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PART 1
AIRWORTHINESS CODES AND DESIGN STANDARDS

CHAPTER 1 — INTRODUCTION AND OVERVIEW

1.1.1 Background

1. The Airworthiness Design Standards Manual (ADSM) is the companion to the Technical Airworthiness Manual (TAM). Together, they form the two key documents of the Department of National Defence/Canadian Armed Forces (DND/CAF) Technical Airworthiness Program. The TAM contains the regulatory rules and standards that are applicable to the Technical Airworthiness Program as a whole, including the Technical Airworthiness Authority (TAA)'s rules related to the aircraft certification process. The ADSM augments the TAM by providing the detailed airworthiness requirements and design standards that are to be applied to the certification of DND/CAF aircraft designs.

1.1.2 Purpose

1. The purpose of this manual is to identify the airworthiness certification requirements and aircraft design standards that are deemed acceptable by the TAA. These are the primary tools that will be used to develop the certification basis and Compliance Program required during the certification of new aeronautical products or design changes to in-service aircraft fleets.

2. The ADSM provides advisory material relating to the selection and application of airworthiness design standards as they relate to the design, manufacture, maintenance and materiel support of military aeronautical products.

1.1.3 ADSM Content and Layout

1. The ADSM is divided into five parts, a List of Abbreviations and a Glossary. It is structured according to the following subjects:

a. Part 1 – Airworthiness Codes and Design Standards;

b. Part 2 – Certification Processes;

c. Part 3 – Aircraft Systems Design and Certification;

d. Part 4 – Uncrewed Aircraft Systems (UAS) – Design and Certification;

e. Part 5 – Miscellaneous Equipment Approval/Certification;

f. List of Abbreviations; and

g. Glossary.

2. **Part 1 – Airworthiness Codes and Design Standards.** This ADSM part contains the following four chapters that provide an overview of the TAA-recognized airworthiness codes and a description of how these codes and associated airworthiness design standards are to be used to develop a certification basis for DND/CAF aircraft designs:

a. Chapter 1 – Introduction and Overview;

b. Chapter 2 – Airworthiness Codes;

c. Chapter 3 – Development of a Certification Basis; and

d. Chapter 4 – Airworthiness Design Standards.

3. **Part 2 – Certification Processes.** There are several engineering disciplines that affect the certification of multiple aircraft systems and may have an impact on the certification of many aspects of the aircraft design. For example, airborne software is present in many of the integrated aircraft systems and equipment, and often performs essential functions for the safe operation of the aircraft. This ADSM part contains the following 13 chapters that identify the certification process requirements and design standards that are to be applied to the certification of DND/CAF aircraft designs:

a. Chapter 1 – System Safety;

b. Chapter 2 – Human Factors;

c. Chapter 3 – Electromagnetic Environmental Effects (E3) Protection;

d. Chapter 4 – Airborne Software and Airborne Electronic Hardware;

e. Chapter 5 – Equipment Environmental Qualification and Aircraft Operations After Cold Soak;

f. Chapter 6 – Aircraft Cybersecurity;

g. Chapter 7 – Air Vehicle - Performance and Handling;

h. Chapter 8 – Structural Integrity;

i. Chapter 9 – Armament and Stores Integration;

j. Chapter 10 – Non-Destructive Testing;

k. Chapter 11 – Systems and Equipment Testability;

l. Chapter 12 – Fuels, Lubricants and Hydraulic Fluids; and

m. Chapter 13 – Material Specifications and Standards.

4. **Part 3 – Aircraft Systems Design and Certification.** This ADSM part contains 18 chapters that identify the certification requirements and design standards that are to be applied to the certification of specific aircraft systems. These chapters also identify the certification requirements related to specific functional and operational capabilities that may involve several aircraft systems and multiple engineering disciplines. For example, the “Navigation Systems” and “Communication Systems” chapters include guidance for certifying Performance Based Navigation (PBN) and Automatic Dependant Surveillance (ADS) capabilities that will allow DND/CAF aircraft to operate without restrictions in advanced air traffic control environments. The following chapters identify the TAA-accepted certification and design standards:

a. Chapter 1 – Flight Instruments, Displays and Controls;

b. Chapter 2 – Airborne Communication Systems;

c. Chapter 3 – Aircraft Navigation Systems;

d. Chapter 4 – Hazard Avoidance Avionics Systems;

e. Chapter 5 – Flight Control and Autopilot Systems;

f. Chapter 6 – Crash Data Recorders and Locator Systems;

g. Chapter 7 – Propellers, Rotors and Rotor Drive Systems;

h. Chapter 8 – Electrical Power Generation, Distribution and Protection;

i. Chapter 9 – Aircraft Lighting and Night Vision Imaging Systems;

j. Chapter 10 – Propulsion Systems;

k. Chapter 11 – Aircraft Fuel Systems;

l. Chapter 12 – Fire Detection and Suppression;

m. Chapter 13 – Aircraft Tires;

n. Chapter 14 – Cabin Safety and Crash Protection;

o. Chapter 15 – Aviation Life Support Equipment (ALSE) and Escape Systems;

p. Chapter 16 – Rescue & Survival Equipment;

q. Chapter 17 – Health and Usage Monitoring Systems (HUMS) for Rotorcraft; and

r. Chapter 18 – Aerospace Rigid Tubing.

5. **Part 4 – Uncrewed Aircraft Systems (UAS) – Design and Certification.** The three chapters included in this part provide the certification and Technical Airworthiness Clearance (TAC) requirements that apply to Uncrewed Aircraft Systems. In addition, chapter 3 provides references to the UAS airworthiness codes and associated advisory material. Part 4 of the ADSM comprises the following chapters:

a. Chapter 1 – Uncrewed Aircraft Systems (UAS) – Certification Requirements;

b. Chapter 2 – UAS Technical Airworthiness Clearance (TAC) Requirements; and

c. Chapter 3 – UAS Airworthiness Codes.

6. **Part 5 – Miscellaneous Equipment Approval/Certification.** The following five ADSM chapters address certification and approval requirements for miscellaneous systems and equipment that require an airworthiness approval for use aboard, or in support of, DND/CAF aircraft:

a. Chapter 1 – Flight & Mission Planning Systems;

b. Chapter 2 – Mission Systems;

c. Chapter 3 – Aeromedical Equipment;

d. Chapter 4 – Electronic Fight Bag; and

e. Chapter 5 – Portable Electronic Devices.

7. D E L E T E D

a. D E L E T E D

b. D E L E T E D

1.1.4 Use of the Manual

1. The ADSM is intended to be used by the TAA staff as a primary reference source in providing advice and guidance to Project Management Office (PMO) and Weapon System Management (WSM) staff.

2. The PMO and WSM staff, with the assistance of the TAA and the engineering support staff of the Director – Technical Airworthiness and Engineering Support (DTAES), may use the ADSM to identify design requirements and standards that will be used during the certification of new DND/CAF aircraft and in-service design changes.

3. With respect to the acquisition of new fleets that are Commercial Off-the-Shelf (COTS) or extant military designs, the ADSM may be used to assess the acceptability of standards used in those designs during the Type Design Examination (TDE) process.

4. It is common for design standards to be updated, especially as a result of identified or perceived weaknesses. It is, therefore, highly desirable that the latest version of a design standard be used, particularly for new designs. However, this may not always be practical, achievable or appropriate (for example, when introducing new systems to old aircraft). Any proposal to use an older standard in place of a more current replacement or updated standard will need to be fully substantiated (refer to Part 3, Chapter 2 of the TAM).

PART 1
AIRWORTHINESS CODES AND DESIGN STANDARDS

CHAPTER 2 — AIRWORTHINESS CODES

1.2.1 Introduction

1. To ensure that DND/CAF aircraft designs provide an acceptable level of safety, they must be certified to airworthiness standards approved by the Technical Airworthiness Authority (TAA). As described in Part 1, Chapter 3, the certification basis for a new aircraft design is created by selecting the appropriate airworthiness standards from a TAA-approved airworthiness code.

2. It is not feasible for the DND to create and maintain its own airworthiness code. As described in this chapter, there are several existing civil and military codes that are published and maintained by TAA-recognized Airworthiness Authorities (AAs). These codes have been approved by the TAA for application to DND/CAF aircraft. Used properly, these codes can be effectively applied to certify DND/CAF aircraft designs.

3. An aircraft developed to a TAA-recognized airworthiness code should substantially meet the level of safety expected by DND. While the TAA might prescribe additional design requirements to address known shortfalls in the airworthiness code, or to encompass DND's unique military requirements, these are not normally substantial additions.

4. This chapter describes the TAA's approach to recognizing airworthiness codes and to identifying where supplementation of the code is needed. This chapter also provides the following information:

a. a definition and description of an airworthiness code;

b. a description of the primary airworthiness codes that have been accepted by the TAA; and

c. the policy on the use of advisory material published by a TAA-recognized AA.

1.2.2 Airworthiness Code

1. An airworthiness code is a comprehensive set of airworthiness standards that define those attributes of aircraft systems or equipment required for safe flight. Airworthiness standards are issued by a civil or military AA to govern all aspects of an aircraft's design, production and maintenance, and are used to form the certification basis for a specific aircraft design. These standards define the attributes that underpin safe flight for the operation of that aircraft design. For example, the airworthiness code that is available from Transport Canada, Civil Aviation (TCCA) includes the following groupings of standards:

a. Chapter 523 – Normal, Utility, Aerobatic and Commuter Category Aeroplanes;

b. Chapter 525 – Transport Category Aeroplanes;

c. Chapter 527 – Normal Category Rotorcraft;

d. Chapter 529 – Transport Category Rotorcraft; and

e. Chapter 533 – Aircraft Engines.

2. For the TAA to accept an airworthiness code, at a minimum, the code must meet the following criteria:

a. be developed and supported by a Civil Airworthiness Authority (CAA) or Military Airworthiness Authority (MAA) recognized by the TAA;

b. provide a comprehensive suite of airworthiness standards applicable to the aircraft types operated by the DND/CAF;

c. provide guidance related to achieving compliance with the airworthiness standards; and

d. be published by the CAA or MAA and available for use by DND.

1.2.3 TAA-Recognized Airworthiness Codes

1. Western countries currently operate their military aviation safety systems independently from each other, with each country being individually responsible for the regulation of its own military and state aircraft. A significant cost driver for the military airworthiness programs is the expense associated with the initial airworthiness certification of the aircraft. There are two avenues available for a nation to minimize these costs. The first is to purchase civil-certified aircraft and modify the design, as necessary, to meet the military requirements. The second option is to acquire a military aircraft based on a design that has already been certified by another military airworthiness authority. Essential to both options is the acceptance of the certification process and airworthiness standards used by the other authority to certify their designs.

2. The formal process used by the TAA and other nations to accept another authority's certification processes, standards and certificates of approval is called 'Recognition'. Recognition allows the TAA to exploit opportunities to realize economies associated with accepting aircraft certification evidence, or conducting joint aircraft certification activities for a common aircraft type on a cooperative program basis. Inherent in the recognition process is the TAA's acceptance of the airworthiness code used by the other authority.

3. The TAA process for recognizing other Civil Aviation Authorities (CAAs) and Military Airworthiness Authorities (MAAs) is described in TAA Advisory 2016-04 – Recognition of Airworthiness Authorities, available on the TAA web pages hosted on the Government of Canada official website – Canada.ca. The advisory provides the following guidance and information:

a. a definition of the term 'recognition';

b. the rationale behind the TAA's undertaking the recognition of other CAAs and MAAs;

c. a description of the processes required to achieve and maintain the recognition of an AA; and

d. a list of the MAAs and CAAs that are currently recognized by the TAA.

4. Amongst all of the airworthiness authorities recognized by the TAA, there are six distinct airworthiness codes that are most commonly used: three civil codes and three military codes. A brief description of each of these codes is provided in the following sections of this chapter.

1.2.4 Civil Airworthiness Codes

1. Aircraft certification procedures for civil aircraft are based on the objectives defined in the International Civil Aviation Organization (ICAO)'s Airworthiness Manual. It is the responsibility of each ICAO contracting state to establish its own legal framework to implement the internationally agreed standards and recommended practices. This includes developing an airworthiness code and procedures for the certification of aeronautical products (aircraft, engines and propellers).

2. The TAA has approved the following civil airworthiness codes for the development of the certification basis for DND/CAF aircraft designs:

a. Transport Canada, Civil Aviation (TCCA) – Canadian Airworthiness Manual (AWM);

b. Federal Aviation Administration (FAA) – U.S. Title 14 Code of Federal Regulations (14 CFR); and

c. European Union Aviation Safety Agency (EASA) – Certification Specifications (CSs).

3. Figure 1-2-1 shows the EASA, FAA and TCCA airworthiness codes with the airworthiness standards and certification specifications grouped according to the different categories of aeronautical products.

EASA	CS	FAA	14 CFR	TCCA	AWM
CS-22	Sailplanes and Powered Sailplanes			**Chapter 522**	Gliders and Powered Gliders
CS-23	Normal, Utility Aerobatic and Commuter Aeroplanes	**Part 23**	Normal, Utility Aerobatic and Commuter Category Aeroplanes	**Chapter 523**	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
CS-25	Large Aeroplanes	**Part 25**	Transport Category Aeroplanes	**Chapter 525**	Transport Category Airplanes
CS-27	Small Rotorcraft	**Part 27**	Normal Category Rotorcraft	**Chapter 527**	Normal Category Rotorcraft
CS-29	Large Rotorcraft	**Part 29**	Transport Category Rotorcraft	**Chapter 529**	Transport Category Rotorcraft
CS-31GB **CS-31HB**	(GAS Balloons) (Hot Air Balloons)	**Part 31**	Manned Free Balloons	**Chapter 531**	Manned Free Balloons
CS-E	Engines	**Part 33**	Aircraft Engines	**Chapter 533**	Aircraft Engines
CS-P	Propellers	**Part 35**	Propellers	**Chapter 535**	Propellers
CS-LSA	Light Sport Aeroplanes				
CS-VLA	Very Light Aeroplanes				

Figure 1-2-1 EASA, FAA and TCCA – Airworthiness Code Breakdown

4. **TCCA – Canadian Airworthiness Manual**

a. TCCA is responsible for all aspects of civil aviation in Canada, including operations, maintenance and certification. TCCA publishes aviation regulatory material in the Canadian Airworthiness Manual (AWM). The AWM is divided into nine functional parts, as follows:

(1) Part I – General Provisions;

(2) Part II – Aircraft Identification and Registration and Operation of a Leased Aircraft by a Non-registered Owner;

(3) Part III – Aerodromes, Airports and Heliports;

(4) Part IV – Personnel Licensing and Training;

(5) Part V – Airworthiness;

(6) Part VI – General Operating and Flight Rules;

(7) Part VII – Commercial Air Services;

(8) Part VIII – Air Navigation Services; and

(9) Part IX – Repeals and Coming into Force.

b. TCCA's airworthiness code is embedded within Part V – Airworthiness. This part regulates aircraft airworthiness from the design and type certification stage, to the maintenance and design change of in-service aircraft. The airworthiness code is part of Part V, Subpart 21 – 'Approval of the Type Design or a Change to the Type Design of an Aeronautical Product'. Within Subpart 21, the airworthiness code consists of 'Standards of Airworthiness' that are organized under the following aircraft chapters:

(1) Chapter 522 – Gliders and Powered Gliders;

(2) Chapter 523 – Normal, Utility, Aerobatic and Commuter Category Aeroplanes;

(3) Chapter 523 – VLA — Very Light Aeroplanes;

(4) Chapter 525 – Transport Category Aeroplanes;

(5) Chapter 527 – Normal Category Rotorcraft;

(6) Chapter 529 – Transport Category Rotorcraft;

(7) Chapter 531 – Manned Free Balloons;

(8) Chapter 533 – Aircraft Engines;

(9) Chapter 535 – Propellers; and

(10) Chapter 541 – Airships.

c. The standard of airworthiness chapters are maintained by the National Certification Office within TCCA. These standards are harmonized with the FAA 14 CFR and EASA Certification Specifications (CSs). Consequently, the standards in chapters 523, 525, 527, 529, 533 and 535 are substantially the same requirements as those defined within the equivalent 14 CFR and CS Parts.

d. The standards of airworthiness chapters of the TCCA Airworthiness manual may be found on the following TCCA website: TCCA Airworthiness Manual.

5. **FAA Title 14 Code of Federal Regulations (14 CFR)**

a. The FAA prescribes certification and airworthiness design requirements as a component of the 14 CFR.

b. The following 14 CFR Parts provide the airworthiness standards that are to be used for the development of a certification basis in support of the FAA's Type Certification process. These are the core components of the FAA's airworthiness codes:

(1) Part 23 – Airworthiness standards: Normal, utility, acrobatic and commuter category airplanes;

(2) Part 25 – Airworthiness standards: Transport category airplanes;

(3) Part 27 – Airworthiness standards: Normal category rotorcraft;

(4) Part 29 – Airworthiness standards: Transport category rotorcraft;

(5) Part 33 – Airworthiness standards: Aircraft engines; and

(6) Part 35 – Airworthiness standards: Propellers.

6. **European Union Aviation Safety Agency – Certification Specifications**

a. The European Union Aviation Safety Agency (EASA) is responsible for conducting civil aircraft type certification on behalf of the countries of the European Union. EASA prescribes airworthiness standards within the published Certification Specifications (CSs). EASA CSs are harmonized with the FAA standards of airworthiness for aircraft type certification. Consequently, EASA CS-23, -25, -27, -29, -E and -P are substantially the same requirements as those within the equivalent 14 CFR Parts.

b. The EASA CSs provide the airworthiness standards that are to be used for the development of a certification basis in support of the EASA's type certification process. These are the core components of the EASA airworthiness codes. The following EASA CSs are recognized by the TAA as providing an acceptable foundation for the safe design of DND/CAF aircraft:

(1) CS-23 – Normal, Utility, Aerobatic and Commuter Aeroplanes;

(2) CS-25 – Large Aeroplanes;

(3) CS-26 – Additional Airworthiness Specifications for Operations;

(4) CS-27 – Small Rotorcraft;

(5) CS-29 – Large Rotorcraft;

(6) CS-E – Engines; and

(7) CS-P – Propellers.

c. The EASA CSs are available on the following EASA website: EASA Initial Airworthiness.

1.2.5 Supplementing Civil Codes with Requirements from Military Codes

1. An aircraft design with a certification basis derived from a TAA-recognized civil airworthiness code is expected to provide the basic level of safety required by the TAA. However, all elements of a civil-military hybrid aircraft design may not necessarily be addressable by the airworthiness standards available in civil airworthiness codes. The TAA might prescribe additional design requirements to address known shortfalls in the airworthiness code, or to encompass the DND/CAF's unique military requirements. This may include airworthiness standards taken either from one of the military airworthiness codes, or from those identified in the other chapters of the ADSM.

1.2.6 Military Airworthiness Codes

1. The TAA has approved the following military airworthiness codes for the development of the certification basis for DND/CAF aircraft designs:

a. U.S. Department of Defense (DoD) – *Military-Handbook (MIL-HDBK) 516 – Airworthiness Certification Criteria*;

b. European Defence Agency (EDA) – *European Military Airworthiness Certification Criteria (EMACC)*; and

c. United Kingdom (UK) *Defence Standard (DEF STAN) 00-970*.

2. Of these three military codes, MIL-HDBK-516 is the one most commonly used by the TAA. The EMACC code mirrors the criteria in MIL-HDBK-516, but has additional material that provides references to the associated EASA CSs, the UK DEF STANs and North Atlantic Treaty Organization (NATO) Standardization Agreements (STANAGs). The UK DEF STANs are rarely employed by the TAA and would only be applicable if DND were to acquire an aircraft that was originally certified to DEF STANs.

3. These codes have been approved by the TAA for use in the development of a certification basis for DND/CAF aircraft designs. However, all elements of DND/CAF aircraft design may not necessarily be addressable by the airworthiness standards available in military codes. The TAA may prescribe additional design requirements to address the DND/CAF's unique military requirements. This may include standards identified in the other chapters of the ADSM.

4. **U.S. Department of Defense (DoD) MIL-HDBK-516 – Airworthiness Certification Criteria**

a. Within the U.S. DoD, each of the three major services (United States Air Force (USAF), U.S. Army and United States Navy (USN)) has their own military airworthiness authority. All three MAAs have been formally recognized by the TAA. Each of the three MAAs have their own set of regulations and procedures pertaining to the certification and flight release of their aircraft. In an initiative to harmonize the military airworthiness codes used by the three services, the USAF Technical Airworthiness Authority has developed the DoD MIL-HDBK-516, titled 'Airworthiness Certification Criteria'. This handbook is approved for use by all departments and agencies of the U.S. Department of Defense. The MIL-HDBK document follows a ‘systems’-based approach, with references to applicable airworthiness criteria, design standards, means of compliance and tailoring for different aircraft types, where required.

b. MIL-HDBK-516 satisfies the criteria for an airworthiness code as outlined in section 1.2.2.2 of this chapter. MIL-HDBK-516 establishes the airworthiness certification criteria, design standards and methods of compliance to be used in the determination of the airworthiness of all crewed and uncrewed, fixed and rotary wing, air systems. It is a foundational document to be used by the U.S. service AAs to define an air system’s airworthiness certification basis. MIL-HDBK-516 is intended to be tailored to develop a certification basis for specific aircraft types and roles.

c. The airworthiness certification criteria prescribed in MIL-HDBK-516 are recognized by the TAA as providing an acceptable foundation for the development of a certification basis for DND/CAF aircraft. MIL-HDBK-516 provides a valuable set of airworthiness certification criteria specific to military aircraft equipment, roles and operating environment that can be converted into airworthiness standards.

d. MIL-HDBK-516 is a large publication with the following topic breakdown:

- Section 1 – Scope;
- Section 2 – Applicable Documents;
- Section 3 – Definitions and Abbreviations;
- Section 4 – Systems Engineering;
- Section 5 – Structures;
- Section 6 – Flight Technology;
- Section 7 – Propulsion and Propulsion Installations;
- Section 8 – Air Vehicle Subsystems;
- Section 9 – Crew Systems;
- Section 10 – Diagnostic Systems;
- Section 11 – Avionics;
- Section 12 – Electrical System;
- Section 13 – Electromagnetic Environmental Effects (E3);
- Section 14 – System Safety;
- Section 15 – Computer Resources;
- Section 16 – Maintenance;
- Section 17 – Armament/Stores Integration;
- Section 18 – Passenger Safety;
- Section 19 – Materials; and
- Section 20 – Air Transportability/Airdrop/Mission/ and Cargo/Payload Safety.

e. Each of the MIL-HDBK-516 paragraphs related to airworthiness certification criteria provides the following information:

(1) Airworthiness Certification Criterion;

(2) Airworthiness Standard;

(3) Method of compliance; and

(4) Additional References.

f. A PDF version of MIL-HDBK-516 is available internally, within DND, under the AEPM RDIMS Library number 1504249 or from the USAF Certification Library at the following web-link: MIL-HDBK-516C.

5. **European Military Airworthiness Certification Criteria (EMACC)**

a. Within the European Defence Agency (EDA), the Military Airworthiness Authorities (MAWA) Forum was created in 2008 with the mandate to harmonize the airworthiness requirements and processes of the EDA member states. The MAWA Forum consists of representatives from each of the EDA member states' National Military Airworthiness Authorities (NMAAs) and is chaired by the EDA, which also provides the organizational and administrative support.

b. MAWA has developed an airworthiness code that has been published in a document titled the *European Military Airworthiness Certification Criteria (EMACC)*. The EMACC is used by the EDA NMAAs to determine the airworthiness of all crewed and uncrewed, fixed and rotary wing, air vehicle systems. It is intended to be a foundational document for defining an air system's certification basis. The EDA website also provides access to the latest version of Approved MAWA Documents that have been published by the EDA MAWA Forum.

c. The certification criteria in the EMACC mirror the U.S. DoD MIL-HDBK-516. However, the EMACC also provide cross-references to the relevant sections of the EASA CSs, the UK Defence Standard 00-970 and NATO STANAG documents. E-copies of the EMACC publication are available internally, within DND, under the AEPM RDIMS library number 1374982, or on the following European Defence Agency Website: EMACC Handbook Edition 3.1.

d. The MAWA documents library also contains a document titled *EMACC User Guidebook* (EMACC Guidebook). This guidebook provides descriptive information about the EMACC document and guidance for selecting the appropriate criteria from the EMACC to define the certification requirements for the 'tailored' certification basis. The guidebook also provides valuable information on the European military airworthiness regulatory system, including the following topics:

(1) Type certification versus qualification;

(2) Certification Codes; and

(3) NATO Standardization Agreements (STANAGs).

6. **UK MoD – Defence Standard 00-970**

a. The United Kingdom Ministry of Defence (UK MoD) is a TAA-recognized MAA. The UK MoD prescribes airworthiness standards in Defence Standard DEF STAN 00-970 – *Design and Airworthiness Requirements for Service Aircraft*. DEF STAN 00-970 is divided into a number of parts that prescribe for specific aircraft types and ancillary equipment categories, as follows:

(1) Part 1 – Combat Aeroplanes;

(2) Part 3 – Small Type Aeroplanes;

(3) Part 5 – Large Type Aeroplanes;

(4) Part 7 – Rotorcraft; and

(5) Part 11 – Engines.

b. Unfortunately, the DEF STANs include a wide range of military design requirements where the airworthiness-related design requirements are not separately identified. The UK DEF STAN 00-970 is accessible on the following internet website: UK MAA - DEF STAN.

1.2.7 Advisory Material

1. Advisory material is published by an airworthiness authority to augment their airworthiness code, by providing 'regulator-accepted' means of demonstrating compliance to the airworthiness standards. Compliance with the advisory material only becomes mandatory if the advisory is specifically called up in the airworthiness standards

listed in the certification basis. The following are the primary forms of advisory material published by civil and military regulators:

a. TCCA Advisory Material;

b. FAA Advisory Circulars (AC);

c. EASA Guidance Material (GM) and Acceptable Means of Compliance (AMC); and

d. Advisory Material – Military Airworthiness Codes. Advisory material is provided with the U.S. MIL-HDBK-516 and European Defence Agency – EMACC.

2. The TAA reviews and selectively uses advisory material published by TAA-recognized civil and military airworthiness authorities. In particular, the FAA, TCCA and EASA have published extensive libraries of advisory material. Accordingly, TAA's policy is that this advisory material is generally acceptable for use in certifying DND/CAF aircraft designs, and may be used as long as they do not conflict with TAA rules, standards, policies, interpretations and advisory material.

3. The TAA policy regarding the use of FAA Advisory Circulars (ACs) is that, except when specifically excluded by the TAA, the FAA ACs that address the adopted design standards of 14 CFR Parts 23, 25, 27, 29 are considered to be acceptable for obtaining design approval for DND/CAF aircraft. A similar policy approach is used for advisory material published by the other CAAs and MAAs recognized by the TAA. The TAA policy, however, is subject to the following:

a. Only the airworthiness content is accepted;

b. Any reference to "FAA Administrator" and "Administration" will read the "TAA";

c. Any reference to 14 CFR sections (Part 23 to 29) will only apply to those 14 CFR elements that have been included in the TAA-approved certification basis for the design; and

d. No advisory circular can modify or change a TAA-specified standard.

4. **Transport Canada Advisory Material.** The TCCA advisory material consists of Staff Instructions, Policy Letters and Advisory Circulars that have been published by the National Aircraft Certification Branch. TCCA's aircraft certification guidance and advisory material is available at the following websites:

a. Post-2007 Material. All new advisory and guidance documents published by Civil Aviation on or after February 2, 2007 are now accessible through the Online Reference Centre web site.

b. Pre-2007 Material. Aircraft certification guidance and advisory materials (Pre 2007).

5. **FAA Advisory Circulars (ACs).** The FAA publishes ACs to provide guidance and information in a designated subject area, or to show a method acceptable to the FAA Administrator for complying with a related 14 CFR Part. Unless incorporated into a regulation by reference, the contents of an advisory circular are not binding on the public. Examples include the FAA Advisory Circulars (ACs) for 14 CFR Parts 21, 23, 25, 28, 29 and 33. The FAA ACs are available at the following web-link: FAA Advisory Circulars (ACs) .

6. **EASA Guidance Material (GM) and Acceptable Means of Compliance (AMC).** The EASA GM and AMCs are incorporated into the certification specification (CS) publications as the second part of the CS, with the title 'Book 2 – Acceptable Means of Compliance'. The EASA GM and AMCs are available at the following website links:

a. CS-25, Book 2 provides the AMCs applicable to the EASA certification of Large Aeroplanes - EASA CS 25 AMC;

b. EASA - AMC 20 – Airworthiness of Products Parts and Appliances

7. **Methods of Compliance – MIL-HDBK-516 and EMACC.** The MIL-HDBK-516 and the EMACC handbooks provide guidance material related to methods of compliance, as well as a wide range of reference material that may

be applied to make a finding of compliance. The advisory material related to MIL-HDBK-516 and the EMACC is provided as ‘methods of compliance’ information that is associated with the individual certification criteria that are published in the handbooks.

8. Advisory material for the UK Defense Standards, and the UK Military Aviation Authority is available at the following web-link: MAA Homepage.

PART 1
AIRWORTHINESS CODES AND DESIGN STANDARDS

CHAPTER 3 — DEVELOPMENT OF A CERTIFICATION BASIS

1.3.1 Introduction

1. This chapter provides guidance for developing a certification basis using the airworthiness standards and certification criteria available in the TAA-approved civil and military airworthiness codes.

2. This chapter provides the following information:

a. a definition and description of the certification basis;

b. the *Technical Airworthiness Manual (TAM)* requirements related to the certification basis;

c. the layout of the certification basis and its place in the compliance matrix; and

d. considerations for establishing the certification basis.

1.3.2 Type Certification and Type-Certification Basis

1. Type Certification is the process by which it is demonstrated that the design of a new or modified aircraft type design complies with the applicable airworthiness requirements. Upon successful completion of the certification process, the TAA may issue a Type Certificate (new or amended), or approve changes to an already certified one. A TAA airworthiness certification process can be divided into the following phases:

a. establish and agree the certification basis;

b. agree the certification plan and process for demonstrating compliance;

c. complete the compliance activities and findings of compliance; and

d. TAA review, reporting and issue of DND Type Certificate, or equivalent assurance.

