the airspace system to substantiate the effects of errors in ATS applications during the safety assessment process. For example, include assumptions about separation standards used to substantiate the time necessary for the air traffic controller to take corrective action in the event the data communications system or the ATS applications induce an undetected error in a change clearance to the flightcrew.

(4) Air/ground subnetwork, ground data communications, and ground applications. Include safety requirements that are allocated to the air/ground subnetwork, ground data communications, and ground ATS applications during the safety assessment to substantiate the effects of errors in data communications ATS applications.

d. Interoperability requirements. Reference industry, federal, and international standards, where applicable, to describe the requirements necessary to ensure that the aircraft systems will operate with the ground systems. If the standards allow for selection of options and/or features, then identify which features and options will be implemented. If standards are not available for the data communications system or applications, then identify the requirements necessary to ensure interoperability. If the data communications system or applications are not entirely in compliance with interoperability requirements available in industry, federal, and international standards, then identify the exceptions to such standards.

e. Performance of the data communications system and applications. Include performance criteria, such as message delivery time and message processing capacity, for the data communications system and the applications. Specify any constraints on the operational environment that may be necessary to maintain the performance criteria.

f. Verification of interoperability and performance. Provide a means to verify that the aircraft data communications system and applications perform their intended function. The means should ensure compatibility between the aircraft systems and a representative ground system and that the performance criteria are satisfied. The means should provide a level of verification coverage commensurate with the integrity required for the data communications application as determined by the safety assessment.

NOTE: This verification means is intended to minimize the certification effort associated with integrating the applications and/or the data communications systems in aircraft with different configurations, such as different ACARS configurations, and to facilitate the operational authorization to use data communications applications.

g. Provisions for in-service evaluations. Provide a means to track the development of the system in operation and report in-service problems to the applicant for evaluation, as necessary.

9. DESIGN CONSIDERATIONS FOR AIRCRAFT DATA COMMUNICATIONS SYSTEMS AND APPLICATIONS. This paragraph provides guidelines for the design of aircraft data communications systems and applications.

a. Interoperability requirements. The aircraft data communications system and applications should be compatible with the non-aircraft parts of the system. Compatibility can be achieved through the use of interoperability requirements contained in industry, federal, and international standards. Once the interoperability requirements contained in these standards have been validated, they need not be revalidated for each implementation. However, interoperability requirements that are unique to the applicant's design for the aircraft systems and exceptions to industry, federal, and international standards should be validated on a case by case basis. In all cases, the applicant should ensure that the implementation provided by the aircraft systems satisfy the interoperability requirements for the aircraft systems.

NOTE: Currently, the FAA does not formally recognize the validity of any interoperability requirements contained in industry, federal, and international standards. The standards identified in the sub-paragraphs that follow will be validated in conjunction with the initial design approvals for data communications systems and applications. Applicants should contact the Aircraft Engineering Division for the status pertaining to the validity of these standards.

b. Aircraft data communications system. The data communications system provides for the transport of application data between the aircraft applications and the ground applications. The aircraft data communications system is the avionics subset of the data communications system. The design of the

aircraft data communications system should be compatible with the aircraft applications, the air/ground subnetwork, the ground data communications system, and the ground applications. The following standards provide interoperability requirements for the data communications system:

(1) Aeronautical Radio, Inc. (ARINC) Specification 622 defines an ACARS convergence function, which allows bit-oriented applications to be supported by the ACARS network, which is character-oriented. ARINC Specification 618 defines the message protocols for the ACARS network. ARINC Specification 620 defines addressing, message protocols, and message formats for the ACARS network. ARINC Characteristic 724B defines the operation of the aircraft ACARS. The ACARS air/ground subnetwork may be either VHF or satellite.

(a) VHF. The VHF protocols are in ARINC Specification 618.

(b) Satellite. The satellite protocols are in ARINC Characteristic 741.

(2) The ICAO ATN Manual, second edition, defines the transport and network protocols which support bit-oriented applications for data communications systems planned to succeed those based on ARINC 622. Industry has developed standards for air/ground subnetworks to support the ATN.

(3) ICAO Doc 9705/Amd 1 effectivity date 5 November 1999 defines air-ground applications (Controller-Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance (ADS), Flight Information Service (FIS), Automatic Terminal Information Service (ATIS), and Context Management (CM)), ground-ground applications (ATSMHS (Air Traffic Services Message Handling Services)), and Aeronautical Interfacility Data Communication (AIDC)), Upper Layer Communications Service, Transport and Network Layer Protocols

(a) VHF. ARINC Specification 631 defines the protocol for an aviation VHF packet communications (AVPAC) protocol. ARINC Characteristic 750 defines the modulation characteristics for AVPAC. The ICAO standards and recommended practices (SARPs) for VHF data link (VDL) will describe the international standards for VDL signal-in-space.

(b) Satellite. RTCA DO-210 provides MOPS for Aeronautical Mobile Satellite Services (AMSS).

(c) Satellite. RTCA DO-215 provides the guidance on AMSS end-to-end system performance.

(d) Mode S. RTCA DO-218 provides MOPS for data communications systems that use Mode S. Mode S transponders that are intended for use by the data communications system should meet the requirements for a level 3 transponder.

(e) HF data communications. AEEC Project Paper 653 describes the protocols for an HF data link (HFDL).

(f) Gatelink. ARINC Characteristic 751 describes the protocols and interfaces for data communications systems that use a gate/aircraft terminal environment subnetwork.

c. Aircraft data communications applications. The design of the aircraft data communications applications should be compatible with the aircraft data communications system, the air/ground subnetwork, the ground data communications system, and the ground applications. Industry has developed standards for the following data communications applications:

(1) Automatic dependent surveillance (ADS). RTCA DO-212 provides MOPS for ADS. ICAO Document 9705 defines the ADS service using the ATN.

(2) Two-way data link (TWDL). RTCA DO-219 provides MOPS for TWDL for pilot-controller communications.

(3) ATS facilities notification (AFN). ARINC Characteristic 622 provides standards for AFN in an ACARS environment.

(4) Pre-departure clearance (PDC). ARINC Characteristic 622 provides standards for PDC in an ACARS environment.

(5) Automatic terminal information service (ATIS). ARINC Characteristic 622 provides standards for ATIS in an ACARS environment. ICAO Document 9705 defines the ATIS service using the ATN.

(6) Waypoint position reports. ARINC Characteristic 702, Supplement 5, provides standards for waypoint position reports in an ACARS environment.

(7) Controller Pilot Data Link Communications. ICAO Document 9705 defines the CPDLC service using the ATN.

(8) Flight Information Service. ICAO Document 9705 defines the FIS service using the ATN.