2. The certification basis must be approved by the TAA. The certification basis identifies the applicable requirements to which the aircraft design must show compliance. This includes any special conditions, exemptions and findings of equivalent safety. The certification basis is created by selecting the appropriate airworthiness standards from one of the TAA-approved civil or military airworthiness codes described in Part 1, Chapter 2, Airworthiness Codes.

3. **Certification versus Qualification.** Qualification is the process used by the DND acquisition project office to establish compliance of an aircraft system with the performance, functional and design requirements established in the contract with the design agency. Since qualification and certification are processes that normally occur simultaneously, but are separately regulated and managed, it would be beneficial to explain the differences between certification and qualification.

4. Generally, type-certification is considered to be a pre-requisite to qualification. Type certification focuses exclusively on aviation safety-related requirements, while qualification expands the scope to encompass all of the aircraft system performance and mission capability requirements. The type certification requirements frequently overlap with the product qualification requirements that are contractually expressed in terms of performance, functionality, availability, reliability and maintainability. Both activities can be conducted in parallel and often share design, analysis and test data.

5. Within DND and the Materiel Group, a clear distinction is made between the type-certification and qualification activities. The TAA's role is to regulate and oversee the type certification process, while qualification is entirely the responsibility of the project manager. Although the type certification process is managed independently from the

qualification process, to minimize the impact on the project's cost and schedule, it is possible, and even desirable that the compliance artefacts from the certification activities should be reused for qualification purposes.

6. Figure 1-3-1 shows the relationship between the type certification and qualification activities.

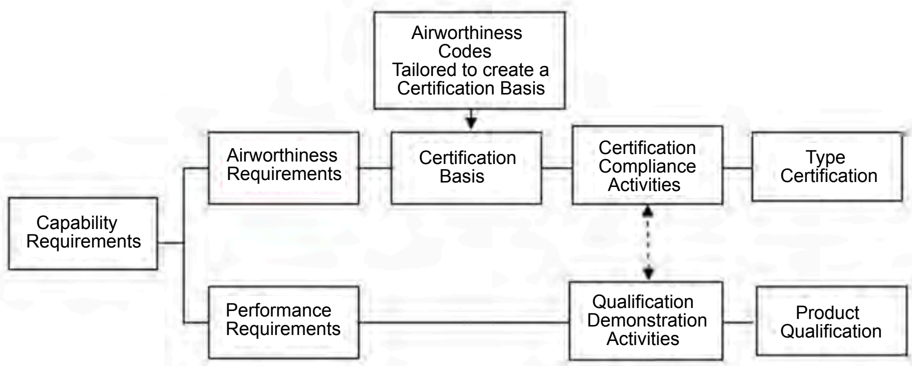

Figure 1-3-1 Relationship between Type Certification and Qualification

1.3.3 Certification Basis Description

1. The TAM defines certification basis as: "A set of airworthiness standards and certification criteria against which Compliance must be demonstrated in order to obtain Airworthiness Approval for a new Type Design or a Design Change. The airworthiness standards that form the Certification Basis are tailored to suit the Aeronautical Product type. The Certification Basis may also include special conditions and environmental requirements".

2. The certification basis, or basis of certification, consists of the complete set of airworthiness standards and certification criteria required to certify a specific type design. The airworthiness standards provide the criteria against which compliance must be demonstrated in order to receive airworthiness approval of the design. The certification basis also represents the 'measure of merit' or 'required level of safety' against which a design is judged with regards to airworthiness.

3. The certification basis for most of the DND/CAF aircraft is composed of the airworthiness standards and certification criteria found in the TAA-approved airworthiness codes described in Part 1, Chapter 2 of the ADSM. The criteria are tailored and augmented, as required, to suit the specific aeronautical product type, its roles and operating environment. This may include the addition of standards from other airworthiness codes, as well as special conditions, when the standards in the codes are not adequate to address a novel or unique design feature.

1.3.4 TAM Requirements Related to a Certification Basis

1. The following are the TAM requirements that apply to the development of a certification basis for a new type design or a design change to an existing DND/CAF aircraft type:

a. **TAM Rule: 2.1.2.R3 Certification Basis for the Airworthiness Approval of a Type Design.** The certification basis, as specified in 2.1.2.S3, shall be submitted to the TAA for approval.

b. **TAM Standard: 2.1.2.S3 Certification Basis for the Airworthiness Approval of a Type Design.**

2. Subject to 2.1.2.S3.2 and 2.1.2.S3.3, the certification basis for a proposed type design of an aeronautical product is:

a. the applicable standards of airworthiness for the type of aeronautical product that were effective on the date of application for the airworthiness approval;

b. the applicable noise, fuel venting and engine emission standards that were effective on the date of the granting of airworthiness approval for the proposed type design; and

c. any special conditions, including additional standards of airworthiness specified by the TAA as necessary to ensure that an adequate level of safety is achieved for the proposed type design.

3. An applicant may, with the approval of the TAA, elect to include any later amendments to the standards of airworthiness specified in 2.1.2.S3.1 that are made after the date of application, in accordance with that paragraph, on condition that any related amendments are also included.

4. The TAA may, upon request by an applicant, grant an exemption or deviation to the applicable standards of airworthiness, in accordance with the *Aeronautics Act*, Section 5.9.

1.3.5 Certification Basis Structure

1. A certification basis consists of the following elements:

a. **Airworthiness Standards and Certification Criteria.** Selected from the following airworthiness codes described in Part 1, Chapter 2 of the ADSM:

(1) Civil Airworthiness Codes (AWM, 14 CFR and CSs); and

(2) Military Airworthiness Codes (U.S. MIL-HDBK-516, EMACC, DEF STAN 970).

b. **Special Conditions – Airworthiness.** Conditions imposed by a regulator when an airworthiness code does not have suitable airworthiness standards for a new or novel design to be certified. In this situation, the regulator can add new requirements to the certification basis by approving and issuing a special condition.

c. **Noise and Emission Standards.** As specified by the regulator.

d. **Exemptions and Deviations.** TAA and Operational Airworthiness Authority (OAA) authorization that allows for a specific certification requirement or standard to not be applied in full (exemption) or in part (deviation).

e. **Other Requirements.** Contractual design requirements or other requirements, as specified by the regulator, e.g., STANAGs.

f. **Advisory Material.** Advisory material may be included, by reference, in the certification basis to indicate the applicant's intention to comply with a specific design or process standards. Once advisory material has been included in the certification basis and accepted by the TAA, compliance becomes mandatory.

1.3.6 Development of the Certification Basis

1. The following are the process steps towards developing a new certification basis, whether for an entire new type design, or a major modification:

a. **Statement of Operating Intent (SOI).** Develop a SOI that identifies the intended roles, missions, tasks and in-service usage of the proposed aeronautical product in sufficient detail to support the selection of the appropriate airworthiness standards that will form the certification basis. The SOI is developed by Royal Canadian Air Force (RCAF) operational staff and approved by the Commander of 1 Canadian Air Division. Additional information about the SOI is available in the TAM, Part 2, Chapter 1, Annex A.

b. **Identification of Hazards.** Identify hazards that will influence the selection of the airworthiness standards and certification criteria, including hazards related to the aircraft's operating environment and military roles. Consider and use historical hazard and mishap data, including lessons learned from other systems. Identification of hazards is a responsibility of all of the participants in the hazard assessment process, including operational, technical and system safety personnel. During hazard identification, consider hazards that could occur over the life cycle of the system.

c. **Identification of the Airworthiness Code.** Identify to the TAA which airworthiness code(s) will be used to develop the certification basis.

d. **Selection of Applicable Airworthiness Standards.** From the airworthiness code, select the airworthiness standards and certification criteria that are applicable to the specific category and type of aircraft. If the military airworthiness codes are used, the MIL-HDBK-516 and EMACC handbooks refer to this process as 'tailoring the certification criteria'. This step is essential since the handbooks do not segregate the code into aircraft categories in the same manner as the civil codes.

NOTE

The ability of a specific aircraft design to meet a specific airworthiness standard has no bearing on the determination of applicability of that standard or the method of compliance. Establishing the certification basis is totally independent of the compliance determination that will come later on in the certification process.

e. **Special Conditions.** Determine if any special conditions will be required to provide suitable certification requirements for a novel or unique design feature that cannot be addressed by the existing standards available in the civil or military airworthiness codes.

f. **Exemptions and Deviations.** An applicant for a type certificate may apply for an exemption or deviation from compliance with specific airworthiness standards that would otherwise be included in the certification basis. The following highlights the difference between a deviation and an exemption:

(1) **Deviation from the Certification Basis.** A written authorization to depart from a certification requirement or a specified portion of the requirement. The airworthiness requirement is still applicable, however the deviation allows for a change (reduction) to a specific part or feature of the requirement. A deviation may be permanent or temporary, as defined in the deviation approval documents.

(2) **Exemption from the Certification Basis.** A written authorization that a specific certification requirement will not be applied. The boundaries of the exemption, with respect to future design changes, are defined in the exemption approval documents. The exemption could be specific to a particular piece of equipment, a system or a capability. For further information about the exemption and deviation approval process, refer to the TAM, Part 5, Chapter 9.

g. As part of the exemption or deviation approval, the TAA or OAA may also specify additional requirements, such as:

(1) The applicant must demonstrate that the consequences of not meeting the standards are negligible or, as a minimum, provide an acceptable level of safety; and

(2) Additional conditions or limitations may be imposed to supplement the unmet standard.

h. **Obtain TAA Approval of the Certification Basis.** As specified in TAM Rule 2.1.2.R3, the certification basis must be approved by the TAA. This may be done as part of the certification plan approval, or at a later time arranged with the TAA staff.

1.3.7 Establishing the Means of Compliance

1. Once the TAA approves the certification basis, a series of reviews and meetings are held as needed between the TAA and the applicant. The goal is to obtain concurrence on the proposed means and methods that will be used to demonstrate compliance for each of the certification requirements in the established certification basis. This is normally documented as part of the certification planning and compliance matrix development process and should include:

a. a complete breakdown of the means and methods of compliance with the applicable standards of the certification basis;

b. the method of compliance and where it is documented;

c. all the delegated functions involved in demonstrating compliance; and

d. the responsibility for findings of compliance (TAA or delegate).

2. The TAA and the applicant may also exchange various technical and issue papers to clarify and document concerns identified during this process and how the two parties have arrived at a consensus. Once the means of compliance have been agreed upon, this information should be added to the compliance matrix and the updated matrix submitted to the TAA for approval.

3. **Means of Compliance.** The term ‘means of compliance’ refers to the method by which compliance of the type design will be demonstrated for each certification. Selection of an appropriate means of compliance for each requirement in the certification basis depends on the appropriate effort necessary to prove compliance, unless a means of compliance is specifically stated in the applicable airworthiness standard, such as ‘must be shown by test’. The four primary means of compliance are the following (see examples in Figure 1-3-2):

a. Description;

b. Inspection;

c. Analysis; and

d. Test.

Means of Compliance	**Compliance Deliverables**
Description	• Drawings • Processes and Plans • Statements of Compliance • Service History • Technical Standards Orders (TSOs)
Inspection	• Mock-Up • Prototype/First Article • Zonal Safety Inspection
Analysis	• Structural Loads Analysis • Stress Analysis • Failure Modes and Effects Analysis (FMEA) • Aerodynamic/CFD • DO254 airborne electronic hardware • DO178 software • System Safety • Electrical Load Analysis • Equivalent Level of Safety (ELOS)
Test	• Component Test • Fatigue Test • Functional Test • Environmental Test • Simulation • Fire Test • Integrated Lab Test • Ground Test • Flight Test

Figure 1-3-2 Means of Compliance

4. **Method of Compliance.** The term ‘method of compliance’ refers to the detailed methodology used to demonstrate that the design complies with the applicable certification requirements. The method of compliance expands upon the ‘means of compliance’ by providing detailed information about how compliance will be demonstrated. Typically, the method of compliance refers to a procedure that contains the following type of information:

a. the specific (or worst case) conditions required to demonstrate compliance;

b. any critical assumptions used;

c. the pass/fail criteria (applicable normally to "Test" as a means of compliance);

d. an explanation of what specific levels of performance a system or component must attain to be in compliance; and

e. any other information considered important for describing how compliance is to be demonstrated.

5. It is recommended that the advisory material provided with the airworthiness codes be used to identify the appropriate means and methods of compliance. The TAA-approved advisory material is described in section 1.2.7 of the ADSM – Airworthiness Codes. It should also be noted that many of the airworthiness codes will directly identify the means of compliance that must be used. For example, 14 CFR 25.1309 (d) states: "*Compliance with*

the requirements of paragraph (b) of this section (i.e., 1309) must be shown by analysis, and where necessary by appropriate ground, flight or simulator tests." However, the detailed methodologies for conducting the required analysis are typically identified in the associated Advisory Circulars, such as, in this case, AC 25.1309.

1.3.8 Compliance Matrix

1. The compliance matrix contains a listing of the certification requirements, airworthiness standards, means of compliance, compliance artefacts and the individuals appointed as the finding authorities. When the findings of compliance have been completed, the compliance matrix, set of compliance artefacts and the approval from the finding authorities collectively form the 'Compliance Record' for the approved design.

2. An example of a compliance matrix structure is provided in Figure 1-3-3 (available internally, within DND, at AEPM RDIMS Library #1886690).

Certification Basis				**Means of Compliance**		**Proof of Compliance**	
Certification Requirement Ref No	**Airworthiness Standard**	**Airworthiness Requirement ID and Title**	**Applicability Comments**	**Means of Compliance**	**Method of Compliance**	**Compliance Artefacts**	**Finding Authority**
3.1.1	FAR 25.1419 Ice Protection	14 CFR 25.1419 (a) – Establishing the Adequacy of Icing Protection		Analysis	Analysis iaw procedure provided in AC 25.1419, para 3	Analysis Report ID #345 & Contractor Report #123	Mr. I.M. Finder
3.4.1	FAR 25.1419 Ice Protection	14 CFR 25.1419 (b) – Demonstrating Effectiveness of Icing Protection	Deviation #2105-04 RDIMS 12355	Test: Lab Test: Flight Test:	Flight testing procedure iaw AC25.1419, para 4-6 and AETE approved flight test plan	Test Reports: - Lab Test Rpt CDRL Item #347 - Flt Test Rpt CDRL Item #348	Mr. I.M. Finder
3.2.1	MIL-HDBK-516C - 1.14.1.1 System Safety	Verify Effective System Safety Process		Analysis	System Safety Program iaw MIL-STD 882E	System Safety Analysis RDIMS #23456	Mr. I.M. Finder
3.3.1	RS 1.2.34	Stores Clearance MIL-HDBK-516C Section 17.2	Mil-Stds and Process Selected from MIL-HDBK-244	Test	Lab Test iaw procedure in MIL-STD 464, Part 3, Section 1	Lab Test Report CDRL Item #345	Mr. I.M. Finder
3.4.1	Special Condition CH148-CERT-SC-003-09	Automatic mode control law transitions…	In addition to FAR 29.1335	Analysis and Ground Test	Safety Assessment Analysis iaw AC 25.1309(b) and ARP 4761	Safety Assessment Report CDRL Item #346	Mr. I.M. Finder

Figure 1-3-3 Sample Compliance Matrix

1.3.9 TAA Policy – Standards of Airworthiness for DND/CAF Aircraft

1. The section defines the TAA's policies regarding those airworthiness codes and standards that are to be used for establishing the initial certification basis for each category of aircraft, as well as for any subsequent design changes to the type design.

2. **Passenger-Carrying Civil Derivative Aircraft.** DND passenger-carrying civil derivative aircraft, used in roles comparable to civil passenger operations, shall normally continue to apply the airworthiness and safety standards defined in the airworthiness standard listed on the Civil Type Certificate for the maintenance and modifications of

that aircraft design. Where airworthiness standards from military airworthiness codes are to be applied to any aircraft modifications, the following shall apply:

a. The selected design and equipage standards shall normally provide a level of passenger safety that is, as a minimum, equivalent to the related civil standard; or

b. Where it is not possible to provide an equivalent level of safety to the civil standard, the differences between the military standard and related civil standard must be defined, assessed and approved during the airworthiness clearance process.

3. **Military Aircraft – Civil Derivative Hybrid Aircraft.** To meet military requirements, the DND will procure and operate civil derivative fixed and rotary-wing aircraft even when the intended use of such aircraft is not consistent with the original design, or a civil equivalent operation does not exist. A civil derivative hybrid aircraft is defined as a civil aircraft design that has been significantly modified for military purposes, either by a physical design change, or by a change in the intended usage.

4. To the extent practicable, DND-registered - civil derivative hybrid aircraft designs shall continue to follow the civil airworthiness standards defined in the DND Type Certificate for that type design. Where airworthiness standards from military airworthiness codes are to be applied to aircraft modifications, the following shall apply:

a. The selected standards should, to the extent practicable, provide, as a minimum, an equivalent level of safety to the related civil airworthiness standard; or

b. Where it is not possible to provide an equivalent level of safety, the differences between the military standard and related civil standard must be defined and approved during the airworthiness clearance process.

5. **Military Aircraft Designs.** DND/CAF military aircraft designs that have a certification basis based on military airworthiness codes shall normally continue to apply the airworthiness and safety standards defined in the certification basis listed in the DND Type Certificate for the maintenance and modifications of that aircraft design. The military airworthiness codes are intended to be tailored to suit a wide range of aircraft types, military functions and operating environments. Accordingly, the accepted level of safety defined in the certification basis for each specific military aircraft type may vary significantly among aircraft types, sizes and roles. For example, the number of redundant systems on a military fighter aircraft will likely be lower than that found on a large military transport aircraft. Similarly, the cargo hold of a military transport aircraft is not optimized for the passenger carriage role and many of the cabin safety features found on commercial passenger-carrying aircraft may be absent. As a result, during the initial certification process for a military aircraft design, it is critical that the certification basis development activities be focused on clearly establishing what the accepted level of safety must be set to, since this will become the baseline for all future design changes.

6. Figure 1-3-4 illustrates the current DND/CAF fleets grouped by certification basis category, depending on the origin of the aircraft design, the airworthiness code used by the original certification authority and the current military role of the fleet.

DND/CAF AIRCRAFT CERTIFICATION BASIS CATEGORY	CAF DESIGNATION	CAF NAME	PRIMARY ROLE
Passenger-Carrying Civil Derivative Aircraft (Civil Certification Basis)	CC150 (A310)	Polaris	Strat PAX Transport
	CT145 (C-90B)	King Air	PAX
	CC144	Challenger	VIP Pax Transport
Military Aircraft – Civil Derivative Hybrid	CC150T	Polaris - MRTT	PAX - AAR
	CT142	Dash 8	Navigation Trainer

Figure 1-3-4 (Sheet 1 of 2) DND/CAF Fleets by Certification Basis Category

DND/CAF AIRCRAFT CERTIFICATION BASIS CATEGORY	CAF DESIGNATION	CAF NAME	PRIMARY ROLE
	CC138	Twin Otter	PAX/Utility
	CT139	Jet Ranger	Trainer
	CT120 A	Grob	Trainer
	CH146	Griffon	Tac Utility /Cargo/Pax
	CH149	Cormorant	SAR
	CH148	Cyclone	Maritime Patrol
Military Aircraft (Military AW Code/Military Design Standards)	CC130J	Hercules	Tac Cargo/Utility
	D E L E T E D	D E L E T E D	D E L E T E D
	CC130E-H	Hercules	Tac Cargo/Utility
	CC177	Globemaster	Strategic Cargo/Utility
	CC295	Kingfisher	SAR/Utility
	CC330	Husky	Strat PAX Transport
	CP140	Aurora	Maritime Patrol
	CH147	Chinook F	Tac Cargo/Utility
	CF188	Hornet	Jet Fighter
	CT156	Harvard II	Turboprop Trainer
	CT155	Hawk	Jet Trainer
	CT114	Tutor	Jet Trainer/Display
	CUXXX	UAS	Uncrewed Aircraft Systems

Figure 1-3-4 (Sheet 2 of 2) DND/CAF Fleets by Certification Basis Category

1.3.10 Considerations for New Aircraft Acquisition Projects

1. Most new DND aircraft acquisition projects acquire existing civil or military aircraft designs that the contractor modifies to meet DND/CAF requirements. Typically, these projects fit into one of the following categories:

a. **Previously Certified Aircraft Design – No Modifications that Require TAA Certification.** The certification strategy is applicable to acquisition projects involving Commercial Off-The-Shelf (COTS) or Military Off-The-Shelf (MOTS) design, where the design is already certified by a TAA-recognized airworthiness authority. For this type of project, the certification basis for the new DND fleet will be based on the one approved by the Original Certification Authority (OCA) for the aircraft type. Examples are the CC177 Globemaster and CC144 Challenger fleets. In addition, any modifications that were required to meet the DND contractual requirements fall into one of the following categories:

(1) Minor design changes; or

(2) Major design changes that have been approved for the aircraft type by a TAA-recognized authority. An example would be a design change approved under a Supplemental Type Certificate (STC) by a TAA-recognized authority.

b. **Previously Certified Aircraft Design – Extensive DND-Unique Modifications.** This is the most common category of acquisition projects. In this case, the typical acquisition strategy is to require the bidders to propose an aircraft that is based on civil or military aircraft design that has been certified by a TAA-recognized airworthiness authority. The contracting term that DND uses in aircraft acquisition projects to describe a previously certified aircraft design is ‘Baseline Aircraft’ or ‘Basic Vehicle’ (BV). The contract will require the aircraft prime contractor to design and implement any DND-unique modifications to the BV that are necessary to meet the requirements specified in the acquisition contract. The contractor will also be required to perform most of the 'Proof of Compliance' testing and analysis required to provide the DND Project Office with the data they need to demonstrate to the TAA that the design changes meet the approved certification basis. The certification basis for those areas of the BV that are not affected by the DND-unique modifications will remain unchanged from the certification basis approved by the Original Certification Authority (OCA) for the aircraft type. The same set of certification requirements will normally be used to develop the certification basis for each of the DND design changes. However, the TAA may request the addition of certification requirements if the original certification basis does not have the capacity to address the military specific aspects of the modification. This is a common practice in situations where the BV was certified to a civil airworthiness code and DND is adding new military roles and mission equipment. In this event, the certification basis for the modifications may well be a mix of civil airworthiness codes, plus extracts from MIL-HDBK-516, as well as special conditions.

c. **New Aircraft Type Design – No Existing Certification Basis.** In the event where the TAA is requested to certify an entirely new type design that was being developed exclusively for the DND/CAF, a full certification basis for the new type design must be developed and submitted to the TAA for approval, in accordance with the guidance provided in section 1.3.5 of this chapter. The starting point in developing the certification basis could be any of the TAA-recognized civil or military airworthiness codes. Since the certification of any entirely new type design is a major undertaking, consultation between the TAA, Project Management Office and the design agency will be required to select the appropriate code(s) and agree on a certification basis.

1.3.11 Tailoring MIL-HDBK-516 and EMACC

1. Unlike the civil airworthiness codes that are divided into aircraft categories, e.g., 14 CFR Part 25 – *Transport Category Aeroplanes* and 14 CFR Part 29 – *Transport Category Rotorcraft*, the airworthiness criteria in the MIL-HDBK-516 and the EMACC handbooks are written to apply to any type of aircraft. As described in para 1.2.6 of the Airworthiness Codes chapter (Part 1, Chapter 2), the criteria in both the EMACC and MIL-HDBK-516 are organized by aircraft system, such as structures, avionics and electrical.

2. Not all of the airworthiness criteria apply to every type of air system. Therefore, it is essential to tailor the total set of criteria to identify a complete (necessary and sufficient) subset of applicable airworthiness criteria that will be used to establish the certification basis for a specific air system.

3. The certification basis should be created using a 'Top-down' approach, ensuring that all appropriate sections of the MIL-HDBK-516 or EMACC handbooks are captured. In some cases, an aircraft or modification may appear to have a narrow scope and, therefore, may seem to only affect a small number of sections of the handbook. However, it is important to capture the effect that changes to one system may have on the design, function or operating environment of other systems.

4. The primary objective in tailoring is to maintain the intent and context of the criteria. It is not an exercise intended to relax and/or degrade the criteria. In fact, for some military applications, tailoring may result in adding criteria beyond those available in the handbooks. Where possible, it is recommended that a risk-based approach to the evaluation of the potential impacts (if any) of the tailoring exercise be conducted.

5. Guidance for tailoring the criteria within the MIL-HDBK-516 and EMACC is provided within the handbooks. As an overview, tailoring rules are as follows:

a. Identify each criterion as either applicable, or non-applicable, considering the system or product's complexity, type, data and intended use. Document the rationale for identifying any criteria as non-applicable;

b. Applicable criteria should not be deleted. However, if a portion of otherwise applicable criteria does not apply or must be modified, it is essential that the intent and context is maintained;

c. Supplement applicable criteria with specific measurable parameters, where appropriate (i.e., they add value to the definition of airworthiness requirements); and

d. Develop additional criteria, as appropriate, for any capabilities or systems (including the whole/complete system) not fully addressed by the criteria contained in this document.

1.3.12 Aircraft Not Designed to a TAA-Recognized Airworthiness Code

1. Since formalized military airworthiness codes, like MIL-HDBK-516 and the EMACC, are relatively new, DND still operates military aircraft designs that have a certification basis that are not directly linked to any civil or military code. For example, the CH-47 Chinook F was developed by the U.S. Army using design standards from *Aeronautical Design Standard ADS-51-HDBK: U.S. Army Rotorcraft and Aircraft Qualification Handbook*. During the initial Type Design Examination (TDE) process, the TAA staff found that, while ADS-51 is not an airworthiness code, the resulting CH-47F was designed and certified (qualified) by the U.S. Army to most of the relevant airworthiness design standards found in MIL-HDBK-516. It is important to note that all of the DND-unique design changes that were developed under the DND contract to create the CH147F model were certified by DND using a certification basis developed from certification criteria selected from MIL-HDBK-516.

2. The DND/CAF has legacy military aircraft designs that may not have a certification basis that can be directly linked to a civil or military airworthiness code. This can be problematic, since the design change certification process, described in the TAM, Part 3, Chapter 2, requires that a certification basis for the areas impacted by the design change be defined and used to make the appropriate findings of compliance. For those military pattern aircraft that were produced to, or qualified against, a weapon system specification and do not have a clearly identifiable certification basis, the start point for developing a certification basis will be the airworthiness and design standards that are embedded within the weapon system specification as a whole. The standards in the original vehicle specifications may not address all of the airworthiness requirements in the ADSM, and additional airworthiness standards taken from one of the military or civil airworthiness codes may be required to form a complete certification basis for the design change.

1.3.13 Considerations for Modifications to In-Service Fleets

1. The following are considerations for establishing the certification basis for modifications to existing DND aircraft designs:

a. As a minimum, any major modifications to DND aircraft must satisfy the certification requirements defined in the aircraft's existing certification basis, regardless of whether or not the aircraft design was originally certified to a TAA-recognized airworthiness code.

b. The TAA may require that the modification meet a more recent version of an airworthiness standard, if providing the associated improvement in the level of safety is warranted and adoption is practicable.

2. The TAA-prescribed certification standards in this publication are not intended to be applied to in-service aircraft that are not undergoing modification (i.e., retroactive application). Where the TAA determines that the retroactive application of any requirements in this publication is warranted, this will be promulgated via separate direction.

PART 1
AIRWORTHINESS CODES AND DESIGN STANDARDS

CHAPTER 4 — AIRWORTHINESS DESIGN STANDARDS

1.4.1 Introduction

1. The term 'standards' appears throughout the ADSM. This chapter sets out the definitions and context for the full range of military and civil airworthiness design standards that are used in the ADSM, as well as throughout the Technical Airworthiness Program documentation.

2. This chapter provides the following information:

a. Definitions for the term 'Airworthiness Design Standard' and other related terms, including:

(1) Airworthiness Standards;

(2) Design Standards;

(3) Certification Standards;

(4) Civil Standards; and

(5) Military Standards;

b. An explanation of how these terms are used throughout the ADSM to provide advisory material for the design and certification of DND/CAF aircraft; and

c. A description of the civil and military design standards that may be used as references in a certification basis and means of compliance.

3. The DND/CAF does not normally develop its own aviation design standards, if acceptable standards have already been published by recognized airworthiness authorities, or if consensus standards of organizations that are recognized world-wide are already in place. The DND/CAF's practice is, therefore, to adopt and utilize a broad range of civil and military design standards that have been reviewed and deemed acceptable by its Technical Airworthiness Authority (TAA).

4. To minimize the cost and risks associated with new aircraft design development, the DND/CAF tends to acquire aircraft fleets that are based on existing designs, which have been certified by a TAA-recognized airworthiness authority. As a consequence, the standards used to design and certify the aircraft may not always be the TAA's preferred standard. However, it is essential that the standards used be 'acceptable' to the TAA. One of the primary objectives of this chapter, as well as the other chapters in the ADSM, is to identify those airworthiness design standards that are acceptable to the TAA for application to DND/CAF aircraft design development and certification.

1.4.2 Categories of Airworthiness Design Standards

1. Airworthiness Design Standards may be categorized in a number of ways. They may be characterized by their origin (e.g., military, civil, commercial, foreign or international), or classified according to their primary purpose (e.g., airworthiness standards, aircraft design standards, general design standards or certification standards). Often within the body of aircraft-related standards, a specific standard may fit into more than one of these categories. These classifications are used throughout the ADSM chapters and are defined as follows:

a. **Airworthiness Standards or Standards of Airworthiness.** These terms are those that are consistently used by major Civil Airworthiness Authorities (CAAs) to refer to the standards that CAAs have issued to govern the certification of aircraft designs. Examples include the U.S. Title 14 Code of Federal Regulations (14 CFR), the Transport Canada, Civil Aviation (TCCA) Airworthiness Manual (AWM) and the European Union Aviation Safety Agency (EASA) Certification Specifications (CSs), as described in the civil airworthiness codes section of Part 1, Chapter 2 of the ADSM. Airworthiness standards are used to define the certification basis for a new aircraft type design and for a major design change to an existing design.

b. **Certification Criteria.** The term 'Certification Criteria' is used extensively in both of the two major military airworthiness codes, the U.S. DoD MIL-HDBK-516 and the European Military Airworthiness Certification Criteria (EMACC) Handbook. The meaning and use of this term in the military handbooks is generally equivalent to the way the term 'airworthiness standard' is used in the civil codes. Certification criteria are used to construct the certification basis for military aircraft designs. Additional details about MIL-HDBK-516 and the EMACC are available in Part 1, Chapter 2 of the ADSM.

c. **Certification Standard.** The term 'Certification Standard' is normally used in the ADSM with the same meaning as the terms 'airworthiness standard' and 'certification criteria'.

d. **Aircraft Design Standards.** Design standards are industry- and government-recognized standards used in the design and development of a range of products to introduce consistency in the operation, manufacture, maintenance and materiel support of equipment and the delivery of related services. Aircraft design standards are a sub-set of the larger body of design standards that specifically apply to the design of aeronautical products. Aircraft design standards are typically published by a military or civilian standards organization for use in the design of aircraft (e.g., the U.S. MIL-STD, or the RTCA Inc. standards). During the design development process, the appropriate design standards are normally 'selected' by the design organization to achieve the functional and performance objectives that have been set for the design, as well as the safety objectives required to receive airworthiness approval. Aircraft design standards are frequently identified in the Advisory Circulars issued by airworthiness authorities as an acceptable means (or method) of demonstrating compliance to a certification standard. For example, in TCCA Advisory Circular (AC) No. 500-002 – *Electromagnetic Compatibility Testing of Electrical and Electronic Equipment*, the design standard SAE ARP 1870, titled *Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety* is identified as an acceptable means of demonstrating compliance to the certification standards identified in the AC.

e. **Airworthiness Design Standards.** The term 'Airworthiness Design Standards' is used in the ADSM as a general label when referring to all of the more specific terms listed above, including airworthiness standard, certification standard and certification criteria. Most of the chapters in Parts 2 through 5 of the ADSM contain a table or list of airworthiness design standards that have been deemed acceptable by the TAA for application to DND/CAF aircraft design and certification.