(9) Context Management. ICAO Document 9705 defines the CPDLC service using the ATN.

d. Environmental qualification for the aircraft data communications system and applications. The hardware for the aircraft data communications system and applications should be qualified to the appropriate sections of RTCA D0-160D or as determined by the certification basis and the original means of compliance for the particular aircraft. The environmental qualifications should be compatible with the environment in which the equipment is installed.

e. Software qualification for the aircraft data communications system and applications. Applicants should use AC 20-115B (RTCA DO-178B) to show that the software aspects of the aircraft data communications system and applications comply with applicable airworthiness requirements. For software developed prior to the availability of RTCA DO-178B, Section 12.1.4 of RTCA DO-178B provides applicants with a method for upgrading a baseline for software development so that changes can be made in accordance with the criteria contained in RTCA DO-178B.

(1) The applicant should substantiate software levels in the safety assessment. However, in lieu of substantiating software level(s) in the safety assessment, the applicant may develop software whose anomalous behavior contributes to failure conditions of ATS applications to at least the Level C criteria, as defined in RTCA DO-178B.

(2) The local ACO may grant a deviation to TSOs, where applicable, for TSO applicants who request to use RTCA DO-178B.

(3) If the applicant uses RTCA DO-178A, such as in accordance with a TSO authorization, the applicant seeking installation approval may need to further evaluate features of the software. RTCA DO-178A does not address some applications of digital technology commonly found in aircraft data communications systems and applications. For example, use of user-modifiable software, including data bases, use of option-selectable software, use of software development and verification tools, use of

previously developed software in modular architectures, and use of field loadable software capabilities. In these cases where RTCA DO-178A is not adequate, the applicant should include, in the software aspects of certification plan, the means for showing that these features comply with applicable airworthiness requirements. One acceptable means for showing that the unique features comply with applicable airworthiness requirements is to meet pertinent portions of the criteria contained in RTCA DO-178B, which would supplement the basic criteria contained in RTCA DO-178A.

f. Aircraft data communications application integrity. The end systems should provide a means to check the integrity of messages that are originated and used by the ATS applications. The means should be commensurate with the integrity required for the aircraft applications as determined by the safety assessment. The aircraft systems should not process messages that fail the integrity check for flightcrew interaction.

g. Recording of data communications messages for accident investigation. For design approvals issued in accordance with this AC, the FAA will not require the recording of data communications messages on the aircraft for accident investigation. However, ATS messages should include the time the messages are sent by the flightcrew to the nearest second using the same time reference used by the flight data recorder (FDR) and cockpit voice recorder (CVR). The Aircraft Certification Service is planning to initiate appropriate action to determine the requirements for recording data communications messages for accident investigation.

h. Data communications message priority and urgency. Message priority refers to the communication protocol priorities required by the International Telecommunications Union (ITU) radio regulations and determines the implementation requirements for ATN compliant data communications systems. Message urgency refers to the processing of data communications messages by the end systems according to their relative importance, which is defined by the RTCA MOPS for the data communications application. The applicant should consider the following guidelines:

(1) Communication priorities are used to manage queues that may occur within the data communications system that provides the connectivity between aircraft and ground applications. A single communication priority level may support multiple categories of application message traffic. For example, AOC applications and ATS applications share the use of a range of communication priorities. Table 1 shows categories of data communications messages together with their corresponding communication protocol priority assignment and applies to data communications systems that use the ATN. ICAO and RTCA standards are derived from ITU and are consistent with the communication protocol priority as shown in table 1.

(2) The aircraft data communications system and applications should process ATS messages consistent with their relative importance. For example, the aircraft data communications system may need to interrupt its processing of a lengthy less important message upon receipt of a more important message to process the more important message.

(3) The aircraft data communications system and applications should process ATS messages of equal importance in the sequence that they were received by the aircraft data communications system.

i. Human/machine interface on the flight deck. The guidelines for the human/machine interface apply to data communications applications that require human/machine interface on the flight deck. The human/machine interface should be consistent with the crew interface and flight deck design of the particular aircraft in which the data communications system and applications are installed.

j. Flight deck annunciation. The annunciation for the aircraft data communications system and applications should comply with the following criteria, and should be integrated into the aircraft's existing alerting scheme.

(1) An aural and visual alert should be provided for each uplink ATS message unless otherwise substantiated by the safety assessment, including those that may not be immediately displayed because they have not yet acknowledged receipt of an earlier ATS message. Visual alerts alone may be used for non-ATS messages.

(2) The system should be capable of alerting the flightcrew of probable aircraft system failures.

(3) The system should provide the status of the data communications system to the flightcrew (e.g., loss of the data communications connection).

(4) If message storage and/or printing capability is provided, the system should alert the flightcrew when storage and/or printing is not possible.

(5) Aural annunciations indicating the receipt of a data communications message during critical flight phases (e.g., takeoff and landing) should be suspended until after the critical flight phase. The criteria that defines critical flight phases should be consistent with the particular flight deck philosophy.

Table 1. *COMMUNICATION PROTOCOL PRIORITIES FOR ATN-COMPLIANT DATA COMMUNICTIONS SYSTEMS*

Application	Category of message	Corresponding communication protocol priority					
		Transport	Network			Subnetwork	
		COTP or CLTP	IDRP	ES-IS	CLNP	Mode S	AMSS
ATN	Network/systems management	0	Normal	14	14	High	14
ATS/AOC	Distress communications	1	N/A	N/A	13	High	14
	Urgency communications	2	N/A	N/A	12	High	14
	Communications relating to direction finding	3	N/A	N/A	11	High	11
	Flight safety messages	4	N/A	N/A	10	High	11
	Meteorological communications	5	N/A	N/A	9	Low	8
	Flight regularity communications	6	N/A	N/A	8	Low	7
	Aeronautical information service messages	7	N/A	N/A	7	Low	6
ATN	Network/systems administration	8	N/A	N/A	6	Low	5
ATS/AOC	Aeronautical administrative messages	9	N/A	N/A	5	Low	5
	<unassigned>	10	N/A	N/A	4	Low	5
AAC/APC	Urgent priority administrative and United Nations charter communications	11	N/A	N/A	3	Low	3
	High priority administrative and state/government communications	12	N/A	N/A	2	Low	2
	Normal priority administrative	13	N/A	N/A	1	Low	1
	Low priority administrative	14	N/A	N/A	0	Low	0

NOTE 1: **Table 1** is derived from the ICAO Document 9705.

NOTE 2: Communication protocol priority is not applicable to the VHF subnetwork.

NOTE 3: Typical AOC messages fall within the Flight Safety and Flight Regularity categories.

NOTE 4: COTP—Connection oriented transport protocol.
CLTP—Connectionless transport protocol.
IDRP—Inter-domain routing protocol.
ES-IS—End system-intermediate system
CLNP—Connectionless network protocol.
AMSS—Aeronautical mobile satellite system
N/A—Not applicable.

k. Flight deck control capability. Control capability for the aircraft data communications system and applications should meet the following criteria:

(1) A means should be provided for the flightcrew to positively acknowledge receipt of ATS messages intended for the flightcrew. The system should allow the flightcrew to respond with their intended action, for example, using ROGER, WILCO, or UNABLE, as required by the application.