2. Airworthiness standards and certification criteria are not further described in this chapter. The airworthiness standards associated with the civil airworthiness codes are described in the Airworthiness Codes chapter (Part 1, Chapter 2). The chapter also provides useful website links to the full range of 14 CFR, AWM and CS airworthiness standards. The military certification criteria associated with U.S. MIL-HDBK-516 and the EMACC are also described in the Part 1, Chapter 2.

1.4.3 Military Design Standards

1. As stated in 1.4.2.1.e above, many of the technical chapters in Parts 2 through 5 of the ADSM include a list or table of airworthiness design standards that have been identified as being acceptable to the TAA for application to DND/CAF aircraft design and certification. This section describes the different classes of military design standards that appear in the equipment chapters of the ADSM.

2. **U.S. Defense Standards**

a. The U.S. Department of Defense (DoD) is the primary publisher of U.S. Defense Standards. The set of U.S. Defense Standards includes military standards, military specifications, military handbooks and Joint Service Specification Guides (JSSGs). The official terms, acronyms and definitions are provided in Figure 1-4-1. Collectively, these documents go by the rubric of 'U.S. Defense Standards' or 'U.S. Military Standards'.

b. U.S. Defense Standards have been issued to cover almost any conceivable aeronautical product. The published MIL-STD and MIL-SPEC standards include a wide range of military design requirements and airworthiness-related design requirements that are not separately identified as aviation-related.

Publication Type	Acronym	Definition
Military Handbook	**MIL-HDBK**	A document that provides standard procedural, technical, engineering, or design information about materiel, processes, practices and methods
Military Specification	**MIL-SPEC**	A document that describes the essential technical requirements for military-unique material or substantially modified commercial items.
Military Standard	**MIL-STD**	A document that establishes uniform engineering and technical requirements for military-unique or substantially modified commercial processes, procedures, practices, and methods. There are five types of defense standards: interface standards, design criteria standards, manufacturing process standards, standard practices, and test method standards.
Joint Service Specification Guide	**JSSG**	The Joint Service Specification Guides (JSSG) establish a common framework for developing program unique requirements documents for Air Systems, Air Vehicles, and major Subsystems. Each JSSG contains a compilation of candidate references, generically stated requirements, verification criteria, and associated rationale, guidance, and lessons learned for program team consideration.
Military Performance Specification	**MIL-PRF**	A performance specification states requirements in terms of the required results with criteria for verifying compliance, but without stating the methods for achieving the required results. A performance specification defines the functional requirements for the item, the environment and interface characteristics.
Detailed Specification	**MIL-DTL**	A specification that states design requirements, such as materials to be used, how a requirement is to be achieved, or how an item is to be fabricated or constructed. A specification that contains both performance and detail requirements is still considered a detail specification.

Figure 1-4-1 United States Defense Standards

c. In general, U.S. Defense Standards represent the combined requirements of operators, military airworthiness authorities and maintenance organizations for all design standards and specifications. As a result, these standards and specifications are based on numerous motivators, including performance, safety, interchangeability, geometry and maintainability. Care must be exercised in the selection of the standards to be used in the certification process, as only a subset of the standards may be specific to airworthiness.

d. Following pressure from industry and government to relax many of the requirements of the military standard system, the U.S. DoD is rationalizing a number of MIL-STDs/MIL-SPECs and their application. In general, MIL-STDs/MIL-SPECs that are equivalent or similar to commercial standards are being cancelled; the commercial equivalent is then either used ‘as is’, or adapted to suit specific requirements. Where there is no equivalent commercial standard, the MIL-STD/MIL-SPEC is being retained. MIL-STDs/MIL-SPECs that have been recognized by industry as being better than the commercial standard have been adopted by industry as a commercial standard to be managed by the appropriate industry body. In particular, the SAE Aerospace Council has an accelerated process for converting certain military standards to SAE standards, which are then maintained under the SAE system; further revisions will follow the established SAE consensus process. Therefore, when selecting a U.S. MIL-STD/MIL-SPEC for DND/CAF use, it must be checked to ensure that it is neither being changed, nor cancelled or out of date.

e. **Joint Service Specification Guides.** The U.S. Department of Defense Joint Service Specification Guides (JSSG) establish a common framework to be used by Government-Industry Program Teams in the Aviation Sector for developing program-unique requirement documents for air systems, air vehicles and major subsystems. Each JSSG establishes general requirements and verification parameters integration, performance and functions for the preparation of air system program-unique specifications. The program specifications developed from the JSSGs are used for contractual commitments between the U.S. Government and the prime contractor for the procurement of an air system.

f. The JSSGs were developed and published by the USAF Aerospace Systems Command (ASC-EN). The following is a list of the primary JSSGs. Electronic copies of the following JSSG are available internally, within DND, under AEPM RDIMS library #858914, or online, at JSSG AcqNotes.

(1) JSSG-2000 Air System;

(2) JSSG-2001 Air Vehicle;

(3) JSSG-2005 Avionic Subsystem, Main Body;

(4) JSSG-2006 Aircraft Structures;

(5) JSSG-2007 Engines, Aircraft, Turbine;

(6) JSSG-2008 Vehicle Control and Management System – VCMS;

(7) JSSG-2009 Air Vehicle Subsystems; and

(8) JSSG-2010 Crew Systems:

(a) JSSG-2010-1 Engineering Handbook;

(b) JSSG-2010-2 Crew Station Automation, Information and Control/ Display Management;

(c) JSSG-2010-3 Cockpit/Crew Station/Cabin Handbook;

(d) JSSG-2010-4 Aircrew Alerting Handbook;

(e) JSSG-2010-5 Aircraft Lighting Handbook;

(f) JSSG-2010-6 Sustenance and Waste Management Handbook;

(g) JSSG-2010-7 Crash Protection Handbook;

(h) JSSG-2010-8 Energetics Handbook;

(i) JSSG-2010-9 Personal Protective Equipment Handbook;

(j) JSSG-2010-10 Oxygen and Breathing Systems Handbook;

(k) JSSG-2010-11 Emergency Egress Handbook;

(l) JSSG-2010-12 Deployable Aerodynamic Decelerator (DAD) Systems Handbook;

(m) JSSG-2010-13 Survival, Search and Rescue (SSAR) Handbook; and

(n) JSSG-2010-14 Aircraft Windshield/Canopy Systems and Transparent Enclosures Handbook.

3. **NATO Standardization Agreements**

a. The Standardization Agreements (STANAGS) are standard agreements, issued by the NATO Military Agency for Standardization (MAS) Air Board, designed to ensure interoperability between aircraft of the NATO countries. Several of these STANAGS have been ratified by the DND/CAF for application on

Canadian military equipment. When ratified by Canada, compliance with STANAGs may be obligatory and could potentially conflict with the other standards listed in the ADSM. During a new aircraft acquisition, STANAGs must be considered and a general prioritization must be established, since these standards could take precedence over standards identified in the ADSM.

b. STANAGs of particular interest to the TAA are, for example, those currently under development by NATO to standardize the development and certification of military Uncrewed Aircraft Systems (UAS). The following NATO STANAGs are being developed to provide the minimum acceptable airworthiness requirements for design, construction and certification of military UAS:

(1) STANAG 4761 – UAS Airworthiness Requirements – Large Fixed-Wing;

(2) STANAG 4703 – UAS Airworthiness Requirements – Light Fixed Wing;

(3) STANAG 4702 – UAS Airworthiness Design Requirements – Heavy Rotary Wing; and

(4) STANAG 4746 – UAS Airworthiness Design Requirement – Light VTOL.

c. Electronic access to STANAGs is available on the following websites:

(1) DND NATO Standardization Coord Site (available only within the DND/CAF Defence Wide Area Network [DWAN]);

(2) DND STANAG Table (available only within the DND/CAF Defence Wide Area Network [DWAN]); and

(3) List of NATO STANAGs.

4. **Air Force Interoperability Council – Air Standards.** The Air Force Interoperability Council (AFIC) consists of air force representatives from the “Five Eyes” countries (Australia, Canada, New Zealand, United Kingdom and the United States of America). The Council’s purpose is to ensure that the five air forces remain interoperable. AFIC’s strength resides in its unique ability to leverage the Five Eyes’ collective expertise to develop timely, effective and economical solutions to potential interoperability problems. The AFIC Working Groups have published informative publications in a variety of focus areas, for example Military Parachuting, Electronic Flight Bags, Flight and Engineering Simulators, Defence Safety Agencies, and Micro UASs/RPAS.

1.4.4 Civil Design Standards

1. Most of the technical chapters in Parts 2 through 5 of the ADSM include a list or table of civil aviation design standards that have been identified as being acceptable to the TAA for application to DND/CAF aircraft design and certification. This section describes the different classes of civil design standards that appear in the ADSM.

2. Many industry organizations (such as the ones listed in sub-bullets a. through i. below) develop standards that are applicable for use in aircraft and aircraft equipment designs. Many standards published by such organizations are categorized as process standards and technical engineering standards.

3. The following are examples of globally-recognized standard-developing organizations for the aviation industry. Advisory material for the application of standards from these organizations is provided in the individual ADSM chapters:

a. RTCA Inc. (formerly the Radio Technical Commission for Aeronautics);

b. Society of Automotive Engineers (SAE);

c. European Organization for Civil Aviation Equipment (EUROCAE);

d. Aeronautical Radio Inc. (ARINC);

e. Institute of Electrical and Electronics Engineers (IEEE);

f. American National Standards Institute (ANSI);

g. International Electro-technical Commission (IEC);

h. Electronic Industries Alliance (EIA); and

i. International Organization for Standardization (ISO).

4. **RTCA Inc. Standards and Guidance Material**

a. RTCA Inc. produces minimum performance standards and guidance materials that are requested by the Federal Aviation Administration (FAA) and become a partial basis for FAA regulations related to aviation systems and equipage. They are produced by committees of volunteers representing the interested and relevant stakeholders. Special Committees (SCs) leverage the expertise of the best and brightest in the aviation community to generate recommendations. RTCA Inc. works with the FAA to develop comprehensive, industry-vetted and -endorsed standards that can be used as means of compliance with FAA regulations. Adherence to RTCA Inc. standards serves as one means of compliance with the related FAA regulations. Many RTCA Inc. documents have been recognized by the International Organization for Standardization (ISO) as de facto international standards.

b. Although RTCA Inc. is sponsored by the FAA, it is not an agency of the U.S. government. Hence, the documents it publishes are treated as guidelines, not as requirements. A listing of the available standards and guidance material published by RTCA Inc. is available on the following RTCA website: Available RTCA Documents.

c. Special Committees develop Minimum Aviation System Performance Standards (MASPS), Minimum Operational Performance Standards (MOPS) and guidance material. These documents shape the certification of the safety and efficiency of new equipment, and provide a competitive market for the implementation of these technologies. RTCA guidance material, MASPS and MOPS are frequently referred to by the FAA in Technical Standard Orders (TSOs) and Advisory Circulars (ACs) and, thereby, provide a partial basis for the certification of equipment.

d. MASPS specify characteristics that are useful to designers and users of systems intended for operational use within a defined airspace. Where the systems are global in nature, international applications are taken into consideration (often working with EUROCAE and/or the International Civil Aviation Organization (ICAO)). MASPS describe the system (subsystems / functions) and provide information needed to understand the rationale for system characteristics, operational goals, requirements and typical applications. Definitions and assumptions essential to a proper understanding of MASPS are provided, as well as minimum system test procedures to verify system performance compliance (e.g., end-to-end performance verification). The following are examples of MASPS that have been accepted by the TAA for use in DND/CAF aircraft design and certification:

(1) DO-236B/C – *Minimum Aviation System Performance Standards (MASPS) for Required Navigation Performance for Area Navigation*; and

(2) DO-242 – *Minimum Aviation System Performance Standards (MASPS) for Automatic Dependent Surveillance Broadcast (ADS-B)*.

e. MOPS provide standards for specific equipment(s) useful to designers and users of the equipment. The term "equipment" used in MOPS includes all components and units necessary for the system to properly perform its intended function(s). MOPS provide the information needed to understand the rationale for the stated equipment characteristics and requirements, describe typical equipment applications and operational goals, and establish the basis for required performance under the standard. Definitions and assumptions essential to proper understanding are provided, as well as installed equipment tests and operational performance characteristics for equipment installations. The following are examples of MOPS that have been accepted by the TAA for use in DND/CAF aircraft design and certification:

(1) DO-216 – *Minimum Operational Performance Standards (MOPS) for Global Positioning System / Aircraft Based Augmentation System Airborne Equipment*;

(2) DO-383A – *Minimum Operational Performance Standards (MOPS) for Required Navigation Performance Area Navigation*;

(3) DO-385 – *Minimum Operational Performance Standards (MOPS) for Airborne Collision Avoidance Systems*; and

(4) DO-367 – *Minimum Operational Performance Standards (MOPS) for Terrain Awareness and Warning Systems (TAWS) Airborne Equipment*.

f. In addition to the MOPS and MASPS, the RTCA document library includes a large number of publications that are considered guidance material. The introductory section of these documents typically uses the following phrases to describe the purpose of the publication: *"This document provides the aviation community with a set of methods and guidelines that may be used to demonstrate compliance with certification standards related to[….]"*. Examples of RTCA guidance documents that are commonly applied to the certification of avionics capabilities of DND/CAF aircraft designs include the following:

(1) DO-178C – *Software Considerations in Airborne Systems and Equipment Certification*;

(2) DO-254 – *Design Assurance Guidance for Airborne Electronic Hardware*;

(3) DO-160 – *Environmental Conditions and Test Procedures for Airborne Equipment*; and

(4) DO-278 – *Guidelines for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance*.

5. **Society of Automotive Engineers**

a. The Society of Automotive Engineers (SAE) is another industry body that publishes many aerospace standards, specifications and associated documents. These include Aerospace Standards (AS), Aerospace Recommended Practices (ARP), Aerospace Information Reports (AIR) and Aerospace Resource Documents (ARD). SAE standards apply to many aerospace applications and are used extensively in the U.S. The various documents are often referenced in FAA ACs and TSOs as acceptable means of compliance for systems (equipment, parts and components) that are not covered by RTCA documents.

b. The SAE Aerospace Council has approved and accelerated a process for converting certain military standards to SAE standards. The result of this process will have SAE continuously involved in reviewing a very large number of the U.S. military standards and specifications and, in due course, incorporating them into their standards system.

c. Two important SAE documents, authorized by the FAA and TCCA as acceptable means of compliance with standards for airworthiness, and accepted by the TAA for application to DND/CAF aircraft (See ADSM System Safety Chapter, Part 2, Chapter 1), are:

(1) SAE ARP 4761 – *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*. This document is primarily associated with showing compliance with FAR/JAR 25.1309 and covers Functional Hazard Assessment (FHA), Preliminary System Safety Assessment (PSSA), System Safety Assessment (SSA) and methods such as, Fault Tree Analysis (FTA), Failure Mode Effect Analysis (FMEA) for Highly Integrated or Complex Aircraft Systems and Common Cause Analysis (CCA).

(2) SAE ARP 4754 – *Certification Considerations for Highly-Integrated or Complex Aircraft Systems*. This document discusses the certification aspects of highly integrated or complex systems installed on aircraft, taking into account the overall aircraft operating environment and functions. The term "highly-integrated" refers to systems that perform or contribute to multiple aircraft-level functions. The term "complex" refers to systems whose safety cannot be shown solely by test and whose logic is difficult to comprehend without the aid of analytical tools. This document has been prepared primarily for electronic systems, which, by their nature, may be complex but readily adaptable to high levels of integration. However, the guidance provided may be considered for other aircraft systems. The focus is towards ensuring that safety is adequately assured through the development process, and towards substantiating the safety of the implemented system.

6. **Aeronautical Radio Inc.**

a. Aeronautical Radio Inc. (ARINC) publishes the standards developed by the Airlines Electronic Engineering Committee (AEEC), an international standards organization comprising major airline operators and other airspace users. The resulting documents are a consensus of the deliberations of airlines, industry, aircraft designers, avionics systems and avionics equipment designers in order to achieve standardization of air transport avionics equipment and systems. ARINC aviation standards are organized under the following series designations:

(1) 400 Series – provides standards for installation, wiring, data buses and databases;

(2) 500 Series – provides standards for analog avionics equipment used on early jet aircraft;

(3) 600 Series – provides standards for avionics equipment specified by the ARINC 700 series;

(4) 700 Series – describes the form, fit and function of avionics equipment installed predominately on transport category aircraft; and

(5) 800 Series – comprises a set of aviation standards for aircraft, including fiber optics used in high-speed data buses.

b. ARINC documents detail standardization characteristics for avionics equipment, such as flight data recorders and satellite communications, and for data buses and avionics architectures. The detailed documents concentrate on interchangeability and standardization of installation and wiring characteristics. These documents are aimed at systems designers to inform them of minimum industrial requirements. Other documents, such as the FAA TSOs and RTCA reports, reference these ARINC documents. Since systems conforming to ARINC "characteristics" are extensively used throughout the aerospace industry, these documents are frequently referenced when specifying highly integrated systems (e.g., flight management systems) design requirements.

c. The list of ARINC aviation-related standards can be found on the following ARINC website: ARINC Standards.

7. **European Organisation for Civil Aviation Equipment**

a. The European Organisation for Civil Aviation Equipment (EUROCAE) documents are considered by EASA to be acceptable means of compliance with Joint Technical Standard Orders and other regulatory documents. The main European administrations, aircraft and equipment manufacturers, and service providers are members of EUROCAE, and they actively participate in the working groups that prepare the EUROCAE documents.

b. The primary task of the EUROCAE working groups is to prepare performance specifications and similar documents that may be adopted as standards by the aviation industry. These standards are often referenced by aviation authorities or international organizations. They are most frequently MOPS or MASPS, although User Guides and other advisory materials are also developed.

c. EUROCAE documents pertain to avionics systems such as, radios, navigation systems, Cockpit Voice Recorders (CVRs), Flight Data Recorders (FDRs) and marker beacons. The following website provides access a summary of the activities of the EUROCAE working groups, as well as the publications and standards published by each working group: EUROCAE WGs .

8. **Institute of Electrical and Electronics Engineers**

a. In 1961, the U.S. electronic and electrical standards were blended under one organization: the Institute of Electrical and Electronics Engineers (IEEE). The standards and publication programs for the two disciplines were unified. The IEEE continues to develop, publish and provide standards in line with the expansion of information technologies and the technical needs of its members. Of particular interest to the DND/CAF are those standards pertaining to avionics, and airborne electronic and electrical equipment and systems. Where appropriate, these standards may be selected as a means of compliance with the DND/CAF airworthiness design standards.

b. A listing of the IEEE Aerospace Standards is available at the following section of the IEEE website: IEEE Standards List.

9. **American National Standards Institute**

a. The American National Standards Institute (ANSI) promotes the use of U.S. standards internationally, advocates U.S. policy and technical positions in international and regional standards organizations, and encourages the adoption of international standards as national standards where these meet the needs of the user community. Although ANSI itself does not develop American National Standards (ANSs), it provides all interested U.S. parties with a neutral venue to come together and work towards common agreements.

b. The DND/CAF can use ANSI to determine the status of standards developed by the two major international organizations: ISO and IEC. The National Standards Systems Network (NSSN), involving approximately 700 organizations, is a vehicle for navigating global standards information, by routing users to the appropriate source of technical data. It also indicates whether the developer has been accredited by ANSI. The NSSN web site also indicates the developers, who are also providing direct electronic access to their standards.

10. **Electronic Industries Alliance.** The Electronic Industries Alliance (EIA) is a U.S. organization that develops numerous standards for the electronics industry. They are regarded as an authoritative source for industry information, including aerospace electronics standards.

11. **International Electro-technical Commission**

a. The International Electro-technical Commission (IEC) was officially founded in 1906, in London, England, to “consider the question of the standardization of the nomenclature and ratings of electrical apparatus and machinery”. By 1914, the IEC had formed the first committees to deal with such topics as Nomenclature, Symbols and Rating of Electrical Machinery, and had also issued a first list of terms, definitions and international letter symbols, as well as names of units. In 1930, the IEC established a number of electrical units (including Hertz, Gauss, Maxwell and Weber) that eventually was extended and refined into a comprehensive system of physical units, which became the present *“Système International”*, or SI for short.

b. The IEC now resides in Geneva, Switzerland, and has expanded its coverage greatly to include standards for light, current, measurements, safety requirements, testing and specification of components for radio receivers and televisions, electro-acoustics, semiconductor devices, lasers, fibre optics, ultrasonics, wind turbine systems, fuel cell technologies, design automation and avionics.

12. **International Civil Aviation Organization**

a. The International Civil Aviation Organization (ICAO) is a United Nations (UN) specialized agency, established by Member States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). ICAO works with the Convention's 192 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

b. The mandate of ICAO is to develop the international civil aviation in a safe and orderly manner. To meet this mandate, ICAO publishes international conventions and protocols, and Annexes to the Chicago Convention on International Civil Aviation, for a wide range of aviation-related activities, including personnel licensing, rules of the air, meteorological services, aeronautical charts and the airworthiness of aeronautical products. ICAO publications have no status of law, unless they are directly referred to in the regulations of, or adopted by, a particular country. However, ICAO publications form the basis of the civil airworthiness codes of many nations throughout the world, including Canada.

c. **ICAO Annexes.** ICAO Annexes to the Convention on International Civil Aviation provide principles and arrangements to develop international civil aviation in a safe and orderly manner. Generally, the text of ICAO Annexes is embedded in the U.S. FAA and TCCA airworthiness and operations regulations. ICAO Annexes deal with a wide range of subjects (such as personnel licensing and rules of the air, as well as airworthiness of aircraft) but are often less stringent than those invoked by airworthiness authorities of the individual nations.

d. **ICAO Documents.** ICAO documents primarily pertain to international requirements as they relate to the operation of aircraft or airborne systems in international controlled airspace. ICAO document DOC 9051-AN/896 – *Airworthiness Technical Manual* covers both initial and continuing airworthiness concerns that are more general in nature. A notable point is that these standards are often less stringent than those invoked by individual regulators.

e. **ICAO Air Navigation Bureau.** The ICAO Air Navigation Bureau develops and maintains the ICAO Global Aviation Safety Plan and the Global Air Navigation Plan. The following two initiatives of the Air Navigation Bureau are of interest to the TAA:

(1) **Performance Based Navigation (PBN).** Performance-based Navigation (PBN) is helping the global aviation community reduce aviation congestion, conserve fuel, protect the environment, reduce the impact of aircraft noise and maintain reliable, all-weather operations, even at the most challenging airports. It provides operators with greater flexibility and better operating returns, while increasing the safety of regional and national airspace systems. Additional information is available at the ICAO website at ICAO PBN Manual; and

(2) **Performance Based Communication and Surveillance (PBCS).** The PBCS concept is aligned with that of PBN. While the PBN concept applies required navigation performance (RNP) and area navigation (RNAV) specifications to the navigation element, the PBCS concept applies required communication performance (RCP) and required surveillance performance (RSP) specifications to communication and surveillance elements, respectively. Additional information is available at the ICAO website at PBSC Overview.

PART 2
CERTIFICATION PROCESSES

CHAPTER 1 — SYSTEM SAFETY

2.1.1 Introduction

1. This chapter identifies those airworthiness design codes, and associated advisory and guidance material, deemed acceptable by the Technical Airworthiness Authority (TAA) with regards to their applicability to conducting a System Safety Program or assessment. It recognizes that the Department of National Defence/Canadian Armed Forces (DND/CAF) acquires, operates and maintains a mix of military and civil pattern aircraft.

2. System Safety Programs and related assessments exist to influence the design ofan aeronautical product through the use of structured methodologies, such that hazards are designed out of the system with an acceptable amount of residual risk. This chapter addresses System Safety Program requirements for a type design approval activity, as well as for type design changes.

2.1.2 Standards

1. Figure 2-1-1 and Figure 2-1-2 list those airworthiness codes that are deemed acceptable by the TAA for defining the certification basis and, specifically, System Safety Programs for DND/CAF aircraft. System Safety-related airworthiness code requirements are also indicated when possible.

Civil Airworthiness Codes	
Transport Canada Civil Aviation (TCCA)	
1.	**Airworthiness Manual (AWM) Chapter 523,** Normal Category Aeroplanes. 523.2510
2.	**AWM 525,** Transport Category Aeroplanes. 525.1309 (b) (c) (d)
3.	**AWM 527,** Normal Category Rotorcraft. 527.1309 (b) (c)
4.	**AWM 529,** Transport Category Rotorcraft. 529.1309 (b) (c) (d)
5.	**AWM 533,** Aircraft Engines. 533.75
6.	**AWM 535,** Propellers. 535.15
United States Federal Aviation Administration (FAA)	
1.	**Title 14 of the Code of Federal Regulations (14 CFR) Part 23,** Airworthiness Standards: Normal Category Airplanes. 23.2510
2.	**14 CFR Part 23,** Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes. 23.1309 (a) (b)
3.	**14 CFR 25,** Airworthiness Standards: Transport Category Airplanes. 25.1309 (b) (c) (d)
4.	**14 CFR 27,** Airworthiness Standards: Normal Category Rotorcraft. 27.1309 (b) (c)
5.	**14 CFR 29,** Airworthiness Standards: Transport Category Rotorcraft. 29.1309 (b) (c) (d)
6.	**14 CFR 33,** Airworthiness Standards: Aircraft Engines. 33.75
7.	**14 CFR 35,** Airworthiness Standards: Aircraft Propellers. 35.15
European Union Aviation Safety Agency (EASA)	
1.	**Certification Specification (CS)-23,** Normal Aeroplanes. CS 23.2510
2.	**CS-23,** Normal, Utility, Acrobatic, and Commuter Category Airplanes. CS 23.1309 (a) (b)
3.	**CS-25,** Large Aeroplanes. CS 25.1309 (b) (c) (d)
4.	**CS-27,** Small Rotorcraft. CS 27.1309 (b) (c)
5.	**CS-29,** Large Rotorcraft. CS 29.1309 (b) (c) (d)

Figure 2-1-1 (Sheet 1 of 2) Civil Airworthiness Codes Related to System Safety

Civil Airworthiness Codes	
6.	**CS-E,** Engines. CS 33.75
7.	**CS-P,** Propellers. CS 35.15

Figure 2-1-1 (Sheet 2 of 2) Civil Airworthiness Codes Related to System Safety

Military Airworthiness Codes	
European Defence Agency (EDA)	
1.	**European Military Airworthiness Certification Criteria (EMACC),** Handbook Edition 3.1, 25 Sept 2018 Section 14
North Atlantic Treaty Organization NATO	
1.	**STANAG 4671,** Unmanned Aircraft Systems Airworthiness Requirements (USAR). USAR.1309
2.	**STANAG 4702,** Rotary Wing Unmanned Aircraft Systems Airworthiness Requirements. USAR-RW.1309
3.	**STANAG 4703,** Light Unmanned Aircraft Systems Airworthiness Requirements. UL.30
4.	**STANAG 4746,** Unmanned Aerial Vehicle (UAV) Systems Airworthiness Requirements (USAR) for Light Vertical Take-Off and Landing (VTOL) Aircraft. UL.30
United Kingdom Ministry of Defence (UK MoD)	
1.	**Defence Standard (DEF STAN) 00-970,** Part 0 through 13, Certification Specifications for Airworthiness
United States Department of Defense (U.S. DoD)	
1.	**MIL-HDBK-516C,** Department of Defense Handbook, Airworthiness Certification Criteria, 12 December 2014, Section 14

Figure 2-1-2 Military Airworthiness Codes Related to System Safety

2.1.3 General

1. The minimum Acceptable Level of Safety (ALOS) for DND/CAF aircraft is defined in A-GA-005-000/AG-001, *DND/CAF Airworthiness Program*, Part 2: Airworthiness Requirements, Section 1 – Airworthiness Safety Criteria. In respect of an aeronautical product, the certification basis reflects the minimum acceptable level of safety as expressed by the airworthiness codes applicable to that product. Beyond this, the minimum ALOS is generally based on an acceptable incident rate that depends on severity and probability of occurrence, and that differs based on the aircraft type. New aircraft acquisitions and modifications to in-service aircraft and their associated systems and equipment shall, per A-GA-005-000/AG-001, comply with the mandated minimum ALOS as expressed by the applicable certification basis. The level of safety achieved during the certification process shall, per A-GA-005-000/AG-001, be maintained throughout the service life of the aircraft type, unless formally agreed upon, and documented by, the TAA.

2. In civil aviation, the system safety activity is required by the civil airworthiness codes for aeronautical products (i.e., aircraft, engines and propellers), such as is required under 14 CFR/AWM/CS section 25.1309. In the case of military aircraft, section 14.1 of both U.S. DoD MIL-HDBK-516C and the EMACC identify the requirements for a System Safety Program. The EMACC refers to UK DEF STAN 00-970 system safety requirements and STANAG 4671.1309 (for UAS) system safety requirements.

a. D E L E T E D

b. D E L E T E D

c. D E L E T E D

d. D E L E T E D

3. System Safety Programs employ a suite of engineering techniques to identify hazards, evaluate those hazards and then provide appropriate mitigations to address the hazards. Identification of hazards may be done using a

top-down approach (i.e., identify what the system does and how it can fail), or a bottom-up approach (i.e., how the components can fail and what the effect of that component failure is). Evaluation of hazards can be done using qualitative or quantitative methods. The treatment of hazards may use a system safety order of precedence, such as designing for minimum risk, incorporating safety devices, providing warning devices and development of procedures and training, or through other options, such as accepting or avoiding risk. Designing for minimum risk can be achieved using design strategies, such as the use of redundancy or backup systems, to enable continued functioning after any single failure, or the use of isolation or segregation of systems, components and elements, the failure of any one subsystem or system does not cause the failure of another.

4. D E L E T E D

a. D E L E T E D

b. D E L E T E D

c. D E L E T E D

d. D E L E T E D

5. An aircraft being acquired under an acquisition program will normally have an existing applicable civil or military system safety standard with associated documentation. Existing safety analyses may not be acceptable when considering the guidance provided in this ADSM chapter and the DND operating intent/environment.

6. Certain military system safety standards can have a larger scope than that of the civil safety system standards (e.g., Operating and Support, Health, or Environmental Hazard-related assessments). The TAA system safety requirements exclude hazards that do not have airworthiness effects, as defined by the applicable system safety program Plan, or the A-GA-005-000/AG-001.

7. The DND/CAF has various safety programs in place such as, General Safety, Laser Safety, Radio Frequency Safety, Nuclear Safety, etc. Although the system safety analyses may consider related hazards, the requirements in this chapter do not replace or alter those programs.

8. To assist in understanding the following paragraphs, a visual depiction of the correlation between the civil and the military system safety processes is provided in the generic system safety model shown by the “dashed” circles in Figure 2-1-3. The civil process key elements are reflected above the “dashed” circles, while the military process elements are shown below.

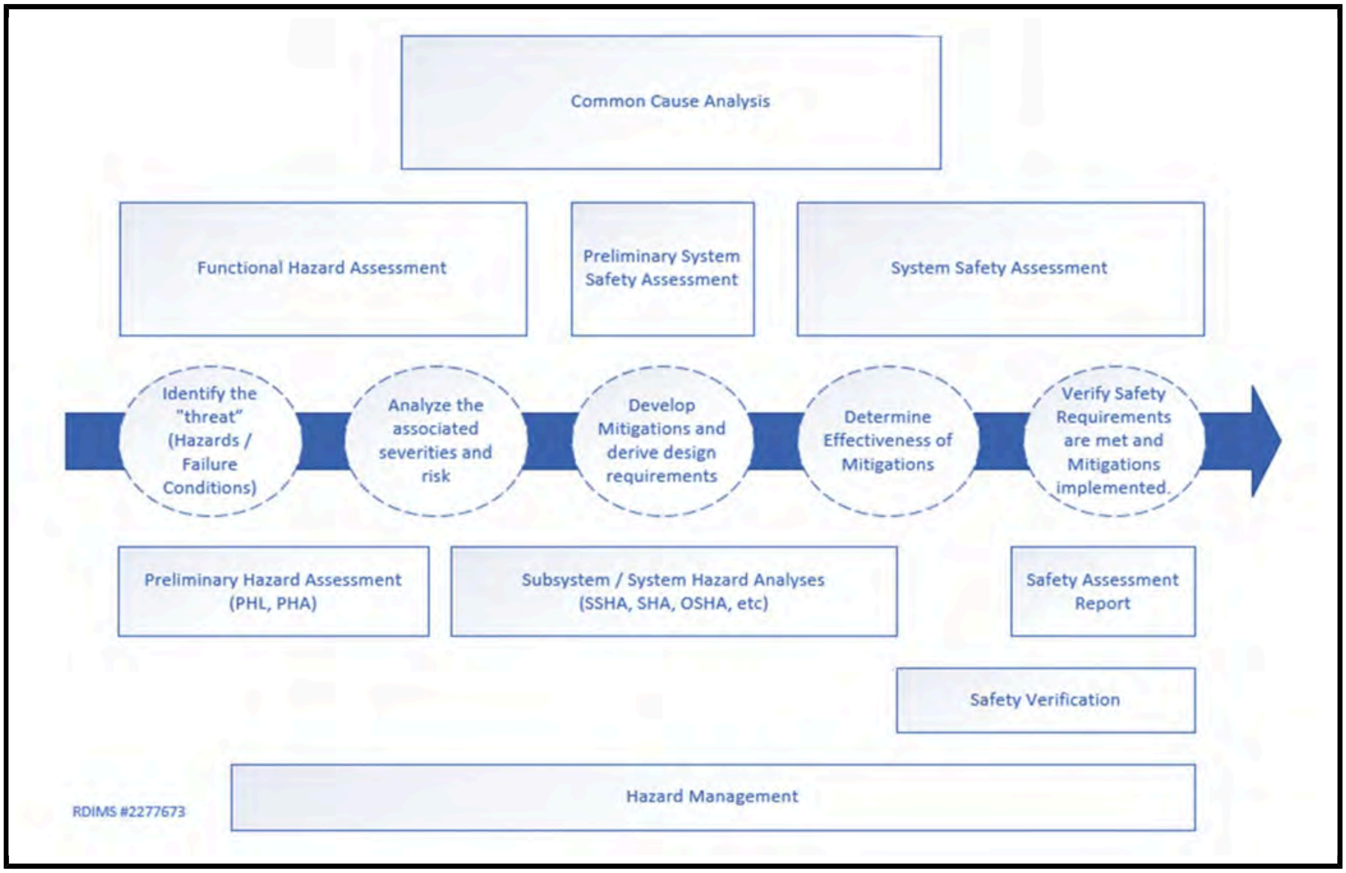

Figure 2-1-3 Generic System Safety Model

2.1.4 System Safety Program Requirements

1. **Standards.** A System Safety Program, which is based on either the civil airworthiness codes of Figure 2-1-1, or the military airworthiness codes of Figure 2-1-2, should meet:

a. from a civil perspective, the requirements of SAE ARP 4754A and ARP 4761. SAE ARP 4761 should be used as a guideline to meet the DND/CAF Airworthiness Program safety requirements; and

b. from a military perspective, the requirements of MIL-STD-882E, or later amendment. In the case of an existing military design aircraft that is being acquired, the version of MIL-STD-882 used at the time of initial airworthiness approval may continue to apply. For an aircraft that has no prior approval, or that is substantially modified, the latest amendment should apply. In each case, the applicability of MIL-STD-882 version should be discussed with the TAA.

NOTE

Annex D of TAA Advisory 2017-01 – Acquisition Contract Requirements for Obtaining Technical Airworthiness Clearance *provides proposed contract clauses that address both civil and military standards. The TAA tends to use the civil-based terms, and Annex D can be useful to identify corresponding terminology between the standards.*

2. **Advisory Material.** The TAA expects that, when available from the applicable airworthiness authorities, the advisory material provided in Figure 2-1-4 (in section 2.1.8) that corresponds to the applicable airworthiness code be applied.

3. **Alternate Standards.** When an applicant proposes to use system safety standards other than SAE ARP 4761 or MIL-STD-882E, the proposed program must:

a. be accepted by the TAA – the applicant should provide the alternate system safety standard and the System Safety Program Plan to the TAA, for evaluation and acceptance, as early as possible;

b. be shown to meet the essential requirements of 2.1.4.4; and

c. be shown to meet the mandated minimum acceptable level of safety defined by the certification basis.

4. **Essential Requirements.** The following is a summary of the essential requirements that a System Safety Program, based on either the civil design standards of Figure 2-1-1, or the military design standards of Figure 2-1-2, should meet (see Figure 2-1-3) and be documented in a System Safety Program Plan. Such a program needs to:

a. implement a defined process to identify the "threat" associated with the system, airborne electronic hardware, software and human system integration, i.e., hazard, hazardous conditions, failure conditions, unsafe conditions;

b. implement a defined process to analyze the severities and risk associated with the "threat" in regards to the operational environment. The software and airborne electronic hardware (AEH) hazard contributions need to be considered. Hazard severities and failure probability objectives must be defined (refer to 2.1.4.5);

c. implement an effective process for treating hazards and reducing risk to an acceptable level based on mitigation strategies, which may consider architecture, installation, or operational prodecures/limitations. Any unacceptable risk that cannot be mitigated must be addressed outside the System Safety Program and raised with the TAA;

d. determine the effectiveness of mitigation strategies to confirm, by some combination of analysis, examination or test, that the required minimum safety level has been achieved, resulting in acceptable risk; and

e. verify the implementation of the mitigation strategies and document the safety evidence. A defined process should be implemented for managing and communicating residual risk with stakeholders.

5. **Safety Objective Considerations**. The System Safety Program should consider the following:

a. the failure condition severity definitions and the corresponding failure probability objectivs are those defined by the airworthiness codes (i.e., used in the certification basis) and the corresponding advisory material (2.1.4.2). Such objectives must meet the airworthiness program's Minimum Required Levels of Safety provided in Part 2, Section 1 of A-GA-005-000/AG-001;

b. the failure condition classification is based on the severity of the failure effect. The A-GA-005-000/AG-001 defines DND/CAF aircraft severities, which include effects to ground personnel and the general public. Those effects have to be considered, if applicable, irrespective of 2.1.4.5.a;

c. the acceptable probability threshold for military aircraft airworthiness codes (Figure 2-1-2), is not clearly defined, since it is usually based on MIL-STD-882. As a result, the A-GA-005-000/AG-001 Part 2, Section 1 must be used to determine the risk acceptability threshold. Any unnacceptable risk either requires further mitigation, or results in a complaince issue that must be addressed outside the System Safety Program and raised with the TAA; and

d. Survivability Risks are considered outside the scope of the system safety requirements (survivability is generally addressed by specific airworthiness codes/design standards requirements).

6. **Documentation.** Documents created by the System Safety Program should include a compliance statement, with a list of all safety standards and regulations to which the design was demonstrated to be compliant, and should contain the following:

a. a technical description of the system;

b. a list of all hazards associated with the system;

c. identification of all related safety requirements (higher level and derived);

d. allocation of system safety requirements (higher level and derived) between software and airborne electronic hardware, including architectural safety devices and interlocks, cockpit warnings and cautions, and Approved Flight Manual (AFM) Limitations, Warnings, Cautions and Notes;

e. allocation of Design Assurance Levels (DALs) for the software and the airborne electronic hardware;

f. all assumptions, descriptions and explanations used for the analysis development;

g. formal verification to show that the safety requirements (high level and derived) have been met;

h. traceability of safety requirements from design to implementation and to verification; and

i. a summary of all resulting operating limitations and certification maintenance requirements, which are applicable to the final system configuration.

2.1.5 System Safety Design Requirements

1. There are specific system safety design requirements that apply to military and civil aircraft subject to type design approval. The overall System Safety Program provides context for the implementation of design requirements, such as determining tolerable risk levels, hazard severity and likelihood definitions, etc. The following are to be considered:

a. The design should not permit a single-point failure, which could cause a hazard of catastrophic severity.

b. The design should adequately protect the power sources, controls and critical components of redundant subsystems from common cause hazards.

c. Software and AEH elements of a design should be assured and designed such that design error probabilities are reduced to an acceptable level when contributing to catastrophic, hazardous or major hazards (or the equivalent critical and marginal MIL-STD-882 severities).

d. The design of a safety-critical system should minimize the inadvertent initiation or operation of the system by human error.

e. Warnings, cautions or other advisory notifications should not be used as the only risk reduction method for hazards assessed with catastrophic, critical (MIL-STD-882 definition) or hazardous (SAE ARP 4761 definition) severities.

f. When failure probability calculations use risk exposure periods, an appropriate risk exposure period should be chosen, and the System Safety Program failure probability objective should be achieved/maintained. A probability of one should usually be used for encountering a discrete condition for which the airplane is designed, such as instrument meterological conditions or Category III weather operations.

2.1.6 Miscellaneous/Mission Equipment

1. There are systems that may be installed on an aircraft, such as military specific mission equipment, that may be essential for performance of the military mission but whose function is not required to safely take off, fly or land the aircraft, from a technical airworthiness perspective. However, malfunctioning and erroneous behaviour of all systems should be addressed under the applicable system safety airworthiness code requirements as listed

in Figure 2-1-1 and Figure 2-1-2 and they should not have adverse effects on the operation of the required systems/equipment during normal operation. They should not have any impact on emergency or abnormal operating procedures, and should not create additional workload for the cockpit crew at critical times/phases of flight. When the equipment provides functions that have a safety impact, such functionality requires certification. TAA Advisory 2006–04 – Installation of Miscellaneous Non-Required Equipment, provides further clarification on the minimum considerations for installation and approval of miscellaneous/mission equipment.

2.1.7 Design Changes

1. Design changes must comply with the System Safety Program processes for the aircraft, in accordance with the advisory material corresponding to the applicable airworthiness code or the System Safety Program Plan, when applicable. As part of a design change, the need to consider system safety impact will be driven by the specific certification basis selected for the design change (such as 14 CFR/AWM/CS XX.1309), the scope and complexity of the design change and whether a System Safety Program had been implemented for the aircraft. The applicant must involve the TAA when system safety processes/plan do not exist, or when alternate standards are intended to be used. In the latter case, the system safety approach to be used must be described or referenced in the certification plan.

2. **Requirements.** The following should be addressed:

   a. Ground personnel failure effects must be considered as part of the assessments (refer to 2.1.4.5.b).

   b. For Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) complex functionalities, the Design Assurance of all systems (new and legacy) contributing to the related hazards must be assessed against civil standard (as per the A-GA-005-000/AG-001, Part 2, Section 1) since DND has a responsibility to operate with due regard for the safety of other traffic.

   c. The new system(s) may have been assessed using a standard that is different from the system safety airworthiness design standard of the aircraft. The installation certification must ensure that the installation is compliant with the aircraft system safety airworthiness design standard.

   d. New systems/installations need to be analyzed to identify new aircraft functional failure conditions. The failure conditions may be the result of a component failure, or a combination of low level failures. This functional assessment determines all possible failure conditions and their severity on the aircraft. In simple cases, a formal Functional Hazard Analysis (FHA) may not be required, but the findings of the process must be documented, as it determines the depth of system safety analysis. The following considerations apply:

      (1) If there is no safety effect, no further analysis is required.

      (2) If the highest severity is Minor, the system(s)/installation should be verified by a design and installation appraisal. The FHA is optional and a System Safety Assessment (SSA) is not required.

      (3) If the highest severity is Major or above, a FHA is recommended. Unless it can be clearly demonstrated in the certification plan that the design change is simple and meets all safety objectives, a SSA is required.

      (4) For the software and AEH integrity, an analysis to determine the required DAL level is required (unless the system has no safety effect).

   e. The impact on the existing aircraft functional failure conditions must be assessed, and it must be demonstrated that the applicable safety objectives are maintained. The following considerations apply:

      (1) The intent is to confirm that the level of safety of the approved type design is maintained.

      (2) The TAA recognizes that data may be limited. In-service maintenance data or other justification/argument (similarity or other) may be used to support the assessment.

f. Legacy systems/installations that contribute to new or existing failure conditions impacted by the design change may not meet all the paragraph requirements of 2.1.5. The following should be considered:

(1) For existing hazards, unmodified legacy systems are acceptable from a Design Assurance perspective.

(2) For new hazards, unmodified legacy systems may be acceptable from a Design Assurance perspective, if the legacy system contributes to other existing hazards that are of the same severity or higher.

(3) Design Assurance of the legacy systems does not require assessment, if the functional hazard severity is unchanged (unless a specific new requirement applies).

(4) Single-Point Failures of legacy systems/installations may be acceptable, if the safety objective for assessed hazards (new and existing) is acceptable. However, such condition should be clearly identified in the certification plan and/or related safety analyses.

2.1.8 Associated Publications, Specifications and Standards

1. Figure 2-1-4 lists those publications that identify means of demonstrating compliance with the airworthiness design standards, or which identify associated advisory material.

Associated Publications and Standards		
Regulator or Organization	**Reference Number**	**Title**
DND	TAA Advisory 2006-04	Installation of Miscellaneous Non-Required Equipment
EASA	AMC 25.1309	System design and analysis
FAA	AC 20-168	Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E)
	AC 20-174	Development of Civil Aircraft and Systems
	AC 20-177	Design and Installation Guidance for an Airborne System for Non-Required Telecommunication Service in Non-Aeronautical Frequency Bands
	AC 21-50	Installation of TSOA Articles and LODA Appliances
	AC 23.1309-1E	System Safety Analysis and Assessment for Part 23 Airplanes
	AC 25-11B	Electronic Flight Displays
	AC 25.1309-1A	System Design and Analysis
	AC 27.1B	Certification of Normal Category Rotorcraft
	AC 29.2C	Certification of Transport Category Rotorcraft
	AC 33-2C	General Type Certification Guidelines for Turbine Engines
	AC 33.28-1	Compliance Criteria for 14 CFR Section 33.28 Aircraft Engines, Electrical and Electronic Engine Control Systems
	AC 33.75-1	RTCA Inc.Guidance Material for 14 CFR Section 33.75 Safety Analysis
RTCA	DO-313	Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems and Equipment
SAE	ARP 4754A	Aerospace Recommended Practice, Guidelines for Development of Civil Aircraft and Systems

Figure 2-1-4 (Sheet 1 of 2) Associated Publications and Standards Related to System Safety

Associated Publications and Standards		
Regulator or Organization	**Reference Number**	**Title**
SAE (Cont)	ARP 4761	Aerospace Recommended Practice, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
U.S. DoD	MIL-STD-882E	Department of Defense, Standard Practice, System Safety
UK MoD	DEF STAN 00-56	Safety Management Requirements for Defence Systems

Figure 2-1-4 (Sheet 2 of 2) Associated Publications and Standards Related to System Safety

PART 2
CERTIFICATION PROCESSES

CHAPTER 2 — HUMAN FACTORS

2.2.1 Introduction

1. Human Factors (HF) is the branch of science that studies human characteristics and uses this information to improve people's interactions with the things they use and the environments in which they use them. HF knowledge can be applied to product design or modification to increase efficiency, safety, well-being and user satisfaction. The focus of HF in the context of airworthiness certification is related to achieving an acceptable level of safety. For the purpose of this chapter, the Human Factors definition in MIL-HDBK-1908 is applicable.

2. For assistance in interpretation and/or Means of Compliance to HF airworthiness certification rules, contact HF specialists in DTAES 6.

3. Airworthiness regulations were initially written, and subsequently updated, to reflect a 'traditional' engineering approach to system design (system-by-system). This is evident in the arrangement of the CS and 14 CFR regulations into major sections with each section containing the control and display requirements for that system. By contrast, the HF approach to systems design is task oriented, considering the interface requirements for performing a task. Inherent to this approach is the idea that the successful completion of many tasks involves interaction with several different systems. Thus, the HF approach recognizes that it is necessary for the different systems to be integrated such that they present a consistent interface to the operator.

2.2.2 Scope

1. This chapter sets out the acceptable airworthiness standards for the HF aspects of the Canadian Armed Forces (CAF) aerospace equipment and systems. It addresses both military and civil pattern aircraft.

2.2.3 Standards and Specifications

1. Airworthiness standards listed in the following figures are acceptable for application to DND/CAF aircraft, with regards to HF aspects.

Military Airworthiness Design Standards	
UK MoD	
1.	**DEF STAN 00-970,** Issue 1, Volume 1, Aeroplanes: Design and Airworthiness Requirements for Service Aircraft
2.	**DEF STAN 00-970,** Issue 1, Volume 2, Rotorcraft: Design and Airworthiness Requirements for Service Aircraft
3.	**DEF STAN 00-25** (Part 1), Issue 2, Human Factors: Human Factors for Designers of Equipment
U.S. DoD	
1.	**JSSG-2009,** Air Vehicle Subsystems
2.	**JSSG-2010,** Crew Systems
3.	**MIL-STD-203,** Aircrew Stations Controls and Displays: Location, Arrangement and Actuation of, for Fixed Wing Aircraft
4.	**MIL-STD-250,** Aircrew Station Controls and Displays for Rotary Wing Aircraft
5.	**MIL-STD-411,** Aircrew Station Alerting Signals
6.	**MIL-STD-490,** System/Segment Specification for the Tactical Work Stations
7.	**MIL-STD-850,** Aircrew Station Vision Requirements for Military Aircraft

Figure 2-2-1 (Sheet 1 of 2) Military Airworthiness Design Standards Related to Human Factors

Military Airworthiness Design Standards	
8.	**MIL-STD-1333,** Aircrew Station Geometry for Military Aircraft
9.	**MIL-STD-1472,** Human Engineering
10.	**MIL-STD-1521,** Technical Reviews and Audits for Systems, Equipment & Computer Software
11.	**MIL-STD-1787,** Aircraft Display Symbology
12.	**MIL-STD-2525,** Common War Fighting Symbology
13.	**MIL-STD-3009,** Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible

Figure 2-2-1 (Sheet 2 of 2) Military Airworthiness Design Standards Related to Human Factors

Civil Airworthiness Design Standards	
TCCA Airworthiness Manual (AWM)	
1.	**AWM 523,** Normal, Utility, Aerobatic and Commuter Category Aeroplanes
2.	**AWM 525,** Transport Category Aeroplanes
3.	**AWM 527,** Normal Category Rotorcraft
4.	**AWM 529,** Transport Category Rotorcraft
U.S. Title 14 Code of Federal Regulations (14 CFR)	
1.	**14 CFR 23,** Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes
2.	**14 CFR 25,** Airworthiness Standards: Transport Category Airplanes
3.	**14 CFR 25.771 (a),** Pilot Compartment
4.	**14 CFR 25.771 (e),** Pilot Compartment
5.	**14 CFR 25.773 (a)(1),** Pilot Compartment View
6.	**14 CFR 25.773 (a)(2),** Pilot Compartment View
7.	**14 CFR 25.773 (b)(2)(i),** Pilot Compartment View
8.	**14 CFR 25.777 (a),** Cockpit Controls
9.	**14 CFR 25.777 (c),** Cockpit Controls
10.	**14 CFR 25.785 (g),** Seats, Berths, Safety Belts, and Harnesses
11.	**14 CFR 25.785 (l),** Seats, Berths, Safety Belts, and Harnesses
12.	**14 CFR 25.1141 (a),** Power plant Controls: General
13.	**14 CFR 25.1301 (a),** Function and Installation
14.	**14 CFR 25.1309 (c),** Equipment, Systems, and Installations
15.	**14 CFR 25.1321 (a),** Arrangement and Visibility
16.	**14 CFR 25.1321 (e),** Arrangement and Visibility
17.	**14 CFR 25.1322,** Warning, Caution, and Advisory Lights
18.	**14 CFR 25.1357 (d),** Circuit Protective Devices
19.	**14 CFR 25.1381 (a)(2),** Instrument Lights
20.	**14 CFR 25.1523,** Minimum Flight Crew
21.	**14 CFR 25.1543 (b),** Instrument Markings: General
22.	**14 CFR 27,** Airworthiness Standards: Normal Category Rotorcraft
23.	**14 CFR 29,** Airworthiness Standards: Transport Category Rotorcraft
European Union Aviation Safety Agency Certification Specifications (CSs)	
1.	**CS-23,** Normal, Utility, Aerobatic and Commuter Category Aeroplanes
2.	**CS-25,** Large Aeroplanes
3.	**CS-27,** Small Rotorcraft

Figure 2-2-2 (Sheet 1 of 2) Civil Airworthiness Design Standards Related to Human Factors

Civil Airworthiness Design Standards
4. **CS-29,** Large Transport Rotorcraft
D E L E T E D
1. D E L E T E D
2. D E L E T E D
3. D E L E T E D
4. D E L E T E D

Figure 2-2-2 (Sheet 2 of 2) Civil Airworthiness Design Standards Related to Human Factors

DND/CAF – Ratified International Airworthiness Design Standards
NATO
1. **AIR STD 61/116/1H,** Operation of All Controls and Switches at Aircrew Stations
2. **AIR STD 61/116/2G,** Location and Actuation of Airframe Controls in Fixed Wing Aircraft
3. **AIR STD 61/116/3K,** Location, Actuation and Shape of Airframe controls for Rotary Wing Aircraft
4. **AIR STD 61/116/4K,** Services Operable from Stick Grips
5. **AIR STD 61/116/5M,** Aircrew Station Warning, Cautionary and Advisory Signals
6. **AIR STD 61/116/6D Ch1,** Human Engineering Design Criteria for the Use of Aircrew Station Controls and Displays
7. **AIR STD 61/116/7C,** Control Shapes
8. **AIR STD 61/116/9B,** Aircraft Mock-Up Inspection Techniques
9. **AIR STD 61/116/13 Ch1,** The Application of Human Engineering to Advanced Aircrew Systems
10. **AIR STD 61/116/15H,** Location and Arrangement of Flight and Engine Parameter Displays in Aircrew Stations
11. **AIR STD 61/116/16,** Electronically and Optically Generated Display Formats and Symbology for Fixed Wing Aircraft.
12. **AIR STD 61/116/21,** Colours and Markings Used to Denote Operating Ranges of Aircraft Displays
13. **AIR STD 61/116/25,** Location and Grouping of Electrical Switches
14. **AIR STD 61/116/26,** Emergency Control Colour Schemes
15. **AIR STD 61/116/27,** Numbering of Engines and their Associated Controls and Displays in Aircraft
16. **AIR STD 61/116/28,** Circular Dial Altimeters and Calibration Procedures
17. **AIR STD 61/116/29,** Aircrew Station Control Panels
18. **AIR STD 61/116/30,** Circular Dial Engine Indicators
19. **STANAG 3217,** Operation of Controls and Switches at Aircrew Stations
20. **STANAG 3219,** Location and Grouping of Electrical Switches in Aircraft
21. **STANAG 3224,** Aircrew Station Lighting
22. **STANAG 3258,** Position of Pilot Operated Navigation and Radio Controls
23. **STANAG 3329,** Numerals and Letters in Aircrew Stations
24. **STANAG 3370,** Aircrew Station Warnings, Cautionary and Advisory Signals
25. **STANAG 3436,** Colours and Markings Used to Denote Operating Ranges of Aircraft Instruments
26. **STANAG 3504,** Cathode Ray Tube Head-Down Displays (Monochrome)
27. **STANAG 3639,** Aircrew Station Dimensional Design Factors
28. **STANAG 3643,** Coating, Reflection Reducing for Glass Elements Used in Aircrew Station Displays
29. **STANAG 3647,** Nomenclature in Aircrew Stations

Figure 2-2-3 (Sheet 1 of 2) DND/CAF–Ratified International Airworthiness Design Standards Related to Human Factors

	DND/CAF – Ratified International Airworthiness Design Standards
30.	**STANAG 3701,** Aircraft Interior Colour Schemes
31.	**STANAG 3705,** Human Engineering Design Criteria for Controls and Displays in Aircrew Stations
32.	**STANAG 3869,** Aircrew Station Control Panels
33.	**STANAG 3871,** NATO Glossary of Aircraft – Aircrew Integration Specialist Terminology and Abbreviations
34.	**STANAG 3940,** Aircraft Electronic Colour Display Systems.
35.	**STANAG 3950,** Helicopter Design Criteria for Crew Crash Protection and Anthropometric Accommodation
36.	**STANAG 3994,** Application of Human Engineering to Advanced Aircrew Systems
37.	**STANAG 7044,** Functional Aspects of Mission Planning Station Interface Design
38.	**STANAG 7095,** Flat Panel Technology Display Design Criteria
39.	**STANAG 7096,** Location, Actuation and Shape of Airframe Controls
40.	**STANAG 7139,** Aircraft Engine Controls, Switches, Displays, Indicators, Gauges and Arrangements
41.	**STANAG 7140,** Aircraft Flight Instruments Layout and Display
42.	**STANAG 7161,** Aircraft Display Symbology

Figure 2-2-3 (Sheet 2 of 2) DND/CAF–Ratified International Airworthiness Design Standards Related to Human Factors

2.2.4 Guidance Information – General

1. The FAA provides considerable guidance regarding their 14 CFR regulations in the form of Advisory Circulars (ACs) and has also published policy documents with respect to HF in certification. This guidance may be of considerable assistance, regardless of the civil standards used for certification, since many of the standards contain equivalent rules.

NOTE

These certification rules will need to be tailored to the specific aircraft type and for the particular build or modification being undertaken. Also, where the civil regulations are insufficient to cover specific military applications, equipment, environments and systems, certification rules may be taken from DEF STANs, MIL-STDs, STANAGs, and AIR STDs (see 2.2.5).

2. 14 CFR 25 is the primary source of acceptable HF certification rules, since the FAA provides considerable guidance that is specific to these rules. Nevertheless, there may be other 14 CFRs specific to particular systems and that have HF implications, which may be cited as an airworthiness requirement. Contact DTAES 6 (Human Factors specialists) directly for assistance or advice in this regard.

3. Figure 2-2-4 shows the 20 desirable certification rules for HF drawn from 14 CFR Part 25 (Transport Category Airplanes) and their equivalents in 14 CFR Parts 23, 27, and 29. In addition, there are equivalent rules in the respective CS and AWM categories.