(2) A means should be provided for the flightcrew to list, select, and retrieve the most recent (approximately ten) ATS messages received and sent by the flightcrew during the flight segment together with their status (e.g., NEW, WILCO, UNABLE, SENT) and the time the ATS messages were received or sent.

(3) A means should be provided for the flightcrew to clear uplink messages from the display. ATS messages that are displayed for flightcrew acknowledgment should remain displayed until acknowledged or until the flightcrew selects another display. ATS uplink messages may be automatically removed from the display after flightcrew acknowledgment.

(4) A means should be provided for the flightcrew to recognize messages that exceed the readable display area and read the messages using means such as scrolling or paging through the message.

(5) A means should be provided for the flightcrew to create, store, retrieve, edit, delete, and send messages.

(6) If the data communications application directly interfaces with other computer functions, such as flight planning and navigation, a means, other than acknowledging receipt of the data communications message, should be provided for the flightcrew to activate the computer function to use the digital data contained in the message.

l. Flight deck display capability. Display capability for the aircraft data communications system and applications should meet the following criteria:

(1) Messages should be understandable by the flightcrew (e.g., not coded and in English).

(2) The flightcrew should be able to read displayed messages without leaving their seats.

NOTE: Certain ATS and weather data communications services such as PDC, ATIS, transfer of communication (TOC), altitude assignments, and initial contact (confirmation of assigned altitude) may be acceptable for flightcrew operations with a display located greater than 60 degrees off the pilot's forward line of sight provided readability and pilot acknowledgment response times are satisfactory. Tactical ATS messages in the terminal area that require short pilot acknowledgment response and execution times may require a display located in the pilots' primary field of view, or a display in a forward location readable by each pilot or by both pilots.

(3) ATS messages should be displayed to the flightcrew and remain displayed until acknowledged or the flightcrew selects another message or display format.

(4) ATS messages should be displayed so that each message is distinguishable. The status of each message should be displayed together with the message.

(5) When the aircraft data communications application is sharing a display with other aircraft functions, the aircraft data communications applications may override the display of the time shared function provided the flightcrew can return the display to the shared function. ATS aircraft data communications applications should not share a display with an aircraft function that is of equal or higher importance than the aircraft data communications application.

m. Flight deck print capability. A flight deck printer may be used as an acceptable means of providing storage of data communications messages received or sent during the current flight. If installed on the flight deck and used for storing data communications messages, it should have the following characteristics:

(1) The printer should be located in a position which does not require either of the pilots to leave his seat to access information and should be able to be serviced without lengthy distraction from other pilot tasks.

(2) A means should be provided for the flightcrew to selectively print any displayed or stored message.

(3) The printer should be capable of printing any data communications message selected by the flightcrew.

(4) The printer quality should be equivalent to at least an ARINC 740 printer.

(5) The printer should accommodate the maximum length message.

(6) The paper capacity should preclude the need for frequent in-flight servicing.

10. GROUND AND FLIGHT TEST EVALUATION. The ground and flight tests for certification should evaluate the aircraft data communications system and applications in the context of the safety and interoperability requirements. Ground and flight tests should consider the following criteria:

a. Self test. Evaluate any self test features against the requirements specified by the manufacturer.

b. Performance of data communications system and applications. Evaluate the functional operation of the data communications applications and their feasibility for operational use. Evaluate message delivery times for uplink and downlink, long messages that require paging, receipt and acknowledgment of multiple uplink messages sent simultaneously from more than one source, and message queue capacities to the performance criteria specified in the safety and interoperability requirements.

c. Human/machine interface. Evaluate the data communications system installation for satisfactory identification, accessibility, and visibility. Evaluate the flight deck arrangement and operation of controls, displays, printers, circuit breakers, annunciators, alerts, and any placards of the data communications system and applications in day, night, and dusk conditions. Evaluate the human/machine interface to ensure that it is consistent with the flightcrew interface and flight deck design of the particular aircraft and the guidelines provided in this AC. Insert failure modes of the data communications system and the applications to evaluate aural and visual annunciations.

d. Operational considerations. Evaluate loss of the data communications system when the primary communication system is out of range (e.g., use of data communications applications in rotorcraft operating in the Gulf of Mexico and the primary means of communication is VHF voice radio). Evaluate operational procedures, such as a procedure to check message integrity, which may be required to

substantiate the classification of effects of failure conditions. Determine that the system provides a means of operation with acceptable effects on crew workload and without excessive reliance on memory for correct procedural steps.

e. System Integration. Evaluate the integration of the data communications system and applications with other systems, such as the flight management system (FMS), to ensure that the integration presents no hazard to existing systems on the aircraft and the data communications system and applications do not interfere with other systems. Evaluate the effects of electromagnetic interference to ensure the data communications system is compatible with existing systems on the aircraft.

11. AIRPLANE/ROTORCRAFT FLIGHT MANUAL (A/RFM) (SUPPLEMENT) WORDING. The A/RFM or A/RFM supplement should provide a description of all normal and submodes of system operation including what actions are expected by the flightcrew for each case. A reduction in the material addressed by the A/RFM or A/RFM supplement may be permitted for those cases where information is included in other related references, such as a flightcrew operating manual that is used by the operator as the basis for flightcrew qualification.

a. Operating Limitations. Operating limitations should be used to control the use of data link applications that are intended for evaluation in operational service or if an operating limitation would provide an alternative to satisfying the criteria contained in this AC. For example, although the printer is optional, a limitation that requires a printer would be appropriate for implementations where the flightcrew must rely solely on the printer to retrieve messages. Operating limitations are not necessary provided the data link system and applications have been shown to satisfactorily operate in the context of the safety and interoperability requirements. For example, operational procedures performed by the flightcrew, service provider, and air traffic controller may be used to substantiate use of the data link system in oceanic and remote areas as a means to compensate for the lack of integrity in the data link system. Those aspects of the procedures that provide the substantiation for such use in the safety assessment would be identified as safety requirements for the operational environment.

b. Operating Procedures. The normal and non-normal operating procedures of the A/RFM or A/RFM supplement should be consistent with and refer to the safety and interoperability requirements that were used to demonstrate the system. For example, "The FAA has approved the data link system and applications to the criteria contained in AC 20-140, dated July 16, 1999. This approval was based on the safety and interoperability requirements contained in (applicant's) (document title) (revision and/or date). This design approval does not constitute operational authorization."

12. CERTIFICATION SUMMARY. The applicant should submit a certification summary to provide the results of the activities proposed in the certification plan. Any deviation to the certification plan should be described in the certification summary together with rationale to substantiate the deviation. In addition to addressing each of the content items in the certification plan, the certification summary should include:

a. Statement of compliance. A statement indicating that the aircraft data communications system and applications in the context of the safety and interoperability requirements complies with airworthiness requirements

b. Open problem reports. A summary of the open problem reports and their impact on safety, airworthiness, operational requirements and any ICAO Document 9705 problem description reports implemented and/or submitted.