14 CFR 25	14 CFR 23	14 CFR 27	14 CFR 29
25.771(a)	23.771(a)	27.771(a)	29.771(a)
25.771(e)	-	27.771(c)	29.771(c)
25.773(a)(1)	23.773(a)(1)	27.773(a)(1)	29.773(a)(1)
25.773(a)(2)	23.773(a)(2)	27.773(a)(2)	29.773(a)(2)
25.773(b)(2)(i)	-	-	29.773(b)(2)
25.777(a)	23.777(a)	27.777(a)	29.777(a)
25.777(c)	25.777(b)	25.777(b)	25.777(b)

Figure 2-2-4 (Sheet 1 of 2) Cross-Reference of Acceptable Human Factors 14 CFR standards

14 CFR 25	14 CFR 23	14 CFR 27	14 CFR 29
25.785(g)	23.785(d)(e)(g)	27.785(c)	29.785(c)
25.785(l)	-	-	-
25.1141(a)	-	-	29.1141(a)
25.1301(a)	23.1301(a)	27.1301(a)	29.1301(a)
25.1309(c)	23.1309(b)(3)		29.1309(c)
25.1321(a)	23.1321(a)	27.1321(a)	29.1321(a)
25.1321(e)	23.1321(e)	27.1321(d)	25.1321(g)
25.1322	23.1322	27.1322	29.1322
25.1357(d)	23.1357(d)	27.1357(d)	29.1357(d)
25.1381(a)(2)	-	25.1381(b)(2)	25.1381(b)(2)
25.1523	23.1523	27.1523	29.1523
25.1543(b)	23.1543(b)	27.1543(b)	29.1543(b)

Figure 2-2-4 (Sheet 2 of 2) Cross-Reference of Acceptable Human Factors 14 CFR standards

2.2.5 Associated Publications and Standards Related to HF

1. The source references listed in Figure 2-2-5 are associated with HF.

Regulator or Organization	Number	Title
FAA	ANM-01-03	Factors to Consider when Reviewing an Applicant's Proposed Human Factors Methods of Compliance for Flight Deck Certification
	ANM-99-2	Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks
	AC 20-88A	Guidelines on the Markings of Aircraft Power plant Instruments (Displays)
	AC 25-11A	Electronic Flight Deck Displays
	AC 25.773-1	Pilot Compartment View Design Consideration
	AC 25.1302 (Proposed)	Installed Systems and Equipment for use by the Flight Crew
	AC 25.1309	Equipment, Systems and Installation
	AC 25.1309-1B	System Design and Analysis
	AC 25.1322	Flight Crew Alerting
	AC 25.1333(b)	Instrument Systems
	AC 25.1523-1	Minimum Flight Crew
	AC 29-2C	Certification of Transport Category Rotorcraft
NATO	AIR STD 61/116/1H	Operation of All Controls and Switches at Aircrew Stations
	AIR STD 61/116/2G	Location and Actuation of Airframe Controls in Fixed Wing Aircraft
	AIR STD 61/116/3K	Location, Actuation and Shape of Airframe controls for Rotary Wing Aircraft
	AIR STD 61/116/4K	Services Operable from Stick Grips
	AIR STD 61/116/5M	Aircrew Station Warning, Cautionary and Advisory Signals

Figure 2-2-5 (Sheet 1 of 4) Associated Publications and Standards Related to Human Factors

Regulator or Organization	Number	Title
NATO (Cont)	AIR STD 61/116/6D Ch1	Human Engineering Design Criteria for the Use of Aircrew Station Controls and Displays
	AIR STD 61/116/7C	Control Shapes
	AIR STD 61/116/9B	Aircraft Mock-Up Inspection Techniques
	AIR STD 61/116/13 Ch1	The Application of Human Engineering to Advanced Aircrew Systems
	AIR STD 61/116/15H	Location and Arrangement of Flight and Engine Parameter Displays in Aircrew Stations
	AIR STD 61/116/16	Electronically and Optically Generated Display Formats and Symbology for Fixed Wing Aircraft
	AIR STD 61/116/21	Colours and Markings Used to Denote Operating Ranges of Aircraft Displays
	AIR STD 61/116/25	Location and Grouping of Electrical Switches
	AIR STD 61/116/26	Emergency Control Colour Schemes
	AIR STD 61/116/27	Numbering of Engines and their Associated Controls and Displays in Aircraft
	AIR STD 61/116/28	Circular Dial Altimeters and Calibration Procedures
	AIR STD 61/116/29	Aircrew Station Control Panels
	AIR STD 61/116/30	Circular Dial Engine Indicators
	STANAG 3217	Operation of Controls and Switches at Aircrew Stations
	STANAG 3219	Location and Grouping of Electrical Switches in Aircraft
	STANAG 3224	Aircrew Station Lighting
	STANAG 3258	Position of Pilot Operated Navigation and Radio Controls
	STANAG 3329	Numerals and Letters in Aircrew Stations
	STANAG 3370	Aircrew Station Warnings, Cautionary and Advisory Signals
	STANAG 3436	Colours and Markings Used to Denote Operating Ranges of Aircraft Instruments
	STANAG 3504	Cathode Ray Tube Head-Down Displays (Monochrome)
	STANAG 3639	Aircrew Station Dimensional Design Factors
	STANAG 3643	Coating, Reflection Reducing for Glass Elements Used in Aircrew Station Displays
	STANAG 3647	Nomenclature in Aircrew Stations
	STANAG 3701	Aircraft Interior Colour Schemes
	STANAG 3705	Human Engineering Design Criteria for Controls and Displays in Aircrew Stations
	STANAG 3869	Aircrew Station Control Panels
	STANAG 3871	NATO Glossary of Aircraft – Aircrew Integration Specialist Terminology and Abbreviations
	STANAG 3940	Aircraft Electronic Colour Display Systems
	STANAG 3950	Helicopter Design Criteria for Crew Crash Protection and Anthropometric Accommodation
	STANAG 3994	Application of Human Engineering to Advanced Aircrew Systems
	STANAG 7044	Functional Aspects of Mission Planning Station Interface Design
	STANAG 7095	Flat Panel Technology Display Design Criteria

Figure 2-2-5 (Sheet 2 of 4) Associated Publications and Standards Related to Human Factors

Regulator or Organization	Number	Title
NATO (Cont)	STANAG 7096	Location, Actuation and Shape of Airframe Controls
	STANAG 7139	Aircraft Engine Controls, Switches, Displays, Indicators, Gauges and Arrangements
	STANAG 7140	Aircraft Flight Instruments Layout and Display
	STANAG 7161	Aircraft Display Symbology
SAE	ARD 50016	Head-Up Display Human Factor Issues
	ARD 50019	Human Engineering Issues for Enhanced Vision Systems
	ARD 50027	Human Engineering Issues for Data Link Systems
	ARD 50048	Human Modeling System User Requirements Survey
	ARD 50062	Human Factors Issues Associated with Terrain Separation Assurance Display Technology
	ARD 50079	Human Factors Issues in Free Flight
	ARD 50083	Human Factors Issues Associated with Cockpit Display of Traffic Information (CDTI)
	ARP 1874	Design Objectives for CRT Displays for Part 25 (Transport Aircraft)
	ARP 4032	Human Engineering Considerations in the Application of Colour to Electronic Aircraft Displays
	ARP 4033	Pilot-System Integration
	ARP 4102	Display Criteria and Associated Controls for Transport Aircraft
	ARP 4107	Aerospace Glossary for Human Factors Engineers
	ARP 4153	Human Interface Criteria for Collision Avoidance Systems in Transport Aircraft
	ARP 4155	Human Interface Design Methodology for Integrated Display Symbology
	ARP 4791	Human Engineering Recommendations for Data Link Systems
	ARP 4927	Integration Procedures for the Introduction of New Systems to the Cockpit
	ARP 5108	Human Interface Criteria for Terrain Separation Assurance Display Technology
	ARP 5288	Transport Category Airplane Head Up Display (Hud) Systems
	ARP 5430	Human Interface Criteria for Vertical Situation Awareness Displays
	ARP 5898	Human Interface Criteria for Flight Deck Surface Operations Displays
	ARP 4102	Flight Deck Panels, Controls and Displays
	AS 18012	Markings for Aircrew Station Displays Design and Configuration of
TCCA	AWM 523	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
	AWM 525	Transport Category Aeroplanes
	AWM 527	Normal Category Rotorcraft
	AWM 529	Transport Category Rotorcraft
UK MoD	DEF STAN 00-970 Issue 1, Volume 1	Aeroplanes: Design and Airworthiness Requirements for Service Aircraft
	DEF STAN 00-970 Issue 1, Volume 2	Rotorcraft: Design and Airworthiness Requirements for Service Aircraft
	DEF STAN 00-25 (Part 1), Issue 2	Human Factors: Human Factors for Designers of Equipment

Figure 2-2-5 (Sheet 3 of 4) Associated Publications and Standards Related to Human Factors

Regulator or Organization	Number	Title
U.S. DoD	JSSG-2009	Air Vehicle Subsystems
	JSSG-2010	Crew Systems
	JSSG-2010-1	Engineering Handbook
	JSSG-2010-2	Crew Station Automation, Information and Control/Display Management Handbook
	JSSG-2010-3	Cockpit/Crew Station/Cabin Handbook
	JSSG-2010-4	Aircrew Alerting Handbook
	JSSG-2010-5	Aircraft Lighting Handbook
	JSSG-2010-11	Emergency Egress Handbook
	MIL-HDBK-46855	Human Engineering Guidelines for Military Systems, Equipment and Facilities
	MIL-HDBK-46855 A	Human Engineering Program Process and Procedures
	MIL-HDBK-759	Department Of Defence Handbook for Human Engineering Design Guidelines
	MIL-STD-203	Aircrew Stations Controls and Displays: Location, Arrangement and Actuation of, for Fixed Wing Aircraft
	MIL-STD-250	Aircrew Station Controls and Displays for Rotary Wing Aircraft
	MIL-STD-411	Aircrew Station Alerting Signals
	MIL-STD-490	System/Segment Specification for the Tactical Work Stations
	MIL-STD-850	Aircrew Station Vision Requirements for Military Aircraft
	MIL-STD-1333	Aircrew Station Geometry for Military Aircraft
	MIL-STD-1472	Human Engineering
	MIL-STD-1521	Technical Reviews and Audits for Systems, Equipment & Computer Software
	MIL-STD-1787	Aircraft Display Symbology
	MIL-STD-2525	Common War fighting Symbology
	MIL-STD-3009	Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible

Figure 2-2-5 (Sheet 4 of 4) Associated Publications and Standards Related to Human Factors

PART 2
CERTIFICATION PROCESSES

CHAPTER 3 — ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3) PROTECTION

2.3.1 Introduction

1. This chapter provides guidance on the airworthiness acceptance process for the certification of equipment and systems for Electromagnetic Environmental Effects (E3) protection. It also identifies the associated specifications, standards and advisory material applicable to E3 protection. The process is applicable to new type certification activities, significant design changes and modification programs/projects.

2. Virtually all aircraft electrical and electronic systems, subsystems and equipment are susceptible to the effects of electromagnetic energy. Whenever a system, subsystem or equipment is to be procured or modified, measures must be taken to ensure that performance is not degraded when it is operating in its intended electromagnetic environment (EME). It is also necessary to ensure that E3 control measures already in place are not compromised. Standards are available giving emission and susceptibility limits, design constraints and specifying test and analytical methods to demonstrate compliance with the standards.

3. A structured program is essential to effectively manage and implement E3 protection. No single standard can provide complete E3 protection standards for CAF aircraft. Although the requirement for control of E3 is recognized in U.S. Title 14 CFR, TCCA AWM and EASA CSs, they lack sufficient detail for military purposes and have only recently been supported by relevant Advisory Circulars (ACs) setting out compliance demonstration guidance. Thus, a combination of military standards and civil standards may be necessary to ensure E3 protection.

2.3.2 Definitions

1. **Electromagnetic Environmental Effects (E3).** E3 is the impact of the electromagnetic environment upon the operational capability and safety of aircraft, systems, and equipment. It encompasses all electromagnetic disciplines, including electromagnetic compatibility (EMC); electromagnetic interference (EMI); electromagnetic vulnerability (EMV); electromagnetic pulse (EMP); electronic protection; hazards of electromagnetic radiation to personnel, ordnance, and volatile materials; and natural phenomena effects of lightning and precipitation static.

2. **Electromagnetic Environment (EME).** EME is the power and time distribution, in appropriate frequency ranges, of the electromagnetic levels that may be encountered by an equipment, subsystem or system when performing its intended function(s). The EME is normally expressed in terms of field strength or power density. Part of the EME is the High Intensity Radiated Fields (HIRF) environment.

3. **Electromagnetic Compatibility (EMC).** EMC is the ability of electronic/electrical equipment, subsystems and systems to operate in their intended operational environments without suffering or causing unacceptable degradation due to electromagnetic interference.

4. **Electromagnetic Interference (EMI).** EMI is the conducted or radiated electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment(s).

5. **Terminology.** The terms 14 CFR xx or AWM 5xx apply or correspond to 14 CFR Parts 23, 25, 27 and 29, or AWM Chapters 523, 525, 527 and 529, respectively.

2.3.3 Standards and Specifications

1. The following standards and specifications are acceptable for the technical E3 protection requirements of DND/CAF aircraft. Applicants may propose alternate equivalent specifications and standards to DTAES 6 for consideration.

Civil Airworthiness Design Standards	
1.	**CBAAC 0106R,** Use of Portable Passenger Operated Electronic Devices Onboard Aircraft and Occurrence Reporting
2.	**14 CFR 27/29.610,** Lightning Protection
3.	**14 CFR xx.954,** Fuel System Lightning Protection
4.	**14 CFR xx 1301,** Function and Installation
5.	**14 CFR xx 1309,** Equipment, Systems, and Installations
6.	**14 CFR xx 1431(a),** Electronic Equipment
7.	**AWM 523,** Sub Chapter F Equipment, Normal, Utility, Aerobatic and Commuter Category Aeroplanes
8.	**AWM 525,** Sub Chapter F Equipment, Transport Category Aeroplanes
9.	**AWM 529,** Sub Chapter F Equipment, Transport Category Rotorcraft
10.	**DO-160** Sections 15 through 21 and Section 25
11.	**ARP 1870,** Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
12.	**ARP 4242,** Electromagnetic Compatibility Control Requirements Systems

Figure 2-3-1 Civil Airworthiness Design Standards Related to E3 Protection

Military Airworthiness Design Standards	
1.	**MIL-HDBK-235,** Electromagnetic (Radiated) Environment Considerations For Design and Procurement of Electrical and Electronic Equipment, Subsystems, and System
2.	**MIL-STD-461,** Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
3.	**MIL-STD-464,** Electromagnetic Environmental Effects Requirements for Systems
4.	**DEF STAN 59-41,** Electromagnetic Compatibility Part 3: Technical Requirements Test Methods and limits
5.	**C-05-005-044/AG-001,** Electromagnetic Environmental Effects (E3) Control Within the Canadian Forces (Air)

Figure 2-3-2 Military Airworthiness Design Standards Related to E3 Protection

2.3.4 Guidance Information – Notes on Best Practices

1. Annex A of this chapter provides applicants with airworthiness design specifications and standards applicable to both new designs and proposed design changes. It also provides information that will assist the applicant in achieving an acceptable level of aviation safety within the DND/CAF Technical Airworthiness Program.

2.3.5 Guidance Information – E3 Control Program

1. The E3 Control Program (E3CP) should include all necessary design, planning, technical criteria, and management controls needed to achieve overall EMC and to verify the design requirements specified. Annex B of this chapter provides the DND/CAF requirements for establishing and maintaining an E3CP.

2.3.6 Guidance Information – Miscellaneous Guidance

1. Annex C of this chapter provides miscellaneous guidance on E3 matters that Project Officers need to consider in planning for and implementing projects.

2.3.7 Guidance Information – E3 Protection Requirements

1. **Equipment/Subsystem.** Equipment that is to be EMC-, HIRF- or Lightning-tested shall be hardware- and software-configured to the level specified for delivery.

a. **U.S. Military Design Equipment – Applicable Documents:**

(1) MIL-HDBK-516 establishes airworthiness certification criteria used in the determination of airworthiness of all fixed wing aircraft. Sections 13 and A13 provide E3 certification criteria. Although this handbook is specific to fixed wing aircraft, Project Officers should consider tailoring the criteria for rotorcraft applications.

(2) MIL-STD-461 establishes interface and associated verification requirements for control of electromagnetic interference (emissions and susceptibility) characteristics of electronic, electrical and electromechanical equipment.

(3) MIL-STD-464 establishes electromagnetic environmental effects interface requirements and verification criteria for military aircraft systems including ordnance. It includes intra-system EMC requirements, inter-systems EMC (external electromagnetic environment (EME)) and Lightning requirements. Section 5.3 Table 1A provides the EME for operation off ships and Tables 1E and 1F provide the EME applicable to other airborne applications. Section 5.4 provides Lightning Direct and Indirect requirements.

b. **UK Military Design Equipment – Applicable Documents.** DEF STAN 59-41 describes the preferred techniques to be used for the measurement of the electromagnetic compatibility characteristics of electrical and electronic equipment.

c. **Civil Design Equipment – Applicable Documents:**

(1) FAA AC/AMJ 20.1317 (Final Draft 8) provides an acceptable means of showing compliance with FAA/JAA regulations regarding operation of electrical and electronic systems on an aircraft when the aircraft is exposed to the external HIRF environment.

(2) RTCA DO-160 provides standard procedures and test criteria for testing airborne equipment. Tests covered include RF susceptibility (including HIRF), RF emissions, lightning and electrostatic discharge.

(3) SAE ARP 5413 provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning environment to electrical/electronic systems installed either on, or within, aircraft. Equipment hazards include those due to lightning indirect effects on equipment and its associated wiring located within the aircraft.

d. **Airworthiness Certification Guidance:**

(1) MIL-STD-461 used with MIL-HDBK-516 is a suitable method of showing EMC compliance for U.S. military design equipment.

(2) MIL-STD-464, Sections 5.3 and A5.3, is a suitable method of showing HIRF compliance for U.S. military design system/sub-systems.

(3) MIL-STD-464, Sections 5.4 and A5.4, is a suitable method of showing Lightning compliance for U.S. military design equipment.

(4) DEF STAN 59-41 Part 3 is a suitable method of showing EMC and Lightning compliance for UK military design equipment.

(5) RTCA DO-160E, Sections 15 through 21, and Section 25, is a suitable method for showing EMC, HIRF and p-static compliance for civil design equipment.

(6) RTCA DO-160E, Section 20 or FAA AC/AMJ20.1317 are suitable methods of showing HIRF compliance for civil design equipment. The method selected is predicated on system/equipment criticality level.

(7) RTCA DO-160E, Sections 22 and 23, used with SAE ARP 5413, is a suitable method for showing indirect effects of lightning compliance for civil design equipment.

NOTE

If the configuration of the hardware and/or software has changed from the configuration that was EMC-, HIRF- or Lightning-tested and certified, the hardware and/or software shall be re-tested to MIL-STD-461, MIL-STD-464, DEF STAN 59-41, RTCA DO-160 or AC/ACMJ20.1317, as applicable. If the OEM believes that re-testing will not be required, the OEM must forward an engineering analysis in support of the claim to the appropriate TAA subject matter expert for consideration.

2. **Systems (Aircraft) Level.** EMC-, HIRF- or Lightning-tested shall be conducted on the fully integrated avionics system installed in a production aircraft.

a. **Applicable Documents:**

(1) AC/AMJ20.1317 (Final Draft 8) provides an acceptable means of showing compliance with FAA/JAA regulations regarding operation of electrical and electronic systems on an aircraft when the aircraft is exposed to the external HIRF environment.

(2) C-05-005-044/AG-001 provides the CAF policy to ensure continued airworthiness of DND/CAF aircraft from the effects of the electromagnetic environment. It contains a section that provides guidance on the use of Portable Electronic Devices (PEDs) in CAF aircraft. Annex A provides safety of flight test (SOFT) requirements for equipment that also applies to PEDs.

(3) FAA AC 20-53 provides information and guidance concerning an acceptable means of compliance with 14 CFR Parts 23 and 25 applicable to preventing ignition of fuel vapours due to lightning.

(4) FAA AC 20-136 provides information and guidance concerning an acceptable means of compliance for preventing hazardous effects, due to Lightning Indirect effects from occurring to electrical and electronic systems performing critical essential functions in 14 CFR Parts 23, 25, 27 and 29 category aircraft/rotorcraft.

(5) MIL-HDBK-516 establishes airworthiness certification criteria used in the determination of airworthiness of all fixed wing aircraft. Sections 13 and A13 provide E3 certification criteria. Although this handbook is specific to fixed wing aircraft, Project Officers should consider tailoring the criteria for rotorcraft applications.

(6) MIL-STD-464 establishes electromagnetic environmental effects interface requirements and verification criteria for military aircraft systems including ordnance. It includes intra-system EMC requirements, inter-systems EMC (external electromagnetic environment (EME)) and Lightning requirements. Section 5.3 Table 1A provides the EME for operation off of ships and Tables 1E and 1F provide the EME applicable to other airborne applications. Section 5.4 provides Lightning Direct and Indirect requirements.

(7) SAE ARP 1870 establishes the minimum requirements for electrical bonding and grounding of electric, avionics, armament, communication and electronic equipment installations for aeronautical and aerospace applications. The bonding and grounding requirements are to ensure that an adequate low resistance return path is achieved which can withstand operating conditions and corrosion. This is essential for reduction of coupling of electromagnetic fields into or out of the equipment.

(8) SAE ARP 5583 is a HIRF certification guide that provides detailed information, guidance and methods related to FAA AC 20-xxx Certification of Aircraft Electrical/Electronics Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment (Draft August 24, 2000).

(9) SAE ARP 5413 provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning environment to electrical/electronic systems installed either on or in the aircraft. Equipment hazards addressed include those due to the indirect effects on equipment mounted on the aircraft exterior and equipment located within the aircraft interior as well as all associated wiring. It applies to new aircraft and equipment designs, modifications of existing aircraft or equipment and applications of existing (off the shelf) equipment on new aircraft.

(10) SAE ARP 5577 provides guidance for a means of showing compliance with the regulations for protection against lightning direct effects for aircraft of conventional design as well as those involving advanced composite structures. It also applies to those aspects of aircraft systems and components not addressed in the regulations covering the protection of electrical/electronic systems (for example, 14 CFR xx.1316) or fuel systems (for example 14 CFR xx.954).

(11) C-05-005-044/AG-001 provides guidance on the use of portable passenger operated electronic devices onboard aircraft and occurrence reporting.

b. **Airworthiness certification guidance:**

(1) MIL-STD-464 used with MIL-HDBK-516 and ground test and flight test is a suitable method of showing EMC, EME, Bonding and Lightning compliance for military aircraft.

(2) EMC ground test and flight test is a suitable method of showing EMC compliance for AWM 523 category aircraft.

(3) EMC ground test and flight test, and FAA AC 25-7A, is a suitable method of showing EMC compliance for AWM 525 category aircraft.

(4) EMC ground test and flight test, and FAA AC 27-1B, is a suitable method of showing EMC and Lightning compliance for AWM 527 category rotorcraft.

(5) EMC ground test and flight test, and FAA AC 29-2C, is a suitable method of showing EMC and Lightning compliance for AWM 529 category rotorcraft.

(6) AC/AMJ20.1317 or AC 20-xxx (24 August 2000) used with SAE ARP 5583 is a suitable method of showing HIRF compliance for AWM 5xx category aircraft.

(7) FAA AC 20-53 is a suitable method of showing protection of airplane fuel systems against fuel vapour ignition due to Lightning compliance for AWM 523 and AWM 525 category aircraft.

(8) FAA AC 20-136 used with SAE ARP 5413 is a suitable method of showing Lightning Indirect effects compliance for AWM 523.1309, AWM 525.1309, AWM 525.1316, AWM 527.1309 and AWM 529.1309.

(9) SAE ARP 1870 is a suitable method of showing Bonding compliance for CAR5xx category aircraft/rotorcraft.

(10) SAE ARP 5577 is a suitable method of showing Lightning Direct effects compliance for AWM 5xx.1309.

(11) C-05-005-044/AG-001 is a suitable method of showing PED compliance for CAF aircraft.

2.3.8 Associated Publications and Standards

1. The following source references in Figure 2-3-3 are associated with the design, installation, maintenance and usage of aircraft electrical and electronic systems, subsystems and equipment which are susceptible to the effects of electromagnetic energy.

Regulator or Organization	Number	Title
DND/CAF	C-05-005-044/AG-001	Electromagnetic Environmental Effects (E3) Control Within The Canadian Forces (Air)
	C-55-040-001/TS-001	Radio Frequency Safety Programme
EUROCAE	ED-14	Environmental Conditions and Test Procedures for Airborne Equipment
	ED-81	Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
	ED-113	Aircraft Lightning Direct Effects Certification
FAA	AC/AMJ20.1317	The Certification of Aircraft Electrical and Electronic Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment
	AC 20-53	Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning
	AC 20-136	Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning
	AC 23-8A	Flight Test for Certification of Part 23 Airplanes
	AC 23-17	Systems and Equipment Guide for Certification of Part 23 Airplanes
	AC 23.1309-1C	Equipment, Systems and Installations in Part 23 Aircraft
	AC 25-7A	Flight Test Guide for Certification of Transport Category Airplanes
	AC 25.1309-1A	System Design Analysis
	AC 27-1B	Certification of Normal Category Rotorcraft
	AC 29-2C	Certification of Transport Category Rotorcraft
	14 CFR xx.954	Fuel System Lightning Protection
	14 CFR xx.1301	Function and Installation
	14 CFR xx.1309	Equipment, Systems, and Installations
	14 CFR 25.1316	Systems Lightning Protection
	14 CFR 25.1431	Electronic Equipment
	14 CFR 27.610	Lightning Protection
	14 CFR 29.610	Lightning Protection
	14 CFR 91.21	General Operating and Flight Rules Portable Electronic Devices
RTCA	DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
	DO-199	Potential Interference to Aircraft Electronic Equipment from Devices Carried Aboard
	DO-233	Portable Electronic Devices Carried On Board Aircraft

Figure 2-3-3 (Sheet 1 of 3) Associated Publications and Standards Related to E3 Protection

Regulator or Organization	Number	Title
RTCA (Cont)	DO-294	Guidance on Allowing Transmitting Portable Electronic Devices (T-PEDs) on Aircraft
SAE	AIR 1221	Electromagnetic Compatibility (EMC) System Design Checklist
	AIR 1394	Cabling Guidelines for Electromagnetic Compatibility
	ARP 1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
	ARP 4242	Electromagnetic Compatibility Control Requirements Systems
	ARP 5583	Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment
	ARP 5412	Aircraft Lightning Environment and Related Test Waveforms
	ARP 5413	Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of lightning
	ARP 5414	Aircraft Lightning Zoning
	ARP 5415	User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
	ARP 5416	Lightning Test Methods (Draft)
	ARP 5577	Aircraft Lightning Direct Effects Certification
NATO	STANAG 3516	Electronic Interference and Test Methods for Aircraft Electrical and Electronic Equipment
	STANAG 3614	Electromagnetic Compatibility (EMC) of Aircraft Systems
TCCA	AWM 523 Sub Chapter F, Equipment	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
	AWM 525 Sub Chapter F Equipment	Transport Category Aeroplanes
	AWM 527 Sub Chapter F Equipment	Normal Category Rotorcraft
	AWM 529 Sub Chapter F Equipment	Transport Category Rotorcraft
	Commercial and Business Aviation Advisory Circular (CBAAC) 0106R	Use of Portable Passenger Operated Electronic Devices Onboard Aircraft and Occurrence Reporting
UK MoD	DEF STAN 59-41	Electromagnetic Compatibility Part 3: Technical Requirements Test Methods and limits
U.S. DoD	AFSCDH 1-4	Design Handbook Electromagnetic Compatibility
	JSSG-2001	Air Vehicle
	JSSG-2005	Avionic Subsystem Main Body
	MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorption
	MIL-D-21625	Design and Evaluation of Cartridges for Cartridge Activated Devices
	MIL-D-81303	Design and Evaluation of Cartridges for Stores Suspension Equipment
	MIL-DTL-23659	Initiator, Electric, General Design Specification

Figure 2-3-3 (Sheet 2 of 3) Associated Publications and Standards Related to E3 Protection

Regulator or Organization	Number	Title
U.S. DoD (Cont)	MIL-HDBK-235	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems, and Systems
	MIL-HDBK-237	Electromagnetic Environmental Effects and Spectrum Certification Guidance for The Acquisition Process
	MIL-HDBK-516	Airworthiness Certification Criteria
	MIL-HDBK-1512	Electro-explosive Subsystems, Electrically Initiated, Design Requirements and Test Methods
	MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
	MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems

Figure 2-3-3 (Sheet 3 of 3) Associated Publications and Standards Related to E3 Protection

ANNEX A

NOTES ON BEST PRACTICES

2.3A.1 Introduction

1. It is recommended that applicants liaise with DTAES E3 staff prior to initiation of a project to establish the certification basis design and airworthiness certification criteria. DTAES E3 staff can also provide recommended documentation/data deliverables that may help to achieve a successful implementation of the project, but which would not necessarily be required for certification activities.

2.3A.2 Requirements

1. **General.** The aircraft has to be electromagnetically compatible (EMC) with itself and with all other equipments in the avionics system, and with environments caused by electromagnetic effects external to the system, such that operational performance requirements are met.

2. **Equipment Level Requirements:**

a. **Specifications and Standards:**

(1) MIL-STD-461 establishes interface and associated verification requirements for control of electromagnetic interference (emissions and susceptibility) characteristics of electronic, electrical and electromechanical equipment.

(2) MIL-STD-464 establishes electromagnetic environmental effects interface requirements and verification criteria for military aircraft systems including ordnance. It includes requirements for lightning protection (paragraph 5.4) and subsystems and equipment EMI (paragraph 5.6).

(3) DEF STAN 59-41 describes the preferred techniques to be used for the measurement of the electromagnetic compatibility characteristics of electrical, and electronic equipment.

(4) RTCA DO-160 provides standard procedures and test criteria for testing airborne equipment. Tests covered include RF susceptibility (including HIRF), RF emissions, lightning and electrostatic discharge.

(5) SAE ARP 5413 provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning environment to electrical/electronic systems installed either on or within the aircraft. Equipment hazards include those due to lightning indirect effects on equipment and its associated wiring located within the aircraft.

b. **Associated Documents:**

(1) EUROCAE ED-14 defines a series of standardized environmental test procedures with the aim to provide a laboratory means of determining the performance characteristics of airborne equipment in these environments.

(2) EUROCAE ED-81 provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning indirect environment. It applies to new aircraft and equipment designs, modifications of existing aircraft or equipment and applications of existing (off the shelf) equipment on new aircraft.

(3) EUROCAE ED-113 provides guidance for a means of compliance with regulations against lightning direct effects for aircraft of conventional design or involving new technologies.

(4) MIL-HDBK-235 establishes a uniform approach for the protection of military electronics from the adverse effects of the electromagnetic environment. The handbook is applicable to any electrical and electronic equipment, subsystems or systems that may be exposed to an electromagnetic environment during its life cycle.

(5) SAE ARP 5412 provides the characteristics of lightning that are encountered by aircraft, as well as transients appearing at the interfaces of equipment associated with electrical/electronic system as a result of that interaction. These characteristics are referred to as the aircraft lightning environment.

3. **System (Aircraft) Level Requirements:**

a. **E3 Control Program (E3CP):**

(1) All new aircraft acquisitions and major avionics design changes to existing aircraft need to have an E3CP.

(2) The E3CP describes how the E3 control requirements of MIL-STD-464, or equivalent standard, will be met. For other avionics design changes, elements of the E3CP will need to be tailored to meet requirements. Annex B of this chapter establishes the E3CP requirements.

(3) Civil design aircraft need to meet the EMC control requirements of SAE ARP 4242.

b. **Installation Requirements.** All interconnecting wiring/cables need to be classified into groupings representing similar signals throughout the avionics system. Each wiring/cable type needs to be provided with shielding and grounding in accordance with sound E3 design.

(1) Avionics and electrical wiring and cables, including installation, need to meet the EMC requirements of AFSCDH 1-4 for military design aircraft.

(2) Avionics and electrical wiring and cables, including installation, need to meet the EMC requirements of SAE AIR 1394 for civil design aircraft.

c. **Electromagnetic Compatibility (EMC):**

(1) Civil design aircraft operated in a military environment need to meet the EMC requirements of MIL-STD-464 Sections 5.2 and A5.2.

(2) Civil design aircraft operated in a civil environment/role need to be EMC ground tested to verify that required flight systems are not affected by the operation of aircraft systems.

d. **Bonding and Grounding.** The combined system, subsystems, and equipment includes the necessary electrical bonding to meet E3 requirements. Electrical bonding provisions need to meet specified control levels for the life of the system. Antennae have to be bonded to obtain the required antenna patterns and to meet the performance requirements for the antenna and associated subsystem(s).

e. **Lightning Effects.** The avionics system/subsystem needs to meet its operational performance requirements for both direct and indirect effects of lightning.

f. **High Intensity Radiated Fields (HIRF) Protection.** Civil design aircraft operated in a military environment need to meet the inter-systems EME requirements of MIL-STD-464 Sections 5.3 and A5.3 tailored to meet the operational environment.

g. **Precipitation Static Control.** Anti-precipitation static systems need to be provided, including insulated wire antennae and wick dischargers where appropriate. The design of the exterior of the aircraft and the location of all antennae has to be such that the generation and coupling of corona type interference is minimized. Plastic canopies such as antenna radomes, windshields, and similar insulating surfaces that protrude into the air-stream (except antenna masts and insulators), need to have semi-conducting surfaces to prevent the accumulation and impulsive re-distribution of charges.

h. **Static Discharge.** An active, passive, or combination discharge system capable of discharging 1 milliampere of static energy needs to be provided.

4. **Specifications and Standards:**

a. MIL-STD-464 establishes electromagnetic environmental effects interface requirements and verification criteria for military aircraft systems including ordnance. It includes intra-system EMC requirements, inter-systems EMC (external electromagnetic environment (EME)) and Lightning requirements. Section 5.3 Table 1A provides the EME for operation off of ships and Table 1D provides the EME applicable to other airborne applications. Section 5.4 provides Lightning Direct and Indirect requirements.

b. SAE AIR 1394 provides cabling guidelines for EMC. The recommendations provide design guidance rather than standardization.

c. SAE ARP 4242 establishes overall systems EMC control requirements. The document is intended for use in procurement of air, land, sea and space systems. Tailoring of specific requirements is necessary.

d. U.S. DoD AFSC DH 1-4 provides design criteria and guidance in EMC areas for Air Force systems and equipment design. Design Note 5B5 provides guidance for cable classification, cable routing, wire shielding, cable shields, connectors and termination to help achieve EMC.

5. **Associated Documents:**

a. EUROCAE ED-113 provides guidance for a means of compliance with regulations against lightning direct effects for aircraft of conventional design or involving new technologies.

b. EUROCAE ED-81 provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning indirect environment. It applies to new aircraft and equipment designs, modifications of existing aircraft or equipment and applications of existing (off the shelf) equipment on new aircraft.

c. EUROCAE ED-113 provides guidance for a means of compliance with regulations against lightning direct effects for aircraft of conventional design or involving new technologies.

d. SAE AIR 1221 provides a checklist to assure that factors required for adequate system EMC are considered and incorporated into a program. It provides a ready reference of EMC management and documentation requirements.

e. SAE ARP 5412 provides the characteristics of lightning that may be encountered by aircraft as well as transients that may appear at the interfaces of equipment associated with electrical and electronic systems as a result of that interaction. These characteristics are referred to as the aircraft lightning environment.

f. SAE ARP 5414 defines lightning strike zones and provides guidelines for locating them on particular aircraft together with examples. The zone definitions and location guidelines are applicable to 14 CFR Parts 23, 25, 27 and 29, aircraft/rotorcraft. The zone location guidelines and examples are representative of in-flight lightning exposures.

g. SAE ARP 5415 provides information and references relevant to identifying: acceptance criteria for the indirect effects of lightning compliance; verification methods; and recommended design options to optimize system immunity to lightning indirect effects. Equipment hazards addressed include those due to the indirect effects on equipment mounted on the aircraft exterior and equipment located within the aircraft interior as well as all associated wiring.

h. U.S. DoD JSSG-2001 establishes general and verification requirements, integration, performance, and functions. Section 3.1.8 provides requirements and verification procedures for emission control (EMCON). It should be noted that this document cannot be quoted in a contract, but should be used in the preparation of performance specifications.

i. U.S. DoD JSSG-2005 provides a template for developing the avionics performance specification and should be tailored to meet program requirements. It is structured with two principal parts, the Main Body and Mission Profiles. The Main Body covers general avionics requirements, and Mission Profiles covers unique requirements for different mission areas and vehicle types.

2.3A.3 Guidance Information – Equipment/Systems

1. The electromagnetic operating environment of airborne equipment and systems needs to be taken into consideration. Airborne equipment and systems have to safely perform their intended functions when operating in EMI, HIRF and Lightning environments. Equipment that is to be EMC-, HIRF- or Lightning-tested will need to be hardware- and software-configured to the level specified for delivery.

2. It is vital that equipment/subsystems do not unacceptably degrade the technical airworthiness of an aircraft. Factors to be considered when establishing the impact of equipment/subsystems on the airworthiness of an aircraft include the following:

a. EMC, HIRF and Lightning;

b. electrical compatibility;

c. environmental qualification;

d. physical compatibility; and

e. ease of operation during airborne mission operations.

3. Equipment/subsystems can be subjected to potentially hostile operational electromagnetic environments. There are three primary sources of electromagnetic interference, as follows:

a. radiated electromagnetic interference from other aircraft systems;

b. conducted electromagnetic interference through equipment electrical power lines or signal lines; and

c. radiated electromagnetic interference that originates externally to the aircraft.

4. The level of electromagnetic interference immunity required for equipment will depend on the role, configuration and operating environment of the host aircraft. For example, if the equipment is to be operated in a military operational (potentially hostile) electromagnetic environment and the failure of the system could have safety implications, the equipment will need to be tested to military standards, such as MIL-STD-461, and the aircraft tested to MIL-STD-464 requirements. Conversely, equipment with minimal consequences of failure, operated in a benign operational environment may only require aircraft level source-victim testing to provide assurance that the equipment is not affected by aircraft systems or that it does not adversely affect other aircraft systems.

5. Electromagnetic emissions from equipment, either conducted or radiated, have the potential to affect installed aircraft equipment performance. In addition, High Intensity Radiated Fields (HIRF) and lightning can adversely affect the performance of equipment or cause damage to the aircraft (lightning). Therefore, equipment will need to be assessed to ensure that it does not adversely affect safety of flight or flight critical equipment on the aircraft.

2.3A.4 Guidance Information – System (Aircraft Level)

1. It is essential within an aircraft that the subsystems and equipment be capable of providing full performance in conjunction other subsystems and equipment that are required to operate concurrently. EMI generated by a subsystem or other subsystems and equipment must not degrade overall aircraft effectiveness.

2. EMC among antenna-connected subsystems is an essential element of system performance. Inability of an antenna-connected subsystem to properly receive intentional signals can significantly affect mission effectiveness. Achieving compatibility requires careful strategic planning for the placement of receiver and transmitter antennas on the aircraft and on the interoperability of the subsystems.

3. EMI from internal and external sources must be addressed from a systems separation aspect. This is of particular concern when redundancy is used to meet the criticality requirements. Designs need to take into account the possibility of EMI affecting the required function because of close physical proximity between redundant systems; wiring and cables need to be separated as much as possible. For example, wiring for one system could run down one side of the aircraft, and wiring for the other system could be routed down the opposite side of the aircraft.

4. Equipment and their effects on critical systems are of particular concern due to the increase in the number of aircraft/rotorcraft with electronic engine controls and the implementation of fly-by-wire technology. When a critical function is provided by some electronic means, there is a requirement for more rigorous tests than a normal aircraft level EMC test.

5. Equipment such as HF radios, radars, hoists, transmitting antennas located near the control systems, etc., are known to have a high potential for interference, thus EMI laboratory testing qualification does not preclude EMI/EMC installation testing. Equipment that meets any one of the following criteria is considered to be equipment known to have a high potential for interference:

a. equipment that requires 25 amps or more to operate;

b. equipment that transmits 30 watts or more;

c. equipment with an antenna located 0.5 metres or less from an electronic control; and

d. HF transmitters of any power.

6. To accomplish the EMI/EMC aircraft level tests, there must be a DTAES-approved EMI/EMC Test Plan that requires, as a minimum, that high potential interference equipment be operated through all reasonable modes of operation in order to determine if electromagnetic interference is affecting other installed equipment. Ground tests alone are usually not sufficient since some equipment may pose safety issues if operated on the ground, while other equipment cannot be satisfactorily operated on the ground, or the equipment would provide misleading results if operated on the ground.

7. EMC, HIRF or Lightning tests need to be conducted on the fully integrated avionics system installed in a production aircraft.

8. **Specifications and Standards:**

a. 14 CFR 25.1316 provides requirements and regulations for system lightning protection.

b. 14 CFR 23/25/29.1431 provides the requirements for electronic equipment.

c. 14 CFR 27/29.610 provides design and construction requirements for lightning protection.

d. 14 CFR xx.954 provides fuel system lightning protection requirements.

e. SAE ARP 1870 establishes the minimum requirements for electrical bonding and grounding of electric, avionics, armament, communication and electronic equipment installations for aeronautical and aerospace applications. The bonding and grounding requirements are to ensure that an adequate low resistance return path is achieved that can withstand operating conditions and corrosion. This is essential for the reduction of coupling of electromagnetic fields into or out of the equipment.

2.3A.5 Guidance Information – Portable Electronic Devices (PEDs)

1. PEDs that include computers, cell phones, CD players, electronic toys, etc., are known to cause EMI that can affect systems located in cockpits, navigation sensors and communication systems. EMI is usually caused by bus

emissions, CPU clock signals and intentional RF radiation (such as cell phones, portable radios). If a line of sight path exists to an antenna or antenna feed, interference is likely to occur. Aircraft and helicopters are particularly vulnerable due to considerable window areas and the extensive use of composite materials. Both the FAA and the Federal Communications Commission (FCC) ban the use of cell phones in operating aircraft. The FAA bans the use of cell phones in operating aircraft because of the effects of EMI on aircraft systems. The FCC bans the use in operating aircraft because of problems caused to the mobile phone service.

2. **Specifications and Standards:**

   a. C-05-005-044/AG-001 provides CAF policy to ensure continued airworthiness of DND/CAF aircraft from the effects of the electromagnetic environment. It contains a section that provides guidance on the use of PEDs in CAF aircraft. Annex A provides safety of flight test (SOFT) requirements for equipment that also apply to PEDs.

   b. TCCA CBAAC 0106R provides guidance on the use of portable passenger operated electronic devices.

3. **Associated Documents:**

   a. FAA AC 91.21-1A provides aircraft operators with information and guidance for assistance in compliance to 14 CFR Part 91.21. Section 91.21 was established because of the potential of PEDs to interfere with aircraft communications and navigation systems.

   b. RTCA DO-199 provides a report on the investigation to determine potential interference effects to aircraft electronic systems due to emissions from self-powered portable electronic and electrical devices operated aboard aircraft.

   c. RTCA DO-233 addresses the potential interference to installed electrical and electronic systems from Portable Electronic Devices (PEDs) carried aboard by passengers. It defines the potential interference phenomena; outlines the risk potential; provides test methods to determine if a potential for interference exists; and addresses acceptable levels of interference.

   d. RTCA DO-294 addresses Transmitting PEDs (T-PEDs) and recommends a process that airlines and/or airframe manufacturers may use in assessing the risks of interference. The recommended guidance provides a means for aviation authorities and others to determine acceptable and enforceable policies and processes for passenger and crew use of T-PEDs.

ANNEX B

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3) CONTROL PROGRAM

2.3B.1 Electromagnetic Environmental Effects (E3) Control Program

1. A structured program is essential to effectively manage and implement E3 protection. When appropriate controls are implemented in system design, such as hardening, EMI requirements on subsystems and equipment, and good grounding and bonding practices, relatively few EMC problems are encountered. MIL-STD-464 discusses the approach required for ensuring overall system EMC. This annex describes the features of one of the tools that may assist in achieving this: an E3 Control Program (E3CP).

2.3B.2 E3CP

1. An E3CP needs to be conducted for any new aircraft acquisition or major avionics design change to an existing DND/CAF aircraft. For other avionics design changes, elements of the E3CP can be tailored appropriately to meet requirements.

2. The E3CP will need to cover the following topics:

a. E3 Control Program Plan (E3CPP);

b. E3 Analysis Reports;

c. E3 Acceptance Test Plans (E3ATP);

d. E3 Test Report (E3TR);

e. Antenna Placement Report (APR); and

f. Frequency Supportability Data Report.

3. The emphasis in an E3CPP is on the management approach of the E3 Control Program to be implemented, the analysis techniques and general design approach to be employed, and the general approach to E3 protection verification. The E3CPP is required as part of any project involving E3 controls and should be updated during the contract to reflect the evolution of the design. A detailed Work Breakdown Structure must be provided for the Project's E3CP with all tasks defined in the scope, and the planned approach to their implementation described. Its essential function is to provide a forum for the contractor to communicate information with the DND and subcontractors. A draft E3CPP should be required as a contract deliverable to enable evaluation of a designers/manufacturers ability to achieve system EMC.

2.3B.3 E3CP Plan (E3CPP)

1. An E3CPP describes the management policies, design philosophies and technical approach to be used to oversee and implement the overall planning, execution, and verification of the E3CP, thus ensuring the EMC of the system. An E3CPP describes the E3 control management organization and responsibilities, technical requirements, tests and documentation required during the program.

2. The following elements of an E3CPP are applicable to any system, and should contain as much detail as is necessary to describe the E3CP that is established to meet contractual E3 requirements. The following subparagraphs identify the content and format requirements for preparing the E3CPP:

a. **Scope.** The scope of the overall E3CPP identifies all major E3CP tasks and their associated schedules. The detail of the task descriptions needs to be sufficient to describe how the contractor will manage the

E3CP and how the E3 requirements will integrate into the final system. This section should be divided into the following paragraphs:

(1) **Identification.** This paragraph contains a full identification of the items of the supplies to which the E3CPP applies.

(2) **Document Overview and Use.** This paragraph summarizes the purpose and contents of the E3CPP and describes any security or privacy considerations associated with its use.

b. **Applicable Documents.** All applicable documents used in the E3CPP need to be listed, including the number, title, revision and issue date of each document, as well as the source of each document that is not available through normal government channels.

c. **Definitions, Acronyms and Abbreviations.** Definitions, acronyms and abbreviations used in the E3CPP should be listed separately as appropriate.

d. **Management.** The E3CPP describes the procedure by which the Contractor will manage E3. This needs to include an overall description of the Contractor's organization as it relates to the project, identification of the responsibilities and authorities for planning and implementing E3 design, and an outline of the major tasks associated with the E3CPP and their schedules. Roles and responsibilities of these groups need to be described and lines of authority clearly stated. The E3 Control responsibilities of all subcontractors need to be clearly specified.

e. **Reporting Relationships.** The E3CPP describes the interfacing and reporting relationships, including the following relationships:

(1) within the Contractor's/Designer's organization;

(2) between those responsible for E3 control from the prime and the subcontractors;

(3) between the E3 Control Program manager and the Design Authority;

(4) between the subcontractor and vendor E3CPPs, and the contractor's E3CPP; and

(5) between the E3 Control Advisory Board (E3CAB) and the other contractor/sub contractor authorities.

f. **Responsibilities.** The E3CAB roles and responsibilities need to be detailed in the E3CPP. The E3CAB will monitor the system E3CP, provide means of expediting solutions to problems, and establish high-level channels of coordination. The methods and procedures for accomplishing E3 design reviews and coordination with subcontractors need to be detailed. The E3CAB needs to define in the E3CPP the management process for substantiating compliance with the EMC standards of ADSM Part 2, Chapter 3, culminating in certification of the aeronautical product design.

g. **Design Concept.** The E3CPP needs to describe the overall system design concept detailing features that have been implemented to address E3 requirements, and how each feature contributes to compliance with each of the E3 requirements, including electrical, hardware and software design considerations applicable. The E3CPP needs to identify the frequency management concept employed for the platform, including the methods used to minimize conflict in frequency. This section must include an appraisal of the identified E3 risks, a TEMPEST vulnerability assessment where required and the measures to be employed in mitigating these.

h. **Design/Development and Flow down of Standards.** The E3CPP needs to identify the development and flow down of the system level E3 standards of MIL-STD-464 (or the agreed equivalent) to the subsystem and equipment levels for both contractor and subcontractor developed items. The proposed methods of verification for each requirement should be specifically addressed in the E3CPP. If significant changes are being made to aircraft systems or its role, then the analysis performed to determine the suitability of the airframe to the particular role will need to be detailed, and supporting data provided.

i. **Wiring Design Considerations.** The E3CPP should detail the approach to E3 design of the electrical cabling installation, including wiring categorization, shielding techniques, shield terminations, wire routing and wire separation.

j. **Bonding and Grounding.** The E3CPP needs to detail the bonding and grounding provisions implemented to ensure compliance with the E3 requirements, including radio frequency (RF) potentials, power current return paths, shock hazards, antenna performance, electrostatic charge control, external grounds, and compatibility both within the system and within the external electromagnetic environment. Particular attention needs to be paid to the control of precipitation static.

k. **Corrosion Control.** The E3CPP should detail the system corrosion control requirements and how they will be compatible with the E3 requirements.

l. **Radiation Hazards.** The E3CPP needs to detail the approach taken for the control of radiation hazards, any potential hazards and the measures adopted to mitigate these. Large aircraft with communications and radar transmitters are particularly susceptible to the dangers of radiation hazards, and these mitigation measures should be addressed in detail. The E3CPP needs to consider radiation hazards to personnel, fuels and electro-explosive devices and detail the analysis performed in determining hazard distances (therefore system compatibility). Methods proposed for verification of the radiation safety of the system should also be detailed.

m. **Facilities.** The E3CPP needs to detail the facilities that will be required for the E3CP, including discussion of the resources available for the various phases of the program, such as design, manufacture, test and analysis.

n. **Integration of Non-Development Items (NDIs).** The E3 integration requirements for NDIs need to be detailed in the E3CPP. Details of testing and analysis performed on NDIs should be provided, along with the philosophy employed in determining the acceptability of this type of equipment.

o. **Criticality Categories.** A list of all the equipment and subsystems that make up the proposed system should be provided. Each equipment and subsystem of the list, without exception, needs to be assigned to a criticality category, where category I are safety critical systems, category II are mission critical systems and category III are all other systems. The MIL-STD-464 definitions for safety and mission critical systems should be applied. This list should be forwarded to the DND/CAF for acceptance prior to commencement of any system integration or testing. Special attention should be paid to the determination of criticality for mission systems, as these, whilst not safety of flight, determine the success or otherwise of a mission, and ultimately, the survivability of the aircraft in a combat scenario. The E3CPP should state the failure criteria for each equipment and subsystem of the system. For equipment and subsystems classified as either Category I or II, safety margins need to be considered. Safety margins will normally be applied to account for equipment and aircraft manufacturing and installation tolerances. Data or reasons for supporting the selection of degradation criteria and safety margins should also be provided.

p. **External EME.** The E3CPP needs to describe in detail how the system and its equipment and subsystems are designed to survive the external EME, as defined by the E3 Requirements and MIL-STD-464 or AC/AMJ20.1317. The DND/CAF will provide the actual external EME, which will be used as the basis for analysis of internal aircraft EME. The designer will also need to detail the platform generated EME for inclusion in the overall aeronautical product EME.

q. **Electromagnetic Compatibility.** The E3CPP needs to detail the approach and provisions used to ensure RF and intra-system electromagnetic compatibility. This section should detail the testing or analysis to be performed on equipment/subsystems to ensure EMC. The E3CPP should demonstrate the design provisions for eliminating all undesired responses and emissions from all electronic and electrical equipment/subsystems that comprise the aircraft. The E3CPP should include a source-victim matrix of all the equipment and subsystems, each unit being represented both as a potential source and victim. The degree of mutual interference between each combination should be quantitatively stated and supported by analysis, evidence from similar tests or by design expectations. Where interference is considered unacceptable or is not in compliance with the minimum standard, design provisions will need to be made to eliminate the problem. The E3CPP should state these design provisions, whether they are installation provisions and/or tailoring of system/equipment E3 Design Requirements.

r. **Life Cycle Considerations.** The E3CPP needs to detail those requirements necessary for ensuring that procedures are in place to maintain the E3 protective measures for the life of the system. These should include details of any E3 hardness assurance procedures, such as periodic testing, inspection, or validation requirements.

s. **Lightning Protection.** The E3CPP should detail the design criteria and philosophy as to how the Contractor intends to protect the aircraft and equipment against the direct and indirect effects of lightning strikes, including, at least, the following:

(1) bonding for lightning protection;

(2) protection at points of entry into the platform;

(3) re-radiation from individual structural currents;

(4) lightning protection for external antennas; and

(5) protection of non-conductive projections.

t. **Nuclear Electromagnetic Pulse (NEMP) Protection (Optional).** The E3CPP should incorporate the contractor's design guidelines and philosophy describing how the contractor will protect against NEMP.

u. **Subsystem and Equipment Requirements.** The E3CPP should state the E3 requirements required of each of the aircraft's equipment and subsystems. Reference can be made to MIL-STD-461 and RTCADO-160, however, specific tailoring according to the specific application will need to be stated in the E3CPP.

v. **Radiation Characteristics.** The E3CPP needs to identify the radiation characteristics of aircraft antennae, including fundamental and spurious energy and antenna-to-antenna coupling. An Antenna Placement Report should be prepared and attached as an Annex to the E3CPP to detail the analysis performed on the placement of system antennae to minimize harmful effects and to maximize performance. Considerations of inter-platform compatibility (such as between like aircraft) should also be detailed.

w. **Spectrum Conservation.** The E3CPP should describe the approach to be employed to minimize emission spectrum, receiver bandwidths, control oscillator frequencies, pulse rise times, harmonics, sidebands, and duty cycles within the constraints of the equipment and subsystem specified design parameters.

x. **Analysis.** The E3CPP should list the prediction and analysis techniques used by the Contractor to determine the adequacy of the solutions described above, including computer programs for analyzing intra-system EMC and electromagnetic modelling of complex systems, and other EMI/EMC analysis programs as required. Analysis should be used to predict and rectify E3 Control problems before the system is assembled and integrated and also to provide initial validation of the E3 Control solutions.

y. **Research and Development (R & D) Testing.** Special and unproven E3 control techniques should undergo validation before the system is assembled and integrated. The E3CPP should describe any special testing to be conducted to demonstrate and/or investigate effectiveness of proposed, but untried, E3 control techniques. Objective evidence of test results should be attached to future issues of the E3CPP or presented at design reviews.

ANNEX C

MISCELLANEOUS GUIDANCE

2.3C.1 Electromagnetic Vulnerability Baseline

1. Each aircraft type should have an Electromagnetic Vulnerability (EMV) profile baseline. A validation should be sought from the applicable operational representative that the current EMV baseline reflects the impact of any recent modifications or other project activities. If the current EMV baseline is unknown, or cannot be validated, then a pre-modification EMV baseline will be required for inclusion in the E3 Control Program Plan (E3CPP). Following the modification, it will need to be confirmed that the EMV baseline has been maintained or improved upon.

2.3C.2 Electromagnetic Environment (EME)

1. The Electromagnetic Environment of an equipment, subsystem or system is the composite of all electromagnetic energy present. It is important that the external EME be defined at the beginning of the design: ideally during the design/design change, planning phase. The external EME is the basis from which the E3 Design Requirements are derived. The DND/CAF will confirm that the applicable EME for all DND/CAF aircraft is as detailed in Tables 1A or 1D of MIL-STD-464 or AC/AM J20.1317.

2.3C.3 Antenna Placement Report (APR)

1. Mutual interference from the myriad of antennae on the fuselage is becoming an ever-increasing problem. Poorly sited antennae will result in poor sensitivity, loss of range and, for certain systems, false targets setting off warning receivers, flares and chaff. The APR is prepared when, on a given aircraft, new antennae are to be installed and/or existing antennae are to be moved. It describes and presents the designer's analysis and results that demonstrate the suitability of the proposed antenna locations from an EMC and performance perspective.

2. The APR should indicate the proposed antenna subsystems, their installed locations and their actual performance characteristics when installed. The APR should also demonstrate that the antennae selected and their locations and integration into the aircraft preclude mutual interference and can be effectively bonded to the aircraft. Aerodynamic effects should also be considered. The APR should be submitted as an Annex to the E3CPP.

2.3C.4 Previous Usage

1. Past experience suggests that contractors will have difficulty proving something that they have “grandfathered” from past designs. The information is important for the DND/CAF as future modifications that involve placing antennae on the fuselage can impact the performance of the existing antennae and associated subsystems. Unfortunately, aircraft whose design and basic communications package have been around for a long time may not be supported by sufficient design data to qualify the initial reasons for sighting antennae that were developed for earlier models.

2.3C.5 Radiation Hazards (RADHAZ)

1. Radiation Hazards to both fuels and ordnance are addressed in MIL-STD-464. For FAR-derivative aircraft, the MIL-STDs should be invoked. However, none of the standards address adequately the issue of hazards to personnel. For this reason, the requirements of C-55-040-001/TS-001 – *Non-Ionizing Electromagnetic Radiation Safety Technical Requirements and Precaution* need to be invoked for this purpose.

2.3C.6 Simulators, Procedural Trainers and System Support Facilities

1. Many procurement projects include simulators, procedural trainers and systems engineering/software support facilities in the scope of the project. All of these systems have E3 considerations, which will affect the design, installation and subsequent testing of the equipment. While the basic philosophy of MIL-STD-464 can be utilized, the invoking of the full range of procedures is not recommended. Invoking MIL-STD-464 and insisting on the use of all qualification methods and standards invoked therein will add tremendous cost to an installation of this type, with little added benefit in terms of performance or EMC. The basic aim of an E3CP for this type of installation should be to ensure that compatibility within the system is achieved and demonstrated by source/victim matrix testing, and

that the equipment installed is certified to a known standard. This will establish a baseline from which changes can be made with a high degree of confidence. As most of the equipment will be Commercial-Off-The-Shelf (COTS), the standards applied should be appropriate.

PART 2
CERTIFICATION PROCESSES

CHAPTER 4 — AIRBORNE SOFTWARE AND ELECTRONIC HARDWARE

2.4.1 Introduction

1. This chapter identifies the airworthiness codes, design standards and associated advisory and guidance material deemed acceptable by the Technical Airworthiness Authority (TAA) with regards to their applicability to the airborne software and Airborne Electronic Hardware (AEH) of airborne systems and equipment. It recognizes that the DND/CAF acquires, operates and maintains a mix of military and civil pattern aircraft. The identified standards, advisory and guidance materials are applicable to both initial type design approval activities and subsequent modifications identified as being major or minor in nature, which impact software and electronic hardware embedded in airborne systems and equipment.

2.4.2 Standards

1. Figure 2-4-1 and Figure 2-4-2 list those airworthiness codes that are deemed acceptable by the TAA for defining the certification basis for software embedded in airborne systems and equipment installed in DND/CAF aircraft.