13. CERTIFICATION DATA. In addition to the certification data that may be necessary to satisfy the criteria contained in other Acs referenced in this AC or as negotiated in the certification plan, the applicant should provide the certification data contained in table 2. The presentation of the data items listed in the table is not intended to imply packaging of the data or form.

Table 2. *CERTIFICATION DATA*

Item #	Description of Data Item	Reference
1	Certification Plan	Paragraph 6
2	Safety Assessment	Paragraph 7 Appendix 3
3	Safety and interoperability	Paragraph 8 Appendix 4
4	Aircraft system requirements	Paragraph 9
5	Ground and flight test plan and procedures	Paragraph 10
6	Airplane flight manual wording	Paragraph 11
7	Certification summary	Paragraph 12

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Manager, Aircraft Engineering Division

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APPENDIX 1. *RELATED INFORMATION*

This appendix provides a list of sections of 14 CFR applicable to determine the certification basis for approving aircraft data communications systems and the applications. This appendix also provides references to advisory circulars (AC), technical standard orders (TSO), and industry documents that may be useful in determining the means for showing that the aircraft data communications system and the applications comply with the certification basis. These references are applicable to the means of compliance described herein only when specifically identified in the body of this AC or as negotiated during the certification planning process described in paragraph 6 of this AC. The appendix also lists industry activities, which are producing documents related to data communications systems, the applications, and their use.

1. Title 14 Code of Federal Regulations (CFR). The following sections of 14 CFR are applicable to the certification aspects of data communications systems and applications:

Description	14 CFR part 23	14 CFR part 25	14 CFR part 27	14 CFR part 29
Subpart C—Structure (Strength Requirements)				
General				
Loads.	§ 23.301	§ 25.301	§ 27.301	§ 29.301
Factor of safety.	§ 23.303	§ 25.303	§ 27.303	§ 29.303
Strength and deformation.	§ 23.305	§ 25.305	§ 27.305	§ 29.305
Emergency Landing Conditions				
General.	§ 23.561	§ 25.561	§ 27.561	§ 29.561
Subpart D—Design and Construction				
General.	§ 23.601	§ 25.601	§ 27.601	§ 29.601
Materials (and workmanship).	§ 23.603	§ 25.603	§ 27.603	§ 29.603
Protection of structure.	§ 23.609	§ 25.609	§ 27.609	§ 29.609
Subpart F—Equipment				
General				
Function and installation.	§ 23.1301	§ 25.1301	§ 27.1301	§ 29.1301
Flight and navigation instruments.	§ 23.1303	§ 25.1303	§ 27.1303	§ 29.1303
Miscellaneous equipment.	§ 23.1307	§ 25.1307	§ 27.1307	§ 29.1307
Equipment, systems, and installations.	§ 23.1309	§ 25.1309	§ 27.1309	§ 29.1309
Instruments: Installation				
Electronic display instrument systems	§ 23.1311	N/A	N/A	N/A
Arrangement and visibility.	§ 23.1321	§ 25.1321	§ 27.1321	§ 29.1321
Warning, caution, and advisory lights.	§ 23.1322	§ 25.1322	§ 27.1322	§ 29.1322
Instruments using a power supply.	§ 23.1331	§ 25.1331	N/A	§ 29.1331
Instrument systems.	N/A	§ 25.1333	N/A	§ 29.1333

APPENDIX 1. *RELATED INFORMATION (*Continued)

Description	14 CFR part 23	14 CFR part 25	14 CFR part 27	14 CFR part 29
Electrical Systems and Equipment				
General.	§ 23.1351	§ 25.1351	§ 27.1351	§ 29.1351
Electrical equipment and installations. (Storage battery design and installations.)	§ 23.1353	§ 25.1353	§ 27.1353	§ 29.1353
Distribution system.	N/A	§ 25.1355	N/A	§ 29.1355
Circuit protective devices.	§ 23.1357	§ 25.1357	§ 27.1357	§ 29.1357
Lights				
Instrument lights.	§ 23.1381	§ 25.1381	§ 27.1381	§ 29.1381
Miscellaneous Equipment	+	+	+	+
Electronic equipment.	§ 23.1431	§ 25.1431	N/A	§ 29.1431
Cockpit Voice Recorders	§ 23.1457	§ 25.1457	§ 27.1457	§ 29.1459
Flight recorders.	§ 23.1459	§ 25.1459	§ 27.1459	§ 29.1459
Subpart G—Operating Limitations and Information				
Operating Limitations				
Instructions for Continued Airworthiness	§ 23.1529	§ 25.1529	§ 27.1529	§ 29.1529
Markings and Placards				
General.	§ 23.1541	§ 25.1541	§ 27.1541	§ 29.1541
Airplane/Rotorcraft Flight Manual				
General.	§ 23.1581	§ 25.1581	§ 27.1581	§ 29.1581
Operating limitations	§ 23.1583	§ 25.1583	§ 27.1583	§ 29.1583
Operating procedures.	§ 23.1585	§ 25.1585	§ 27.1585	§ 29.1585

2. Advisory Circulars (AC). The following AC's may provide additional information to assist in the approval of data communications systems for certification:

a. AC 20-115B, RTCA, Inc., Document RTCA/D0-178B, dated January 11, 1993.

b. AC 23.1309-1A, Equipment, Systems, and Installations in Part 23 Airplanes, dated June 3, 1992, and Change No. 1, dated August 5, 1992.

c. AC 23.1311-1, Installation of Electronic Display Instrument Systems in Part 23 Airplanes, dated June 11, 1993.

d. AC 25.1309-1A, System Design and Analysis, dated June 21, 1988.

e. AC 25-11, Transport Category Airplane Electronic Display Systems, dated July 16, 1987.

APPENDIX 1. *RELATED INFORMATION (*Continued)

f. AC 27-1, Certification of Normal Category Rotorcraft, dated August 8, 1985, including Change 1, dated September 16, 1987 and Change 2, dated April 24, 1989.

g. AC 29-2A, Certification of Transport Category Rotorcraft, dated September 16, 1987, including Change 1, dated April 24, 1989.

3. FAA Technical Standard Orders (TSOs). The following documents are available for equipment approvals:

a. TSO-C31d, High Frequency (HF) Radio Communications Transmitting Equipment Operating Within the Radio Frequency Range 1.5-30 Megahertz, dated April 30, 1984.

b. TSO-C32d, High Frequency (HF) Radio Communications Receiving Equipment Operating Within the Radio Frequency Range 1.5-30 Megahertz, dated April 30, 1984.

c. TSO-C37d, VHF Radio Communications Transmitting Equipment Operating Within the Radio Frequency Range 117.975 to 137.000 Megahertz, dated September 23, 1992.

d. TSO-C38d, VHF Radio Communications Receiving Equipment Operating Within the Radio Frequency Range 117.975 to 137.000 Megahertz, dated September 23, 1992.

e. TSO-C112, Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated February 5, 1986.

f. TSO-C113, Multi-Purpose Electronic Displays, dated October 27, 1986.