Military Airworthiness Codes	
European Defence Agency (EDA)	
1.	**European Military Airworthiness Certification Criteria (EMACC)**, Handbook Edition 3.1, 25 Sept 2018. Section 15
United Kingdom Ministry of Defence (UK MoD)	
1.	**Defence Standard (DEF STAN) 00-970,** Parts 1, 3, 5, 7, 9, 11, 13, 15 Design and Airworthiness Requirements
United States Department of Defense (U.S. DoD)	
1.	**MIL-HDBK-516C,** Department of Defense Handbook, Airworthiness Certification Criteria, 12 December 2014. Section 15

Figure 2-4-1 TAA-Acceptable Military Airworthiness Codes for the Certification Basis of Airborne Systems and Equipment Software

Civil Airworthiness Codes	
European Union Aviation Safety Agency (EASA)	
1.	**Certification Specification (CS)-23,** Normal Category Aeroplanes. CS 23.2510
2.	**CS-23,** Normal, Utility, Acrobatic, and Commuter Cateogry Airplanes. CS 23.1301 (a), CS 23.1309 (a) (b) (c)
3.	**CS-25,** Large Aeroplanes. CS 25.1301 (a), CS 25.1309 (a) (b) (c)
4.	**CS-27,** Small Rotorcraft. CS 27.1301 (a), CS 27.1309 (a) (b) (c)
5.	**CS-29,** Large Rotorcraft. CS 29.1301 (a), CS 29.1309 (a) (b) (c)
6.	**CS-E,** Engines. CS 33.28 (g)
7.	**CS-P,** Propellers. CS 35.23 (c)

Figure 2-4-2 (Sheet 1 of 2) TAA-Acceptable Civil Airworthiness Codes for the Certification Basis of Airborne Systems and Equipment Software

Civil Airworthiness Codes	
Transport Canada Civil Aviation (TCCA)	
1.	**Airworthiness Manual (AWM) Chapter 523,** Normal, Category Aeroplanes. 523.2510
2.	**AWM 525,** Transport Category Aeroplanes. 525.1301 (a), 525.1309 (a) (b) (c)
3.	**AWM 527,** Normal Category Rotorcraft. 527.1301 (a), 527.1309 (a) (b) (c)
4.	**AWM 529,** Transport Category Rotorcraft. 529.1301 (a), 529.1309 (a) (b) (c)
5.	**AWM 533,** Aircraft Engines. 533.28 (g)
6.	**AWM 535,** Propellers. 535.23 (c)
U.S. Federal Aviation Administration (FAA)	
1.	**Title 14 of the Code of Federal Regulations (14 CFR) Part 23,** Airworthiness Standards: Normal Category Airplanes. 23.2510
2.	**14 CFR 23,** Airworthiness Standards: Normal, Utility, Acrobatic and Commuter Category Airplanes. 23.1301 (a), 23.1309 (a) (b) (c)
3.	**14 CFR 25,** Airworthiness Standards: Transport Category Airplanes. 25.1301 (a), 25.1309 (a) (b) (c)
4.	**14 CFR 27,** Airworthiness Standards: Normal Category Rotorcraft. 27.1301 (a), 27.1309 (a) (b) (c)
5.	**14 CFR 29,** Airworthiness Standards: Transport Category Rotorcraft. 29.1301 (a), 29.1309 (a) (b) (c)
6.	**14 CFR 33,** Airworthiness Standards: Aircraft Engines. 33.28 (g)
7.	**14 CFR 35,** Airworthiness Standards: Propellers. 35.23 (c)

Figure 2-4-2 (Sheet 2 of 2) TAA-Acceptable Civil Airworthiness Codes for the Certification Basis of Airborne Systems and Equipment Software

2.4.3 Means of Demonstrating Compliance

1. **RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 Documents**

   a. The integrity required of both software and AEH is determined at the system functional level through the conduct of a system safety assessment, as set out in Part 2, Chapter 1. The conduct of the system safety assessment process provides an appreciation of how software and AEH integrity fits into the whole aircraft and its systems development process. Demonstration of compliance for software and AEH should consider the required design assurance level (DAL) determined by the system safety assessment.

   b. RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 provide considerations for determining, in a consistent manner and with an acceptable level of confidence, that the software and AEH aspects of airborne systems and equipment comply with the airworthiness design standards in the certification basis. They present an acceptable means to be used in demonstrating compliance for initial type design approval activities, type design examination (TDE) activities, and for subsequent major or minor modifications, which impact software embedded in airborne systems and equipment.

   c. Notwithstanding, RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 are the means that will be used in demonstrating compliance for DND/CAF software and AEH, respectively, with the airworthiness design standards in the certification basis. RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 will be used where the DND/CAF will be the initial software and AEH approval authority, or where no prior approval exists from an airworthiness authority that the TAA recognizes.

   d. The TAA may accept an airworthiness approval from a military or civil airworthiness authority that the TAA recognizes, upon consideration of the exceptions of 2.4.3.1.e and 2.4.3.1.f.

   e. Exceptions to 2.4.3.1.c may exist where a previously acceptable, or a previously used, means of demonstrating compliance may continue to be acceptable to the TAA upon consideration of the applicable System Safety Program (refer to Part 2, Chapter 1). This should be discussed with the TAA through the certification liaison process to agree on the certification basis and the means of compliance to be used.

f. Exceptions to 2.4.3.1.c may also exist in the case of systems and equipment used strictly in the performance of its operational role/mission, specifically in the case of those systems or equipment whose function is not required by the airworthiness code or operational airworthiness rules, where the performance of such function or its failure will not adversely affect airworthiness, including the proper functioning of required systems and equipment. In this case, means of compliance for software and AEH are not required. Although minimum development standards may be used for the purpose of assuring the performance of operation functions of such system and equipment, this is strictly considered qualification and falls outside the airworthiness program and related certification. Support can be provided for the software/AEH qualification activities, upon request, from DTAES 6 staff, in their engineering support capacity.

2. RTCA DO-178C/EUROCAE ED-12C Supplements

a. To support the use of RTCA DO-178C/EUROCAE ED-12C, several supplements were developed by RTCA/EUROCAE, including DO-331/ED-218, DO-332/ED-217 and DO-333/ED-216, to address specific software development techniques. These supplements add, delete, or modify objectives, activities and life cycle data called out in RTCA DO-178C/EUROCAE ED-12C, and as such, they cannot be used as stand-alone documents or in conjunction with RTCA DO-178B/EUROCAE ED-12B. The exception to this is RTCA DO-330/EUROCAE ED-215, which provides considerations for tool qualification and can be considered a stand-alone document.

b. When a specific development technique covered by a supplement is used, the guidance within that supplement is to be applied. The Plan for Software Aspects of Certification (PSAC) is to identify the applicable supplements and how they will be used. If the intent is to use multiple software development techniques, more than one DO-178C/ED-12C supplement may apply.

3. RTCA DO-254/EUROCAE ED-80 Scope and Additional Guidance

a. The TAA requires RTCA DO-254/ED-80 as the means for demonstrating compliance for the following hardware items:

(1) Custom micro-coded components, such as Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) and Programmable Logic Devices (PLDs), including any associated macro functions; and

(2) Commercial-Off-The-Shelf (COTS) components.

b. DO-254/EUROCAE ED-80 guidance is applicable to the additional hardware items below. Although the applicability to the scope of all hardware items is encouraged, the TAA does not require demonstrating compliance:

(1) Line Replaceable Units (LRUs);

(2) Circuit Board Assemblies (CBA); and

(3) Integrated technology components, such as hybrids and multi-chip modules.

c. For AEH contributing to hardware Design Assurance Level (DAL) D functions (or equivalent), the acceptable means of compliance include DO-254/ED-80 or existing Level D hardware development assurance practices that demonstrate that the requirements allocated to the DAL D AEH have been satisfied. Additionally, system-level development assurance practices, such as ED-79A/ARP 4754A or other means, may be used if the applicant can demonstrate at the system level that the requirements allocated to the DAL D AEH have been satisfied.

d. Civil airworthiness authorities recognize that RTCA DO-254/EUROCAE ED-80 (dated in 2000) did not fully address the current AEH technologies and practices. Therefore, FAA AC 20-152A/EASA AMC 20-152A are also deemed to provide acceptable means of compliance guidance to DO-254/ED-80.

2.4.4 Use of Previously Acceptable Means of Compliance

1. Civil and military airworthiness authorities recognize that there are software development techniques that RTCA DO-178B/EUROCAE ED-12B did not adequately address or envision. Notwithstanding the fact that DO-178C/ED-12C is the preferred means of demonstrating compliance, there may be cases where it may be necessary or desirable to continue to use a previously acceptable means of compliance.

2. Previously acceptable means of compliance for software in a civil context means use of DO-178, DO-178A, or DO-178B/ED-12B. In a military context, previously acceptable means of compliance may include MIL-STD-498, DOD-STD-2167A or other military or non-DO-178/ED-12 standards, depending on the criticality of the software. For modifications to legacy system software or the use of unmodified legacy system software, it may be desirable or necessary to continue to use a previously acceptable means to demonstrate compliance with the software aspects of certification.

3. Notwithstanding the fact that DO-254/ED-80 is the preferred means of demonstrating compliance for AEH, there may be cases where it may be necessary or desirable to continue to use a previously acceptable means of compliance. Previously acceptable means of compliance for AEH refers to the use of internal organization sound engineering processes that were in place before the enforcement of RTCA DO-254 by the AC 20-152 in 2005. Any new, or modification to an existing, AEH product after that date should follow the guidance provided by RTCA DO-254, or by additional guidance, such as FAA AC 20-152A/EASA AMC 20-152A.

4. Assessment of legacy software and AEH to be modified, or re-used in a different product, requires an understanding of the software and AEH criticality from a system safety perspective. If a Functional Hazard Assessment (FHA) and Preliminary System Safety Assessment (PSSA) are not available to substantiate the Development Assurance Level (DAL) for the software and electronic hardware, then the FHA/PSSA may need to be developed, as this is an entry criterion for the evaluation process in determining the required DAL.

5. To determine the acceptability of continuing to use a previously acceptable means of compliance for legacy software/AEH, or a component, the exception process considerations set out in 2.4.3.1.e will be used. As stated in 2.4.6, the certification liaison will identify the specific process that will be used in determining whether that previously acceptable means of compliance may continue to be used. It will also identify any required review process and analysis to be conducted as part of the evaluation process.

6. Completion of the evaluation process will result in a determination on whether or not the means of compliance that has been used is acceptable, or if the original approval basis needs to be upgraded. Further, it will identify if the upgraded baseline has compliance gaps that require mitigation.

2.4.5 Means of Assessing Compliance

1. The considerations of RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 will be used as the measuring standards to assess the level of compliance achieved to the airworthiness design standards in the certification basis where a version of DO-178 and DO-254/ED-80 had not been previously used as the means of compliance. The output of this assessment will identify gaps to the required processes and what, if any, mitigation is required to address the identified gaps. This means of assessment will be applicable to all projects involving software and AEH.

2. Exceptions to 2.4.5.1 exist where system level verification using ASTM F3153-15 may be used in lieu of traditional design assurance approach for software and AEH. The TAA recognizes this standard for 14 CFR Part 23 – Airplanes and, as such, extends its applicability to all aircraft with a military certification basis for Major failure conditions (or equivalent) and below, when the control category (per MIL-STD-882E) is no more than Redundant Fault Tolerant.

2.4.6 Certification Liaison and Involvement

1. The TAA staff is to be consulted during the planning stages for projects that involve software and AEH in airborne systems and equipment, which will require the conduct of software and AEH validation and verification activities. The intent of this liaison is to discuss the software and AEH evaluation/approval approach, means of demonstrating compliance, requirement for life cycle documentation and the TAA level of involvement in approval activities.

2. The considerations contained in RTCA DO-178C/EUROCAE ED-12C and RTCA DO-254/EUROCAE ED-80 do not define or imply the level of involvement of the TAA in a software verification and validation activity.

2.4.7 Associated Publications and Standards

1. Figure 2-4-3 lists those publications that identify means of demonstrating compliance with the airworthiness design standards or associated advisory materials.

2. TAA Advisories will be used to provide clarification and guidance on the application of the standards and the means of demonstrating compliance. All applicable advisory material is posted on the TAA/DTAES websites or available through DTAES staff, on demand.

Associated Publications and Standards		
Regulator or Organization	**Number**	**Title**
DND/CAF	A-GA-005-000/AG-001	Department of National Defence/Canadian Armed Forces Airworthiness Program
EDA	n/a	European Military Airworthiness Certification Criteria (EMACC), Guidebook, Edition 1.0, 29 Jan 2014
FAA	AC 00-71	Best Practices for Management of Open Problem Reports (OPRs), September 2022
	AC 00-72	Best Practices for Airborne Electronic Hardware Design Assurance Using EUROCAE ED-80( ) and RTCA DO-254( ), October 2022
	AC 20-115D	Airborne Software Development Assurance Using EUROCAE ED-12() and RTCA DO-178(), July 2017
	AC 20-148	Reusable Software Components, December 2004
	AC 20-152A	RTCA DO-254 Development Assurance Guidance for Airborne Electronic Hardware, October 2022
	AC 20-189	Management of Open Problem Reports (OPRs), September 2022
	AC 20-170	Integrated Modular Avionics Development, Verification, Integration and Approval using RTCA DO-297 and Technical Standard Order C-153
	AC 20-171	Alternatives to RTCA/DO-178B for Software in Airborne Systems and Equipment
	AC 20-174	Development of Civil Aircraft and Systems
	AC 21-50	Installation of TSOA Articles and LODA Appliances
	AC 23.1309-1	System Safety Analysis and Assessment for Part 23 Airplanes
	AC 23.1309-1	System Design and Analysis
	AC 27-1309	Equipment, Systems, and Installations (included in AC 27-1, Certification of Normal Category Rotorcraft)

Figure 2-4-3 (Sheet 1 of 3) Associated Publications and Standards Related to Airborne Software and Electronic Hardware

Associated Publications and Standards		
Regulator or Organization	**Number**	**Title**
FAA (Cont)	AC 29-1309	Equipment, Systems and Installations (included in AC 29-2, Certification of Transport Category Rotorcraft)
	AC 33.28-1	Complaince Criteria for 14 CFR § 33.28, Aircraft Engines, Electrical and Electronic Engine Control Systems
	AC 33.28-2	Guidance Material for 14 CFR 33.28, Reciprocating Engines, Electrical and Eletronic Engine Control Systems
	AC 35.23-1	Guidance Material for 14 CFR 35.23, Propellor Control Systems
EASA	AMC 20-115D	Airborne Software Development Assurance, Using EUROCAE ED-12 and RTCA DO-178, 2017
	AMC 20-152A	Development Assurance for Airborne Electronic Hardware (AEH), 2020
	AMC 20-170	Integrated modular avionics (IMA), 2018
	AMC 20-189	The Management of Open Problem Reports (OPRs), 2020
	AMC 20-193	Use of multi-core processors, 2022
RTCA Inc.	DO-178C	Software Considerations in Airborne Systems and Equipment Certification, December 2011
	DO-178B	Software Considerations in Airborne Systems and Equipment Certification, December 1992
	DO-178A	Software Considerations in Airborne Systems and Equipment Certification, March 1985
	DO-178	Software Considerations in Airborne Systems and Equipment Certification, January 1982
	DO-248C	Supporting Information for DO-178C and DO-278A, December 2011
	DO-248B	Final Annual Report for Clarification of DO-178B “Software Considerations in Airborne Systems and Equipment Certification”, October 2001
	DO-297	Integrated Modular Avionics (IMA) Development Guidance and Certification Considerations, November 2005
	DO-330	Software Tool Qualification Considerations, December 2011
	DO-331	Model-Based Development and Verification Supplement to DO-178C and DO-278A, December 2011
	DO-332	Object-Oriented Technology and Related Techniques Supplement to DO-178C and DO-278A, December 2011
	DO-333	Formal Methods Supplement to DO-178C and DO-278A, December 2011
	DO-254	Design Assurance Guidance for Airborne Electronic Hardware, April 2000
EUROCAE	ED-12C	Software Considerations in Airborne Systems and Equipment Certification, January 2012
	ED-12B	Software Considerations in Airborne Systems and Equipment Certification, December 1992
	ED-215	Software Tool Qualification Considerations, January 2012

Figure 2-4-3 (Sheet 2 of 3) Associated Publications and Standards Related to Airborne Software and Electronic Hardware

Associated Publications and Standards		
Regulator or Organization	**Number**	**Title**
EUROCAE (Cont)	ED-218	Model-Based Development and Verification Supplement to ED-12C and ED-109A, January 2012
	ED-217	Object-Oriented Technology and Related Techniques Supplement to ED-12C and ED-109A, January 2012
	ED-216	Formal Methods Supplement to ED-12C and ED-109A, January 2012
	ED-80	Design Assurance Guidance for Airborne Electronic Hardware, April 2000
SAE	ARP 4754A	Guidelines for Development of Civil Aircraft and Systems, December 2010
	ARP 4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, December 1996
U.S. DoD	AC-17-01	Airworthiness Circular (USAF) – Verification Expectations for Select Section 15 Criteria, 23 Mar 2017
	MIL-STD-498	Military Standard: Software Development and Documentation, December 1994
	DOD-STD-2167A	Military Standard: Defense System Software Development, February 1988
	JSSG-2001B	Department of Defense, Joint Service Specification Guide, Air Vehicle, 30 April 2004
	JSSG-2008A	Joint Service Specification Guides, Vehicle Control and Management System (VCMS), 22 Oct 2008
UK MoD	DEF STAN 00-55	Requirements for Safety of Programmable Elements (PE) in Defence Systems
NATO	AOP-52	Guidance On Software Safety Design and Assessment of Munition-Related Computing Systems, Edition 1, 9 December 2008

Figure 2-4-3 (Sheet 3 of 3) Associated Publications and Standards Related to Airborne Software and Electronic Hardware

PART 2
CERTIFICATION PROCESSES

CHAPTER 5 — EQUIPMENT ENVIRONMENTAL QUALIFICATION AND AIRCRAFT OPERATIONS AFTER COLD SOAK

2.5.1 Introduction

1. This Chapter identifies the airworthiness design standards and requirements related to the environmental qualification of equipment for installation on DND/CAF aircraft, as well as certification requirements for aircraft operations after cold soak. This Chapter does not include Electromagnetic Environmental Effects (E3), which are discussed in Part 2, Chapter 3, structural integrity which is discussed in Part 2, Chapter 8 and propulsion systems which are discussed in Part 3, Chapter 10. Furthermore, the requirements included in this chapter may be insufficient to cover equipment for which the certification basis directly imposes other specific requirements (e.g., air data probes).

2. During military aircraft operations, avionics and other aircraft equipment are often exposed to extreme environmental conditions. To demonstrate that such exposure will not impact the safe flight and operations of the aircraft, equipment must satisfy the requirements of an appropriate environmental standard.

3. Equipment that is installed on a DND/CAF aircraft is normally designed to comply with either a civil or military environmental standard. However, the environmental conditions defined in the standard may not reflect the actual conditions in which the aircraft will operate. Furthermore, civil Airworthiness Codes may not require equipment qualification for operations in the often much harsher environments experienced during military operations. Consequently, to supplement the Airworthiness Codes and provide a basis for verifying the acceptability of aircraft equipment for safe flight and operation, the Technical Airworthiness Authority (TAA) may specify airworthiness design standards that are deemed acceptable for the environmental qualification of aircraft equipment to meet the conditions set out in the Statement of Operating Intent (SOI).

2.5.2 Definitions

1. **Environmental Qualification.** Identifies the process used to show compliance to environmental airworthiness standards identified in an aircraft certification basis.

NOTE

This use of the term “qualification”, in this context, is different from the one described in Part 1 of this manual; however, it is aligned with the usage of “environmental qualification” by other recognized airworthiness authorities.

2. **Mission Equipment.** Equipment or systems installed on an aircraft whose function is not required (essential) to safely take off, fly or land the aircraft. This type of equipment or systems may be essential for the performance of a military mission, and their installation and operation must not have an adverse effect on the safe flight of the aircraft.

2.5.3 Standards

1. Figure 2-5-1 and Figure 2-5-2 identify those equipment environmental qualification standards that are deemed acceptable by the TAA.

Civil Environmental Airworthiness Standards, Qualification Standards and Associated Means of Compliance	
1.	**14 CFR Part 2x./CS-2x./AWM 52x.1309a,** Equipment, systems and installations

Figure 2-5-1 (Sheet 1 of 2) Civil Standards and Guidance Related to Environmental Qualification

Civil Environmental Airworthiness Standards, Qualification Standards and Associated Means of Compliance	
2.	**14 CFR Part 2x./CS-2x./AWM 52x.1301,** Function and installation
3.	**14 CFR Part 23./CS-23./AWM 523.2500,** Aeroplane Level Systems Requirements
4.	**RTCA DO-160,** Environmental Conditions and Test Procedures for Airborne Equipment
5.	**European Organisation for Civil Aviation Equipment (EUROCAE) ED-14,** Environmental conditions and test procedures for airborne equipment
6.	**FAA AC 21-16G,** RTCA Document DO-160 Versions D, E, F and G
7.	**FAA AC 23-17C,** Systems and Equipment Guide for Certification of Part 23 Airplanes and Airships, Chapter 2, Section 1, 23.1301
8.	**Society of Automotive Engineers (SAE) AIR 6811,** Equivalence of Equipment Environmental Qualification Standards for Civil and Military Aircraft Equipment

Figure 2-5-1 (Sheet 2 of 2) Civil Standards and Guidance Related to Environmental Qualification

Military Airworthiness and Environmental Qualification Standards

1. **MIL-HDBK-516C Airworthiness Certification Criteria**
   a. **Chapter 4 Systems Engineering**
      i. 4.1.5 Operating environment
   b. **Chapter 6 Flight Technology**
      i. 6.2.2.2 Flight critical components
      ii. 6.2.2.7 Environmental requirements
   c. **Chapter 8 Air Vehicle Subsystems**
      i. 8.1.11 Qualification testing
      ii. 8.3.13.1 Explosive atmosphere
      iii. 8.4.1.2 Qualification tests
      iv. 8.4.3 Hazard consideration in designs
      v. 8.5.12.17 Qualification testing
   d. **Chapter 11 Avionics**
      i. 11.2.4 Operational environment
      ii. 11.3.1 Avionics air vehicle installation
   e. **Chapter 12 Electrical System**
      i. 12.2.6.1 Prevention of ignition
   f. **Chapter 14 System Safety**
      i. 14.2.7 Environmental conditions
   g. **Chapter 15 Computer Systems and Software**
      i. 15.3.4 Environmental qualification
2. **MIL-STD-810,** Test Method Standard, Environmental Engineering Considerations and Laboratory Tests

Figure 2-5-2 Military Environmental Standards

2.5.4 Guidance Information – Equipment Required for Safe Take-Off, Flight and Landing

1. This section identifies environmental qualification requirements and guidance for equipment required for continued safe flight, take-off and landing when exposed to expected environmental conditions. Required equipment, when subjected to expected environmental conditions, must continue to function properly and not affect other equipment essential to safe operation.

2. It is the responsibility of the applicant for the type certification or modification of a DND/CAF aircraft to identify the aircraft certification basis required to satisfy the conditions of the Statement of Operating Intent (SOI), and acceptable means and methods of compliance, associated with environmental qualification. For equipment associated with failure conditions of Major, Hazardous or Catastrophic severity, the TAA expects that equipment environmental qualification will be conducted in two parts:

a. laboratory testing of the equipment using RTCA DO-160/ED-14 or MIL-STD-810. Note that an acceptable similarity analysis may be used to leverage testing conducted on another equipment; and

b. an analysis that identify how the accomplished laboratory testing is acceptable for the foreseeable installed environmental conditions.

3. For equipment associated with Minor failure conditions or below installed on aircraft, the TAA recognizes the FAA Guidance of AC 23-17C, extends it to all certification bases, and accepts that compliance may also be demonstrated, as appropriate, in full or in part, by representative ground or flight evaluation. An analysis is still required to identify how the testing is acceptable for the foreseeable installed environmental conditions.

4. For aircraft with a civil certification basis, the minimum level of safety in the expected civil operating environment is that provided by the testing methodology of RTCA DO-160/ED-14. While the TAA recommends the latest version of RTCA DO-160/ED-14 be used, it is understood that commercial off-the-shelf equipment may be qualified against an earlier version. If the equipment is approved to the minimum performance standards of a TSO, no further justification regarding the version is required, provided the equipment is qualified to the RTCA DO-160/ED-14 version identified in the TSO, or later. If the equipment is not approved to the minimum performance standards of a TSO, FAA AC 21-16G identifies a summary of changes between revisions D to G, which may be used to substantiate testing to an earlier version of the RTCA DO-160/ED-14. Earlier version than D should never be used without prior agreement with the TAA.

5. Military operations may expose aircraft with civil certification basis to conditions that are different from, or harsher than accounted for, by RTCA DO-160/ED-14. If this is the case, then the certification basis must account for the harshest environment expected. An example is the vibration induced by the use of armament. In those situations, an acceptable strategy is to augment or replace applicable RTCA DO-160/ED-14 tests with the appropriate methods of MIL-STD-810.

NOTE

The provisions of this paragraph may not be used to reduce the level of safety for specific tests where RTCA DO-160/ED-14 is more severe than MIL-STD-810. See 2.5.4.6 for more details.

6. Most TAA-recognized military airworthiness codes prescribe the qualification of required equipment using MIL-STD-810. The TAA does not have a policy with regards to which version of MIL-STD-810 should be used. However, use of the latest version is recommended. For design changes to an already approved aeronautical product, the version used at the time of initial certification is normally considered acceptable.

7. In some cases, military equipment qualified against MIL-STD-810 must be installed on civil pattern aircraft, or civil equipment qualified against RTCA DO-160/ED-14 must be installed on military pattern aircraft. In such cases, the applicant must perform a comparison analysis to substantiate that the equipment environmental qualification provides an equivalent level of safety in the expected operating environment. The TAA recognizes the analyses contained in SAE AIR 6811 – *Equivalence of Equipment Environmental Qualification Standards for Civil and Military Aircraft Equipment*. If the comparison analysis identifies gaps, those gaps may be dispositioned via additional testing, changes in the installation, or any other method acceptable to the TAA.

2.5.5 Guidance Information – Mission Equipment

1. This section identifies environmental qualification requirements and guidance for mission equipment. Installation guidance is documented in TAA Advisory 2006-04 – Installation of Miscellaneous Non-Required Equipment. Environmental qualification requirements, for the purpose of type certification or design change

certification, will depend on whether or not this equipment has a function or mode that creates the possibility for the equipment to affect the safe flight and operation of the aircraft.

NOTE

MIL-STD-810 or RTCA DO-160/ED-14 may also be used to validate the robustness of mission equipment in specific operating environments, however this is not related to certification and thus falls outside the scope of the DND Technical Airworthiness Program. The contract requirement specification will include requirements for mission equipment environmental qualification, as directed by the Project Management Office or Weapon System Manager.

2. If the mission equipment has a function or mode that may affect safe flight and operation of the aircraft, it must be demonstrated that it functions properly and does not affect the required equipment when subjected to environmental conditions. The environmental qualification requirements are the same as those for the required equipment detailed in 2.5.3, except that equipment performance evaluation during environmental testing can be limited to functions or modes with a safety impact.

3. If the mission equipment does not have a function or mode that can affect safe flight and operations of the aircraft, there is no technical airworthiness requirement to demonstrate that it will function properly when subjected to environmental conditions. However, it must still be demonstrated that the equipment will not affect the crew, the aircraft, or any required equipment, when subjected to environmental conditions, by means of safety of flight environmental testing. The type of environmental tests to be considered will depend on the specifics of the installation. Examples of tests that may be required include:

a. **Shock-Crash Hazard Testing.** May be required if the equipment has the potential to present a hazard to occupants, engine and fuel systems, or impede emergency evacuation following an emergency landing.

b. **Rapid Decompression Testing.** May be required for equipment using high voltage electrical/electronic circuits (e.g., displays), rapid moving parts (e.g., spinning hard drives) or equipment located in proximity to personnel that may create a hazard when subjected to rapid decompression

c. **Explosive Atmosphere Testing.** May be required for equipment that may come into contact with flammable fluids and/or vapors, to ensure it does not ignite and cause an explosion or contains an explosion occurring within the equipment.

d. **Flammability.** May be required to check the non-propagation of flames in case of ignition in or outside the equipment.

4. However, if mission equipment determined to have no function or mode that can affect safe flight or operations shares an interface with required equipment, for example via a databus, technical airworthiness compliance must include demonstration that the equipment does not affect said interface under foreseeable operating conditions that include representative installed vibration, temperature and altitude environments. While the standards identified in Figure 2-5-1 and Figure 2-5-2 are the preferred means of compliance, Original Equipment Manufacturer environmental specification and demonstrated flight test performance may be considered to demonstrate technical airworthiness compliance when found acceptable by the TAA.

5. Although the TAA only requires safety of flight environmental testing for some mission equipment for technical airworthiness approval, the TAA recognizes the importance that this equipment may play in the accomplishment of the aircraft operational mission. As such, the TAA recommends that the in-flight and on-ground environmental conditions be established, and that all mission equipment be shown to be capable of functioning properly in those conditions.

2.5.6 Additional Guidance Specific to Gunfire Shock Environmental Qualification

1. The usage of installed guns may increase the vibration level experienced by onboard equipment. MIL-STD-810 Method 519 is the preferred method recognized by the TAA to demonstrate equipment environmental compliance to vibration levels induced by gunfire operations.

NOTE

The title of MIL-STD-810 Method 519 was modified in revision H from "Gunfire Vibration" to "Gunfire Shock". Within this chapter, both terminologies are used interchangeably.

2. Contrary to MIL-STD-810 Method 514 and DO-160 Section 8, which deal with vibration testing for non-gunfire environment, Method 519 recognizes that the level of vibration experienced by equipment will depend on the specifics of the aircraft and installation, and therefore does not define standard vibration profiles for laboratory testing. As such, a fundamental step of Method 519 is to determine the vibration levels experienced by the equipment as installed. Acceptable methods to determine a vibration level will depend on the severity of failure conditions associated with the equipment:

a. **Equipment associated with Catastrophic or Hazardous failure conditions.** Unless the distance between the gun and equipment is such that it is evident that gunfire-induced vibrations on the equipment will be negligeable, the TAA expects that vibration levels will be determined by using on-aircraft measurements directly at the equipment installed location.

NOTE

The distance between the equipment must be such as to be evident that there will be no effect on experienced vibration levels. In some cases, instrumentation may be used to document at which point gunfire induced vibration become insignificant.

b. **Equipment associated with Major failure conditions.** Given the impracticality of instrumenting all equipment during gunfire vibration surveys, the TAA concedes that acceptable theoretical or extrapolation techniques may be used to augment in-service measured data and determine a reasonable vibration level. For example, an applicant may instrument a specific small rack and use the measured vibration levels for all equipment installed on the rack. Extrapolation techniques may be used if the rack is large and was instrumented in multiple locations. Furthermore, Method 519 includes Sine-on-Random equations that may be used to predict gunfire vibration. Those equations are acknowledged in later revisions of MIL-STD-810 to be largely unreliable. The TAA does not accept sole application of those equations for certification and will only consider their use to extrapolate measured data over short distances.

c. **Equipment associated with Minor failure conditions.** Vibration levels may be determined as per equipment with Major failure conditions. Alternatively, compliance may be based on the equipment having functioned properly during a gunfire vibration survey, provided flight testing was of reasonable duration. See 2.5.4.2 and 2.5.4.3 for more details.

d. **Equipment associated with No Safety Effect failure conditions.** Vibration levels need only be determined if there is a reasonable expectation that, when subjected to gunfire vibration, the equipment will respond in such a way as to create a physical hazard to the aircraft or occupant. Normally, the equipment may be demonstrated to not cause a physical hazard during gunfire vibration surveys. See 2.5.5 for more details regarding mission equipment.

3. Once gunfire vibration levels are determined for the equipment, a comparison can be made against vibration levels for which the equipment is already qualified. If gunfire-induced vibration levels are equivalent or below the levels for which the equipment is qualified per DO-160 Section 8 or MIL-STD-810 Method 514, then compliance to gunfire vibration is automatic. If gunfire vibration levels have exceedances, laboratory qualification using the appropriate procedure of Method 519 is required using the vibration levels determined in paragraph (2). In some cases, exceedances may be minor or believed to be unrelated to gunfire (e.g., exceedances at very low frequencies). In such cases, the applicant is responsible to present a suitable engineering argument to the TAA documenting why the equipment is compliant to the gunfire vibration environment. QETE may be engaged to provide specialized environmental qualification support.