4. RTCA, Inc. (RTCA) documents. The following documents are available from RTCA, Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, D.C. 20036-4001:

a. RTCA D0-160D, Environmental Conditions and Test Procedures for Airborne Equipment, dated July 29, 1997.

b. RTCA D0-178B, Software Considerations in Airborne Systems and Equipment Certifications, dated December 1, 1992.

c. RTCA D0-181A, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated January 14, 1992.

d. RTCA D0-205, Design Guidelines and Recommended Standards to Support Open System Interconnections for Aeronautical Mobile Digital Communications, Part 1 - Internetworking, dated March 21, 1990.

e. RTCA DO-210D, Minimum Operational Performance Standards (MOPS) for Aeronautical Mobile Satellite Services, dated January 16, 1996.

f. RTCA DO-212, Minimum Operational Performance Standards (MOPS) for Airborne Automatic Dependent Surveillance (ADS) Equipment, dated October 26, 1992.

APPENDIX 1. *RELATED INFORMATION (*Continued)

g. RTCA DO-215, Guidance on AMSS End-to-End System Performance, dated April 13, 1993.

h. RTCA D0-218, Minimum Operational Performance Standards for Mode S Aircraft Data Link Processor, dated August 27, 1993.

i. RTCA DO-219, Minimum Operational Performance Standards (MOPS) for Two-Way Data Link (TWDL) Communications, dated August 27, 1993.

j. RTCA DO-240, Minimum Operational Performance Standards (MOPS) for Aeronautical Telecommunication Network (ATN) Avionics, dated July 29, 1997.

5. Society of Automotive Engineers, Inc. (SAE) documents. The following documents are available from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096:

a. SAE Aerospace Recommended Practice (ARP) 926A, Fault/Failure Analysis Procedure.

b. SAE ARP 1834, Fault/Failure Analysis Guidelines for Digital Equipment.

c. SAE ARP 4101, Flight Deck Layout and Facilities.

d. SAE ARP 4102, Flight Deck Panels, Controls and Displays.

e. SAE ARP 4791, Human Engineering Recommendations for Data Link Systems.

6. International Civil Aviation Organization (ICAO) documents. The following documents are available from International Civil Aviation Organization, 1000 Sherbrooke Street W, Suite 400, Montreal, Quebec, Canada H3A2R2.

a. ICAO ANNEX 10 to the Convention of International Civil Aviation; Volume II.

b. ICAO ANNEX 10 to the Convention on Internation Civil Aviation; Volume III; Part I - Digital Data Communication Systems, Chapter 3, Aeronautical Telecommunication Network.

c. ICAO Circular 226-AN/135, Automatic Dependent Surveillance.

d. ICAO Doc 9524, FANS/4, Special Committee on Future Air Navigation Systems.

e. ICAO Doc 9578-AN/935, Second Edition, ATN Manual, dated November 19, 1993.

f. ICAO Doc 9705-AN/956, Manual of Technical Provisions for the Aeronautical Telecommunication Network.

7. Aeronautical Radio, Inc. (ARINC) documents. These documents are available from Aeronautical Radio, Inc., 2551 Riva Road, Annapolis, Maryland 21401-7465.

a. ARINC Specification 429-14, Mark 33 Digital Information Transfer System (DTIS), dated March 1993.

APPENDIX 1. *RELATED INFORMATION (*Continued)

b. ARINC Specification 618, Air-Ground Character Oriented Protocol Specification, dated January 1993.

c. ARINC Specification 619, ACARS Protocols for Avionic End Systems, dated December 1993.

d. ARINC Specification 620-1, Data Link Ground System Standard and Interface Specification, dated January 1994.

e. ARINC Specification 623-1, ATS Data Link Applications Over ACARS Air-Ground Network, dated November 1993.

f. ARINC Specification 631-1, Aviation Packet Communications Functional Description, dated January 1993.

g. ARINC Characteristic 702-4, Flight Management Computer, dated January 1993; and Supplement 5, dated February 1992.

h. ARINC Characteristic 724B-2, Aircraft Communications Addressing and Reporting System, dated November 1993.

i. ARINC Characteristic 740-1, Multiple-Input Cockpit Printer, dated June 1988.

j. ARINC Characteristic 741, Aviation Satellite Communication System, Part 1-5, dated March 1994; Part 2, dated July 1992; Part 2, Supplement 2, dated February 1994; Part 3, dated January 1994; and Part 4, dated May 1992.

k. ARINC Characteristic 745-2, Automatic Dependent Surveillance, dated June 1993.

l. ARINC Characteristic 751, Gate-Aircraft Terminal Environment Link (Gatelink) - Aircraft Side, dated January 1994.

m. ARINC Charactersitic 758, Communications Management Unit.

8. Other related material.

a. International Organization for Standardization (ISO) Standards; ISO 7498 - Basic Reference Model. This document can be obtained from the American National Standards Institute (ANSI), 11 West 42nd Street, New York, NY 10036.

b. International Telecommunication Union (ITU) Radio Regulations. This document may be obtained from the ITU in Geneva, Switzerland.

c. Air Transport Association of America (ATA) Information Transfer Subcommittee, Human Factors Requirements for Data Link, dated June 18, 1992.

9. Current industry and FAA activities. Industry and FAA are currently working technical issues and developing documents for recognition by the FAA in advisory material.

APPENDIX 1. *RELATED INFORMATION (*Continued)

The draft versions of these documents contain material relevant to data communications systems and applications. Relevant material has been included in the body of this AC to allow for timely implementation of data communications systems and the applications and to minimize the implications of applying these documents to follow-on design approvals.

The FAA intends to refer to these documents by reference only in future advisory material pertaining to the design approval of data communications systems and applications. This paragraph includes a summary of current industry activities.

a. Flight Standards Service is planning to issue two documents to implement recommendations of the C/SOIT. Draft AC 120.COM will provide criteria for operational authorization.

b. FAA/Joint Aviation Authority (JAA) 25.1309 Systems Design and Analysis Harmonization Working Group/ARAC Working Group is revising § 25.1309 of 14 CFR, the Joint Airworthiness Requirements (JAR) and associated AC 25.1309-1A and Advisory Material Joint (AMJ) 25.1309.

c. RTCA SC-189 and EUROCAE WG53 are developing guidelines for developing operational context, safety assessment, and performance requirements methodology for airborne data communications.

d. RTCA SC-180 and EUROCAE WG 46 are developing guidelines for airborne systems and equipment to address increased complexity in hardware designs resulting from micro-circuit technology. RTCA and EUROCAE are planning to develop design assurance techniques that will consider errors in hardware designs for avionics systems.

e. SAE Systems Integration Requirements Task Group (SIRT) is developing guidelines for systems development and supporting processes, which include the safety assessment, requirements validation, design verification, configuration management, process assurance, and certification.

f. SAE S-18 is developing a handbook which provides tools and detailed information on safety assessments.

APPENDIX 2. DEFINITIONS AND ACRONYMS

This appendix contains definitions of terms and acronyms used throughout this AC.

1. Definitions.

Aeronautical administrative communication (AAC). AAC applications are non-safety related services which include cabin services, seat assignments, passenger travel arrangements, and baggage tracing.

Aeronautical operational control (AOC). AOC applications provide safety related services for routine operational control which includes weather information, flight plans, company operational communications, and connecting flight information; emergency which includes in-flight emergency communications and special medical requests; and aircraft maintenance which includes the delivery of engine, avionics, and airframe information to expedite maintenance services.

Aeronautical public correspondence (APC). APC applications are non-safety related services which include voice (e.g., telephone) and data (e.g., facsimile and computer) communication services that passengers and crew can use to connect with ground based network subscribers worldwide.

Aircraft -level function. An aircraft-level function is defined by the functional requirements established from basic aircraft performance and operational requirements. For example, aircraft data communications applications satisfy operational requirements. The aircraft data communications system is a requirement that is derived from the aircraft data communications applications requirements and does not perform an aircraft-level function by itself.

Air traffic management (ATM). ATM applications include pilot/controller communications which include the operational communications between pilots and controllers, advanced ATM which includes air/ground digital data transfers supporting more efficient operations, and traffic flow management (TFM).

Air traffic services (ATS). ATS applications are divided into four categories: Air Traffic Management, Flight Information, Surveillance, and Navigation. The definitions of these categories are contained in this appendix.

Design approval. Design approval describes the process that an applicant and the certification authority use to substantiate that the aircraft data communications system and applications comply with airworthiness requirements appropriate for the certification authority (e.g., 14 CFR parts 21 through 29 if the certification authority is the Aircraft Certification Service within the FAA).

Availability. Although this AC does not use the term "availability" other than in its normal usage, it is defined here because it is used within the aviation community. Availability criteria refer to the criteria associated with loss of the function, system, and equipment. For example, the effects of indefinite loss of an ATS data communications application is classified during the safety assessment. Depending on design constraints and assumptions made about the operational environment, loss of an ATS data communications application for more than a specified period of time (e.g., 30 minutes) may be the failure condition considered.

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Data communications applications. Data communications applications comprises the software and hardware necessary to perform a task that can be used to provide an operational benefit. Data communications applications can reside on the aircraft as an aircraft application or at an air traffic, service provider, or operator facility as a ground application.

Data link system. The data communications system comprises the aircraft data communications system, one or more of the air/ground subnetworks, and the ground data communications system. The data communications system supports data communications applications.

Flight information services (FIS). FIS applications include real-time advisories and warnings which have a direct effect on flight safety; flight information planning services which are used in strategic flight planning; and collection of aircraft observations which support wider dissemination of pilot and instrument observations of current atmospheric conditions.

Ground/space system commissioning. Ground/space system commissioning describes the process(es) that service providers and certification authorities use to commission an air/ground subnetwork, ground data communications system, or ground application for operational service in accordance with established requirements (e.g., FAA Orders and Directives, 14 CFR parts 170 through 191, international and federal telecommunication regulations, and other requirements, if the certification authority comprises the air traffic services, the airways facilities services, system development services, and other participating services of the FAA).

Integrity. Integrity describes the characteristics of a function indicating a level of confidence that the function will perform as intended under all operating scenarios. For example, validating the safety requirements for the system design and ensuring that the implementation satisfies those requirements provide integrity for the system.

Interoperability requirements. Interoperability requirements define the requirements that provide the basis for ensuring compatibility among the various components comprising the distributed data applications and the communications infrastructure in the aircraft and external to the aircraft.

Navigation communication services. Navigation communication services include the delivery of DGPS data and other supplemental information and for the delivery of information related to observed and expected flight path (e.g., route conformance monitoring). Navigation communication services may require use of protected navigation frequencies for delivery of this information in certain cases.

Operational authorization. Operational authorization describes the process that an operator and certification authority use to obtain the authorization to use the aircraft data communications system and applications in operations in accordance with operational requirements (e.g., 14 CFR parts 91 through 139 if the certification authority is the Flight Standards Service of the FAA).

Operational environment. The operational environment consists of the air/ground subnetwork, the ground data communications system, the ground applications, and the operational aspects.

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Performance. Performance describes the characteristics of the data communications system and applications associated with the functionality and capabilities of the data communications system or application, regardless of its availability and integrity. For example, message length, time to process a data communications message, memory capacity, and operational features are measures of performance. This AC uses performance in the context of a MOPS.

Safety requirements. Safety requirements are derived from the safety assessment and allocated to the aircraft systems or the operational environment.

Surveillance. Surveillance applications include the delivery of position and intent data (e.g., position waypoint passage and next waypoint) to permit ATS and other aircraft to monitor for safe and efficient separation. Surveillance applications include air-ground transmissions and air-air transmissions intended to supplement or eliminate the need for ground-based surveillance. Surveillance applications include automatic dependent surveillance (ADS).

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

2. Acronyms. The following acronyms are used in this AC.

Acronym	Description
AAC	Aeronautical administrative control
AC	Advisory circular
ACARS	Aircraft communications addressing and reporting system
ACO	Aircraft certification office
ADLP	Aeronautical data link processor
ADS	Automatic dependent surveillance
AEEC	Airlines Electronic Engineering Committee
AFN	ATS facilities notification
AMSS	Aeronautical mobile satellite service
AOC	Aircraft operational control
APC	Aeronautical public correspondence
ARAC	Administrator's Regulatory Advisory Committee
A/RFM	Airplane/rotorcraft flight manual
ARINC	Aeronautical Radio, Inc.
ARP	Aerospace recommended practice
ATA	Air Transport Association of America
ATC	Air traffic control
ATCRBS	Air traffic control radar beacon system
ATIS	Automatic terminal information service
ATM	Air traffic management
ATN	Aeronautical telecommunication network
ATS	Air traffic services
AVPAC	Aviation VHF packet communications
C/SOIT	Communications/Surveillance Operational Implementation Team
CFR	Code of Federal Regulations
CLNP	Connectionless network protocol
CLTP	Connectionless transport protocol
CMA	Context management
CNS	Communications, navigation, and surveillance
COTP	Connection oriented transport protocol
CPDLC	Controller Pilot Data Link Communications
CRC	Cyclic redundancy check
CVR	Cockpit voice recorder

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Acronym	Description
DER	Designated engineering representative
DGPS	Differential global positioning system
ES-IS	End system-intermediate system
EUROCAE	European Civil Organization for Aeronautics
FAA	Federal Aviation Administration
FANS	Future air navigation system
FCAA	Foreign civil air authority
FDR	Flight data recorder
FIS	Flight information services
FMEA	Failure modes and effects analysis
FMS	Flight management system
HF	High frequency
HFDL	HF data link
ICAO	International Civil Aviation Organization
IDRP	Inter-domain routing protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JAA	Joint Aviation Authority
JAR	Joint airworthiness requirements
Mode S	Mode select
MOPS	Minimum operational performance standard
NAS	National airspace system
PDC	Pre-departure clearance
RTCA	RTCA, Inc.
SAE	Society of Automotive Engineers, Inc.
SARPS	Standards and recommended practices
SIRT	Systems Integration Requirements Task Group
TOC	Transfer of communications
TSO	Technical standard order
TWDL	Two-way data link
UNABLE	Unable to comply
VDL	VHF digital link
VHF	Very high frequency
WILCO	Will comply

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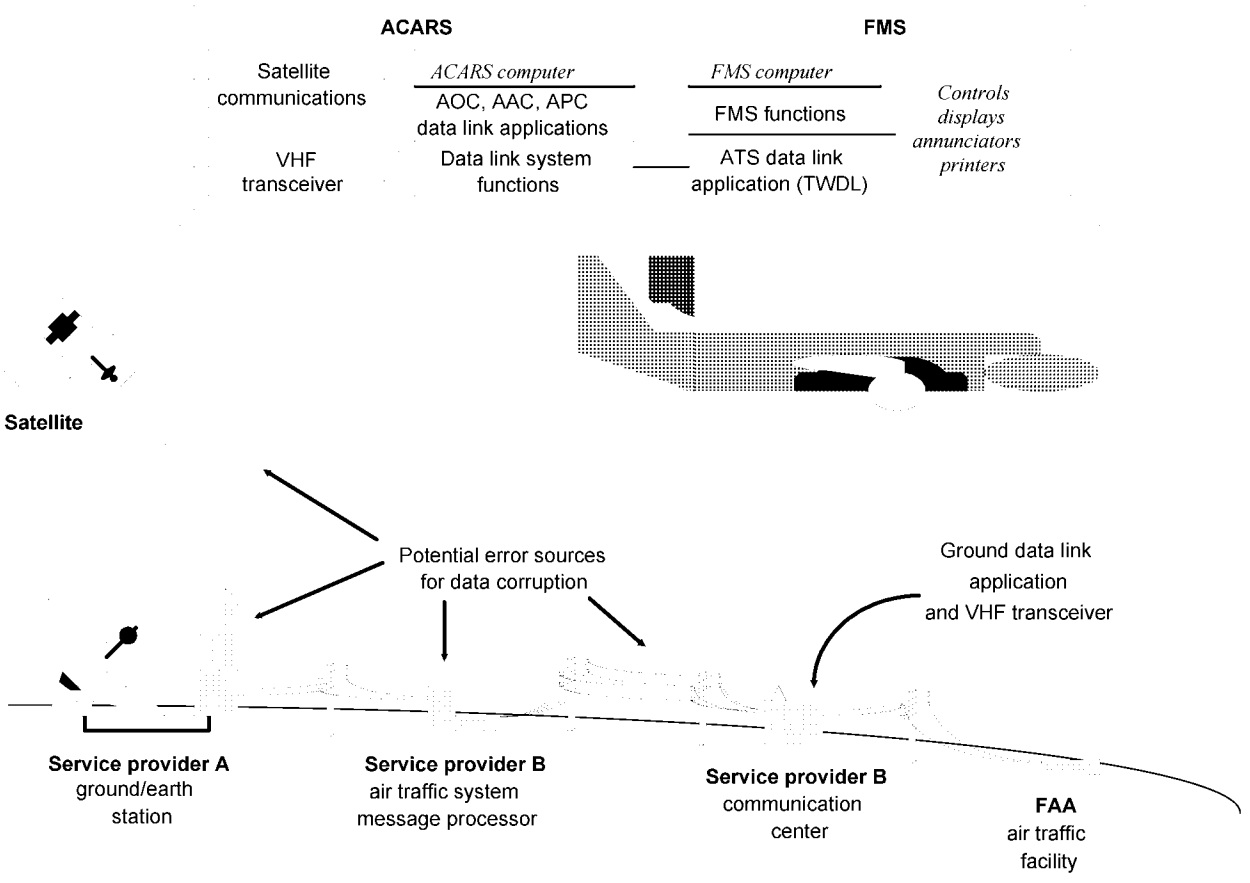
APPENDIX 3. *EXAMPLE OF A PARTIAL SAFETY ASSESSMENT*

This appendix provides an example of a partial safety assessment on an ATS data communications application to assist in understanding the safety assessment process and the types of assumptions that are made to substantiate the results of the safety assessment. The safety assessment interacts with the system development process to evaluate different system architectures and designs and the effects of failures, design errors, and environmental conditions on the aircraft. For data communications systems and applications, the safety assessment may choose one particular architecture and design over another to minimize the effects of data communications system failures that are external to the aircraft. However, where assumptions are necessary, they are captured as safety and interoperability requirements (See paragraphs 1(f) and 1(g) of this appendix).

1. Introduction. One of the objectives for applying data communications technology is to provide digital communications between ground computers and aircraft computers, such as the flight management system (FMS), to minimize procedural and human errors in the delivery of ATM information from the air traffic controller to the flightcrew. To meet this objective, however, the data communications system and applications need to be of sufficient integrity. The aviation community has accepted safety assessments and design assurance techniques to ensure that adequate levels of integrity are achieved.

Figure 3-1. *EXAMPLE OF DATA COMMUNICASIONS APPLICATIONS*



APPENDIX 3. *EXAMPLE OF A PARTIAL SAFETY ASSESSMENT* (Continued)

a. Identification of aircraft level function and description of system. Figure 3-1 provides an example of an implementation of a TWDL data communications application intended for use in oceanic and remote airspace by the flightcrew to obtain changes from an air traffic controller to the flight plan filed prior to departure. The TWDL application uses the message set contained in Appendix A of RTCA DO-219 and the existing ACARS data communications system, which uses the VHF and satellite subnetworks. Service provider A operates the satellite subnetwork and service provider B operates the VHF air/ground subnetwork, the ground data communications system, and the ground TWDL application. Service provider B has an existing ground-ground communication network with the FAA ATC center.

b. Aircraft systems. The aircraft TWDL application shares the computer resources of the aircraft flight management system (FMS) with other FMS functions and uses the aircraft ACARS data communications system to interface with the satellite and VHF subnetworks. The TWDL application uses existing controls, displays, annunciators, and printers to provide information to the flightcrew.

c. Failure condition classification. The partial safety assessment considers the effects of an undetected error in the "altitude" variable in TWDL messages (as defined in RTCA DO-219) that the air traffic controller uplinks to the flightcrew. An undetected error in the uplink "altitude" variable has "major" effects on the aircraft when the "altitude" variable is used in an altitude change clearance to alter the filed flight plan. This failure condition is classified as "major" according to the failure condition categories defined in AC 25.1309-1A. The narrow spacing between altitude levels in oceanic and remote airspace does not allow time for correction of undetected errors by the ATC controller.

d. Fault Tree Analysis. Figure 3-2 provides a top level fault tree of the failure condition under consideration. The fault tree indicates potential hardware and software design errors, hardware failures, and environmental conditions that can cause or contribute to the failure condition. A common mode analysis shows that the inputs to the AND gate in the fault tree are independent, that is, both inputs to the AND gate are shown not to fail under the same condition. To show independence a 16 bit CRC is implemented in the FMS computer and the end system that hosts the ground TWDL application.

e. Design assurance. The aircraft TWDL application is integrated in the FMS with other FMS functions. A failure modes and effects analysis (FMEA) is conducted on the FMS hardware to show that the FMS system architecture and design adequately protect against undetected hardware failures contributing to the failure condition under consideration. The software for the TWDL application, the 16 bit CRC, and the controls, displays, and annunciators are developed to Level C, in accordance with RTCA DO-178B, to adequately protect against design errors. The analysis assumes that the end system that hosts the ground TWDL application, the 16 bit CRC, and controller interface provides an adequate level of design assurance.

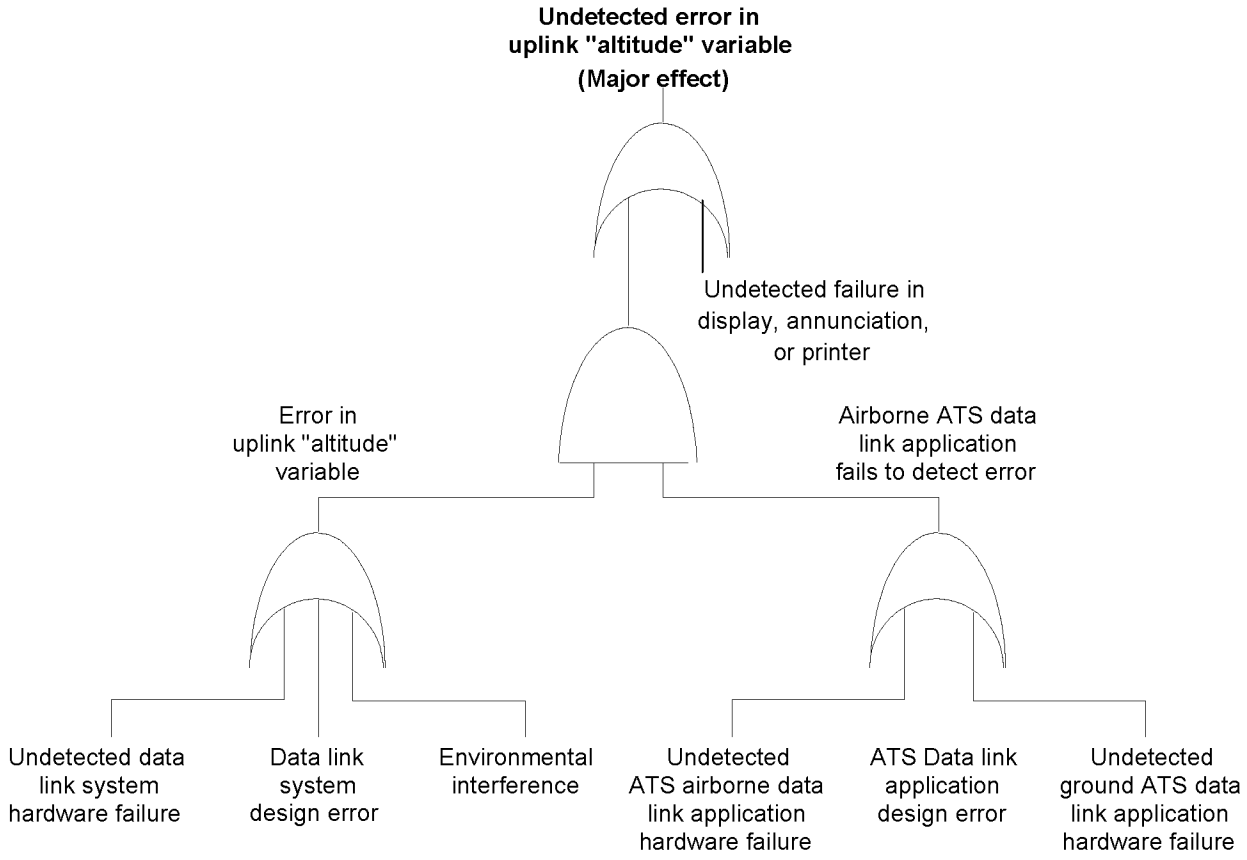
f. Safety requirements allocated to aircraft systems. The following requirements have been identified for the aircraft data communications system and TWDL application:

(1) A 16 bit CRC shall be implemented in FMS computer.

(2) The software for the FMS computer shall be developed to Level C, in accordance with RTCA DO-178B.

APPENDIX 3. *EXAMPLE OF A PARTIAL SAFETY ASSESSMENT* (Continued)

Figure 3-2. *TOP-LEVEL FAULT TREE FOR TWDL FAILURE CONDITION*



(3) The software for the aircraft human/machine interface (i.e., controls, displays, and annunciators) shall be developed to Level C, in accordance with RTCA DO-178B.

(4) A primary communication system that meets current operating rules is required. The data communications system and applications supplement the primary communication system.

g. Safety requirements allocated to the ground end system. The following safety requirements have been identified for the end system that hosts the ground TWDL data communications application:

(1) A 16 bit CRC is implemented in the end system that hosts the ground TWDL application.

(2) The organization responsible for commissioning end system should adequately ensure that the safety requirements are implemented.

h. Evaluation of aircraft systems implementation. The safety assessment relies on design assurance activities and determines that the implementation of aircraft systems satisfies the requirements identified.

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APPENDIX 4. *FORM TO SUBMIT SUGGESTIONS FOR IMPROVEMENT*

Use this form or create your own to submit comments for improving future releases of advisory material pertaining to design approval of data communications systems and applications.

<table>
<tr><th colspan="2">Suggestion for Improvement</th></tr>
<tr><td>Send To: FAA, Aircraft Certification Service
Aircraft Engineering Division (AIR-130)
800 Independence Avenue
Washington, D.C.</td><td>Date:</td></tr>
<tr><td colspan="2">Name:</td></tr>
<tr><td>Voice:</td><td rowspan="3">Address</td></tr>
<tr><td>Fax:</td></tr>
<tr><td>Internet:</td></tr>
<tr><td colspan="2">Reference sections:</td></tr>
<tr><td colspan="2">Rationale (Describe the reason for the change)</td></tr>
<tr><td colspan="2">Proposed change (Attach marked-up text or proposed rewrite)</td></tr>
<tr><td colspan="2">Please provide any general comments for improvement of this AC</td></tr>
</table>

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