4. For equipment requiring laboratory qualification, when operational checks are conducted will depend on whether the equipment failure conditions are applicable to flight during gunfire operations. For example, it may be

acceptable operationally for an Air Data Computer (ADC) to have a function or performance degradation during gunfire operations, provided sufficient information is included in the aircraft Flight Manual to warn crews. In this case, operational checks may only need to be conducted after the ADC is subjected to gunfire vibration levels in the laboratory. However, if the ADC is connected to a flight control computer and its erroneous functioning may lead to unsafe altitude loss, then operational checks must also be conducted while the ADC is exposed to gunfire vibration levels in the laboratory. The number and scope of operational checks during laboratory qualification will be determined on a case-by-case basis during the test planning phase.

NOTE

Method 519 uses the terminology “operational check”, which is equivalent to determining compliance with applicable equipment standards as used in DO-160. It is a verification of function and performance of the equipment.

5. For design changes where a gun configuration is modified, or when new equipment is installed, the applicant may attempt to substantiate the validity of prior established vibration levels. For example, if a modification is made to the gun mount, the applicant may demonstrate that vibration levels have been reduced. Similarly, if equipment is replaced, the applicant may demonstrate that vibration levels will be, for the new equipment, sufficiently similar to those experienced by the replaced equipment, given similarities in equipment weight, build form and installation. Should the validation of prior levels not be possible, new levels will need to be established in accordance with 2.5.6.2.

2.5.7 Cold Soak

1. Figure 2-5-3 identifies the airworthiness standards and guidance associated with aircraft operations after ground cold soak.

Airworthiness Standards and Guidance for Cold Soak
1. **TCCA AWM 52x.1301-1,** Aeroplane/Rotorcraft Operations After Ground Cold Soak
2. **TCCA AC 500-006, Issue 1,** Aircraft Operations after Ground Cold Soak

Figure 2-5-3 Airworthiness Standards and Guidance Related to Operations after Ground Cold Soak

2. The TAA recognizes that aircraft and their associated systems may not always function as expected after prolonged cold soak, despite the individual equipment-level environmental qualification. Cold soak testing is, therefore, required to demonstrate that the aircraft systems will continue to function properly in service, and that no potential effect on safety will result from the low temperature soak.

3. For any initial airworthiness projects, TCCA Airworthiness Manual (AWM) Section 52x.1301-1 must be added to the aircraft certification basis, notwithstanding what was the original certification basis. This should be directly identified by the applicant in the Certification Plan and proposed Certification Basis. To satisfactorily accomplish the objectives of the cold soak test, a systematic check of the operation of components and systems is required to show that the aircraft and its systems function properly, and do not introduce hazards to safety.

4. The TAA recognizes that a temperature of -35 degrees Celsius is a realistic low temperature for most aircraft. However, for aircraft with a Statement of Operating Intent that specifically identifies expected operations after cold soak below -35 degrees Celsius, the TAA recommends that the worst-case temperature value be used for the cold soak compliance program. Failure to do so may result in a limitation being placed in the Aircraft Flight Manual commensurate with the test results achieved and compliance demonstration.

PART 2
CERTIFICATION PROCESSES

CHAPTER 6 — AIRCRAFT CYBERSECURITY

2.6.1 Introduction

1. Increased connectivity of aircraft systems to each other, as well as to external entities, presents a growing risk for cyber-attacks that could potentially lead to compromising critical avionics systems that are required for safe operation of the aircraft. Current technologies allow for aircraft to be connected to sources of unknown design/security assurance, such as satellites, removable media devices, and ground networks enabling internet access. Aircraft cybersecurity is a requirement against which the Technical Airworthiness Authority (TAA) verifies that these sources cannot affect the safe flight of the aircraft. This chapter identifies those airworthiness design standards, and associated advisory and guidance material, deemed acceptable by the TAA to address aircraft cybersecurity. It recognizes that the Department of National Defence/Canadian Armed Forces (DND/CAF) acquires, operates and maintains a mix of military and civil aircraft.

2. Aircraft cybersecurity is a relatively new airworthiness requirement that is being applied by all civil and military airworthiness authorities. Amendments to the European Union Aviation Safety Agency (EASA) civil airworthiness regulations have already been made to contribute to the protection of products and equipment against cybersecurity threats, and it is expected that other civil regulators, such as the Federal Aviation Administration (FAA) and Transport Canada Civil Aviation (TCCA), will follow with amendments to their regulations in the coming years.

3. While the airworthiness certification process has traditionally addressed failures and errors, the standards and associated guidance material identified in this chapter extend the scope of this process to address Intentional Unauthorized Electronic Interaction (IUEI) with aircraft systems resulting in safety effects. Just as failures and errors are treated as manageable risks to aircraft safety by the airworthiness certification process, the threat of IUEI is treated equally through the aircraft cybersecurity activities. This chapter addresses aircraft cybersecurity for type design approval and type design changes.

4. Aircraft cybersecurity requirements should apply to the overall aircraft weapon system, which includes the aircraft and associated Aircraft Support Equipment (ASE).

2.6.2 General

1. Recent designs for aircraft systems incorporate novel design features that may allow exploitation of system or network security vulnerabilities resulting in intentional or unintentional destruction, disruption, degradation, or exploitation of data, systems, and networks critical to the safety and maintenance of the aircraft. This creates the need for protection of aviation information systems from IUEIs. The following are examples of such novel design features:

   a. Digital systems architecture composed of several connected networks that may enable IUEI with flight safety-related control, communication, and navigation systems;

   b. Aircraft connectivity to networked services, such as the internet and tactical networks;

   c. Aircraft connectivity to ASE and in-service support products and services, such as mission planning systems, data loaders, maintenance computers and portable electronic devices; and

   d. Use of commercial off-the-shelf technologies.

2. The role of the weapon system as well as the conditions and environments in which the aircraft will be operated are important factors to consider when conducting Security Risk Assessments (SRAs). This information can be found in the Statement of Operating Intent (SOI) and Concept of Operations (CONOPS) for the aircraft fleet.

3. Civil standards are also recommended for civil derivative aircraft that have been modified for a military role. Civil aircraft cybersecurity guidance only addresses technical and operational airworthiness in a civil context; they do not address military-specific systems or equipment. The TAA and the Project Management Offices (PMOs) or the Weapon System Managers (WSMs) will need to discuss and agree on the standards to be used to address aircraft-related security issues specific to military systems or equipment.

4. For military derivative aircraft, if the EASA aircraft cybersecurity airworthiness codes were not applied, then the standards and methods of compliance that address security requirements for the aircraft will need to be reviewed and accepted by the TAA or its Authorized Individual (AI).

5. To assist in understanding the guidance information presented in the following sections of this chapter, a visual depiction of the civil aircraft cybersecurity process model is provided in Figure 2-6-1. This figure shows how the security process interacts with the safety assessment process and the system development process.

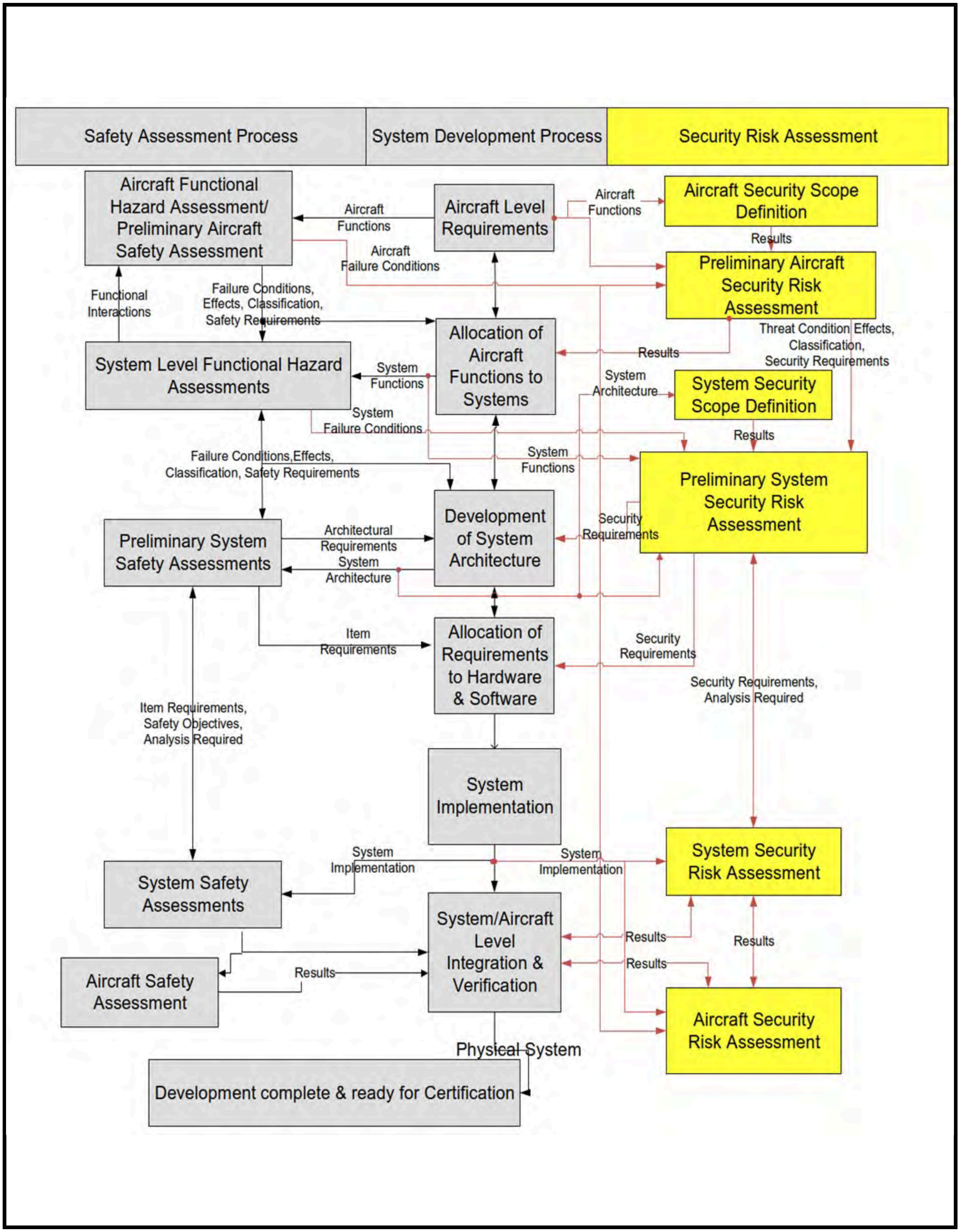

Figure 2-6-1 Civil Aircraft Cybersecurity Process Model

2.6.3 Aircraft Cybersecurity Certification Requirements

1. **Certification Requirements.** Figure 2-6-2 lists the certification requirements that are deemed acceptable by the TAA for defining the certification basis for an aircraft, engine, propeller, or Auxiliary Power Unit (APU) and, specifically, for aircraft cybersecurity for DND/CAF aircraft.

Civil Certification Requirements		
Certification Requirement	**Description**	**Means/Methods of Compliance**
CS-23.2500(b)	**Normal-Category Aeroplanes** General requirements on systems and equipment function	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-25.1319	**Large Aeroplanes** Equipment, systems and network information protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-27.1319	**Small Rotorcraft** Equipment, systems and network information protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-29.1319	**Large Rotorcraft** Equipment, systems and network information protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-E 50(l)	**Engines** Engine Control System – Information System Security Protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-P 230(g)	**Propellers** Propeller Control System – Information System Security Protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-APU 90(d)	**Auxiliary Power Units (APU)** APU Control System – Information System Security Protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A
CS-ETSO Subpart A Para 2.6	**European Technical Standard Orders (ETSO)** Information Security Protection	AMC 20-42 DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A

Figure 2-6-2 Civil Certification Requirements Related to Aircraft Cybersecurity

NOTE

Currently, EASA is the only certification authority that has developed and published airworthiness requirements for aircraft cybersecurity. TCCA, the FAA and Military Airworthiness Authorities have *not yet published requirements for aircraft cybersecurity, and instead continue to use Special Conditions. For this reason, it is the TAA's preference that applicants use the EASA airworthiness code for aircraft cybersecurity in their certification basis.*

2. **TAA-Accepted Standards.** It is the TAA's preference that the standards listed in Figure 2-6-2 be used as a guideline for demonstrating compliance to the aircraft cybersecurity certification requirements, as follows:

a. From a civil perspective, RTCA DO-326A/EUROCAE ED-202A should be used as a guideline to meet the DND/CAF aircraft cybersecurity certification requirements found in Figure 2-6-2. In the case of acquisition of an existing type design aircraft, design standards used at the time of initial airworthiness approval may continue to apply. For an aircraft that has no prior aircraft cybersecurity consideration, the applicant should discuss aircraft cybersecurity applicability with the TAA.

b. RTCA DO-326A/ED-202A provides process guidance for aircraft certification to handle the threat of IUEI to aircraft safety. It adds data requirements and compliance objectives, as organized by generic activities for aircraft development and certification, with other applicable guidance material, including SAE ARP 4754A/ED-79A, DO-178C/ED-12C, and DO-254/ED-80 and with the advisory material associated with FAA and EASA regulations on equipment, systems and installations.

c. RTCA DO-355A/ED-204A is a resource for civil aviation authorities and the aviation industry to ensure that the effects of IUEI on the safety of the aircraft are confined within acceptable levels during operation and maintenance.

d. Both DO-326A/ED-202A and DO-355A/ED-204A capture the TAA's preferred guidance and methodology to meet the DND/CAF Airworthiness Program security requirements.

e. RTCA DO-356A/ED-203A was developed as a companion document to DO-326A/ED-202A. The methods and considerations of this document provide guidance for applicants accomplishing the aircraft cybersecurity process activities specified in DO-326A/ED-202A. Appendix E of DO-356A/ED-203A is the preferred method to be used to calculate the level of threat in the SRA.

3. **Alternative Standards.** When an applicant proposes to use alternative design standards, the proposed alternative standards must be accepted by the TAA, and the applicant should provide the plan for the security aspects of certification to the TAA, for evaluation and acceptance, as early as possible.

4. **Essential Activities.** The following is a summary of the aircraft cybersecurity process for aircraft development and certification, to handle the threat of IUEI to aircraft safety. These essential objectives are modeled after the civil process in RTCA DO-326A/ED-202A, as depicted in Figure 2-6-1. These basic activities exist in both civil and military aircraft cybersecurity requirements and processes, with some variance. Annex A of this chapter provides applicants with notes on best practices developed by cybersecurity specialists within DTAES describing the process to successfully meet cybersecurity requirements. Such a process should establish and support the following aircraft cybersecurity objectives with necessary certification data (tailoring of objectives and documents should be considered in the case of a change to the type design):

a. Objectives:

(1) Develop a systems security engineering management plan, or a plan for the security aspects of certification, to identify the scope and content of the security activities that are applicable at both the aircraft and system level, and include the means for demonstrating compliance with airworthiness requirements related to security concerns;

(2) Ensure the aircraft and system security scope (security perimeter, aircraft Assets, and security environment) are identified, correct and complete;

(3) Conduct aircraft and system SRAs to identify and assess all security risks and vulnerabilities at both aircraft and system levels;

(4) Determine and validate security requirements and establish an effective aircraft security architecture and measures;

(5) Demonstrate compliance with aircraft security requirements and evaluate the security effectiveness of the security measures of the aircraft for its intended environment;

(6) Ensure aircraft and system security risks are acceptable; and

(7) Develop aircraft and system security maintenance and operator guidance that is consistent and complete with requirements and implementation.

b. Certification documents created by the aircraft cybersecurity process should address the following:

(1) A technical description of the system;

(2) A list of all threat conditions associated with the aircraft and system Assets;

(3) Identification of all related security requirements (including derived requirements);

(4) Allocation of system security requirements (including derived requirements) to dedicated Software/Hardware sub-components, including security architecture and measures;

(5) Overview of aircraft and selected system level architectures, with emphasis on elements pertinent to security threats and security measures;

(6) All assumptions (e.g., assumptions related to the security environment of the aircraft digital network system and its interfaces), descriptions and explanations used for the analysis development;

(7) SRA with security verification and test results/analysis;

(8) Traceability of security requirements from design to implementation and through to verification; and

(9) A summary of all operating limitations and certification maintenance requirements, which are applicable to the final system configuration.

2.6.4 Type Design Changes

1. Any modification to aircraft systems or interfaces requires an assessment (or re-assessment) to ensure that an acceptable level of safety is maintained. A Change Impact Analysis (CIA) is required for modifications that permit access by unauthorized persons or equipment, either during modification, or maintenance. The CIA should verify the following (section 4.2.1 of DO-326A/ED-202A):

a. The aircraft and its systems, networks and other Assets are protected from an IUEI;

b. Procedures exist to ensure the continued airworthiness of the Aircraft;

c. Malicious or inadvertent change to aircraft systems and networks required for safe flight and operations are prevented; and

d. Previously approved security measures are maintained.

2. To assist in identifying and analyzing the integration issues between the proposed modification and the connectivity to existing aircraft networks and systems, a high-level overview of the modification process is provided in Figure 2-6-3.

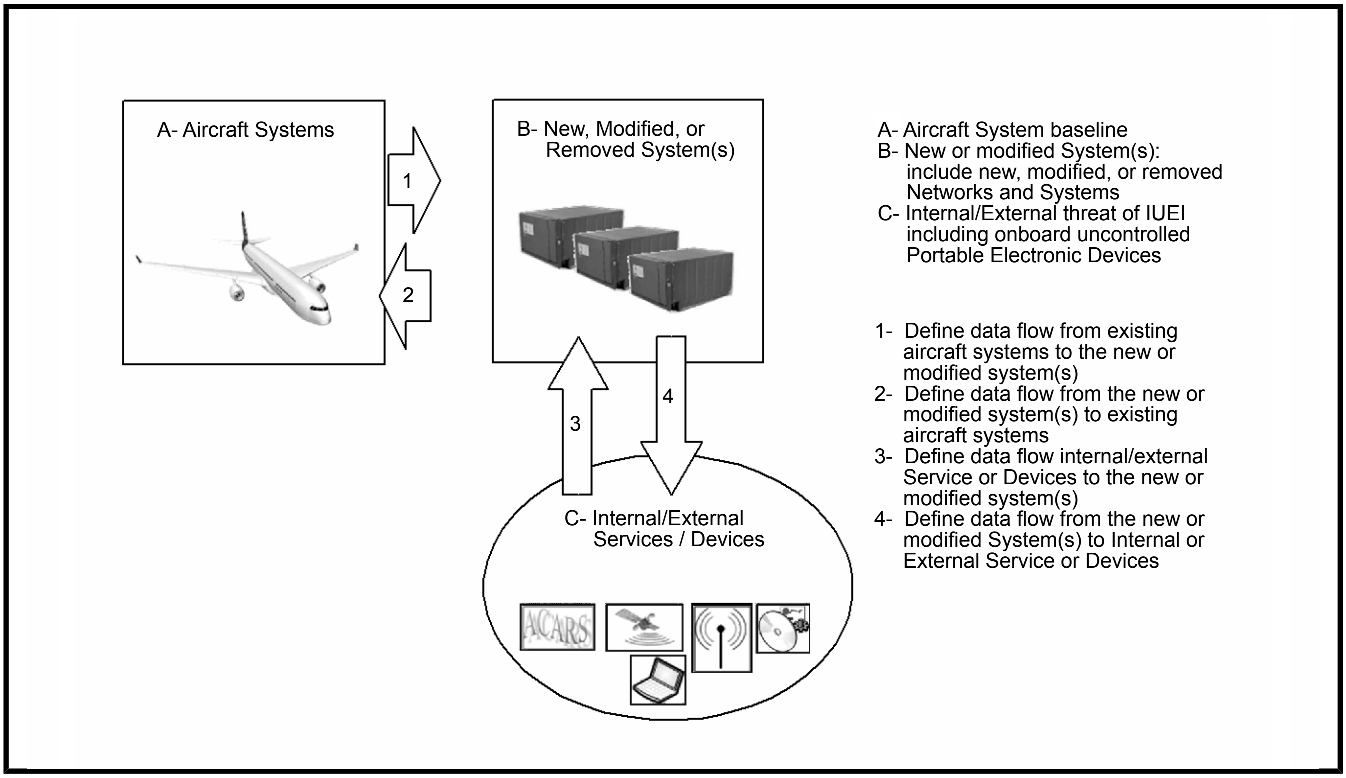

Figure 2-6-3 Interconnectivities of New, Modified, or Removed Aircraft Systems

3. The result of the CIA may be used to determine if an aircraft or system level SRA is required. Section 4.1 of DO-326A/ED-202A provides guidance on how to determine when an aircraft level, versus a system level, SRA is required. In most cases, federated avionics systems with unidirectional data busses could limit activities to a system level SRA. Highly integrated aircraft with bi-directional data busses typically require an aircraft level SRA.

2.6.5 Associated Publications and Standards

1. Associated references for the aircraft system security requirement and assessment are listed in Figure 2-6-4.

Associated Publications and Standards		
Regulator or Organization	**Reference Number**	**Title**
Radio Technical Commission for Aeronautics (RTCA)	DO-326A	Airworthiness Security Process Specification
	DO-355A	Information Security Guidance for Continuing Airworthiness
	DO-356A	Airworthiness Security Methods and Considerations
	DO-391	Aeronautical Information System Security Framework Guidance
	DO-392	Guidance for Security Event Management
The European Organisation for Civil Aviation Equipment (EUROCAE)	ED-202A	Airworthiness Security Process Specification
	ED-203A	Airworthiness Security Methods and Considerations
	ED-204A	Information Security Guidance for Continuing Airworthiness

Figure 2-6-4 (Sheet 1 of 2) Associated Publications and Standards Related to Aircraft System Security Requirement and Assessment

Associated Publications and Standards		
Regulator or Organization	**Reference Number**	**Title**
EUROCAE (Cont)	ED-201A	Aeronautical Information System Security Framework Guidance
	ED-206	Guidance for Security Event Management

Figure 2-6-4 (Sheet 2 of 2) Associated Publications and Standards Related to Aircraft System Security Requirement and Assessment

ANNEX A

NOTES ON BEST PRACTICES

2.6A.1 Introduction

1. Part 6, Chapter 2 of the ADSM is focused on aircraft cybersecurity as it relates to airworthiness for the certification of aircraft and type design changes. However, ensuring a cyber-resilient platform requires consideration of Cyber Mission Assurance (CMA) as well as traditional IT Security processes. The Harmonized Assessment of Cybersecurity Risk (HACR) Process for Weapon Systems utilizes RTCA/DO-326A (supplement by DO-356A and DO-355A), Risk-based Cyber Mission Assurance (CMA) Process (RCMAP), IT Security policies and standards, and industry best practices to support the achievement of Aircraft Cybersecurity Certification, IT Security and CMA. The resulting outcome is both compliance to the certification basis requirement for Aircraft Cybersecurity, and the issuing of an Authorization to Operate (ATO) by DTAES, the Security Authority for Aerospace Systems. The HACR process is described in more detail within this annex. Applicants are encouraged to apply the process to their platforms and systems.

2. Applicants should liaise with DTAES 8 before project initiation to establish the certification requirements for cybersecurity. DTAES 8 can provide a template of requirements and data deliverables to support the successful implementation of cybersecurity activities within the project.

3. To support the applicant in the application of the HACR process, DTAES 8 recommends the Project Management Office (PMO), Weapon System Manager (WSM) and Contractor attend the Short Course in Cybersecurity Risk Assessment Methodology (SCCRAM) conducted by faculty of the Royal Military College (RMC) of Canada Computer Security Lab (CSL) and DTAES 8. The SCCRAM teaches security practitioners the application of the HACR process and how to meet contractual requirements.

2.6A.2 Requirements

1. **General.** The overarching aircraft cybersecurity requirements are listed in Figure 2-6-1. Specifications, standards and guidance documents describing the steps to create and maintain a cyber-resilient aircraft weapon system are listed in 2.6.6A.1.2.

2. **Specifications, Standards and Guidance Documents (most recent revision):**

    a. SAE ARP 4761 describes the guidelines and methods of performing the safety assessment for certification of civil aircraft.

    b. SAE ARP 4754A discusses development of aircraft systems and validation of requirements and verification of the design implementation for certification. The guidelines provided in this document are directed towards systems that support aircraft-level functions and have failure modes with the potential to affect safety of the aircraft.

    c. RTCA DO-326A/ED-202A provides guidance for aircraft certification to handle the threat of IUEI to aircraft safety. This specification provides guidance in addressing airworthiness security during the aircraft product life cycle from project initiation until the aircraft Type Certificate is issued.

    d. RTCA DO-356A/ED-203A provides guidance for accomplishing the airworthiness security process activities identified in RTCA DO-326A/ED-202A.

    e. RTCA DO-355A/ED-204A provides guidance for operation support, maintenance, and administration and destruction stages of the product life cycle.

    f. RTCA DO-254/ED-80 provides design assurance guidance for airborne electronic hardware.

    g. RTCA DO-178C/ED-12B provides software considerations in airborne systems and equipment certification.

h. RTCA DO-391/ED-201A provides Aeronautical Information System Security (AISS) guidance and best practices for addressing increasing potential for IUEI with aeronautical information systems.

i. RTCA DO-392/ED-206 provides guidance for security event management and addressing information security threats that can affect aviation safety.

j. Risk-based Cyber Mission Assurance Process (RCMAP) is a publication prepared by Defence Research and Development Canada, which describes the activities required for the cyber risk management of military systems throughout their whole life cycle.

2.6A.3 HACR Process

1. The HACR process for Weapon Systems is grouped into the following three focus areas:

a. Planning and Approval;

b. Security Risk Assessment; and

c. Security Development.

2. Each focus area is described below. Subject Matter Experts (SMEs) from DTAES 8 may be contacted for further details and guidance on the analysis and outputs required.

2.6A.4 Planning and Approval

1. **System Security Working Group (SSecWG)**. The SSecWG is a recurring working group comprised of system security personnel from the applicant organization, the Aircraft Cybersecurity Finding Authority and other security stakeholders to support successful implementation of cybersecurity requirements within the project.

2. **System Security Engineering Management Plan (SSEMP)**. The SSEMP documents and provides an understanding of the systems security engineering management program and details the organizational responsibilities (DND/CAF and contractors) and procedures used to implement the system security engineering program. The SSEMP may also address the Plan for Security Aspects of Certification (PSecAC), which is to be developed in accordance with DO-326A/ED-202A.

3. **Security Requirements Traceability Matrix (SRTM)**. The SRTM establishes and documents traceability of security specific requirements from their origins to their realization in design and functional specifications, and eventually the development, implementation, verification, validation, and deployment. Tracking of Security Objective compliance is also done within the SRTM.

4. **Plan of Actions and Milestones (POAM)**. The POAM documents cybersecurity risks and/or assurance activities that have not been remediated or fully met, and provides the timings and resources required to complete the activity or mitigate the risk.

2.6A.5 Security Risk Assessment

1. **Security Scope Definition (SSD)**. The SSD, as part of the security risk assessment, documents the reduction of aircraft weapon system Assets to a subset of Assets susceptible to IUEI that either directly, or indirectly, interact with external entities (potential threat sources). Establishing the security scope at the aircraft level and system level requires access to aircraft and system architecture documentation. The SSD process can be grouped into the following:

NOTE

The term Asset in the HACR process extends the DO-356A/ED-203A definition to include cyber mission assurance.

a. **Aircraft SSD:**

(1) **Security Environment.** Identifies all the external entities interfacing with the aircraft, which are considered potential threat sources. All interfaces between the aircraft and its security environment must be considered (wired, wireless, data entry and/or mechanical interaction). This includes documenting assumptions and requirements about the external entity (persons, organizations and external systems) that interact with the aircraft.

(2) **Security Perimeter.** Identifies the aircraft external interfaces, data flows and associated external entities, showing the points that expose the aircraft to attack.

b. **System SSD:**

(1) **Decomposition.** The aircraft is decomposed from aircraft level systems down to the lowest level applicable (e.g., LRU, item). At each level of decomposition, Asset questions are used to determine if an Asset is susceptible to IUEI.

(2) **Security Perimeter and Environment.** For each Asset that is susceptible to IUEI, interfaces are analysed to determine if they can propagate an IUEI. The remainder of the security risk assessment focuses on a subset of Assets (Assets that are susceptible to IUEI and that either directly or indirectly interact with external entities identified through the Aircraft SSD).

2. **Mission Criticality Analysis and Asset Valuation (MCAAV)**. The MCAAV is a method for identifying the cyber dependencies of missions on functions and quantifying the mission impact caused due to the loss of Confidentiality, Integrity and Availability of the system functions. The MCAAV process can be grouped as follows:

a. **Mission Dependency Model (MDM)**. Documents a list of mission objectives and capabilities that are used to map the criticality of capabilities to mission objectives. This supports the impact assessment during Asset Valuation.

b. **Asset Valuation**. Maps the final set of Assets from the SSD to their associated function losses based on each security attribute (Confidentiality, Integrity or Availability) and assess the impact of these losses to both airworthiness and mission objectives. This impact rating supports the subsequent risk assessment and security development activities. The Aircraft and System Functional Hazard Assessment (FHA) is a key document required for this analysis. In the case that an FHA is not available for a particular aircraft, a generic FHA can be applied and evaluated for adequacy on a fleet-by-fleet basis.

3. **Security Risk Assessment (SRA)**. The SRA is an iterative process beginning with a Preliminary Security Risk Assessment (PSRA) and ending with a full SRA. The PSRA deals with susceptibility of IUEI in the architecture and design or operational procedures; the full SRA considers susceptibility to IUEI in the implementation. At each iteration, the security risk assessment documents the threat scenario identification, security measure characterization, and calculation of security risk for each threat scenario.

a. **Threat Scenario Identification.** Identifies all the potential Threat Scenarios that could compromise a Security Attribute of the Assets determined through the SSD process.

b. **Security Measure Characterization.** A continuous process – from first identification of the requirement for security measures in the SRA, to ensuring correct implementation of the measures during development, to providing evidence that security measures have achieved the required effectiveness at the end of development. All identified security measures need to be characterized to be applicable in a threat scenario. Security Measure Characterization provides information to threat scenario identification and calculating security risk for each threat scenario.

c. **Calculate Security Risk for each Threat Scenario (Level of Threat Evaluation).** The security risk for each Threat Scenario is calculated by compiling the total Protection Effectiveness against the Threat Scenario in accordance with DO-356A/ED-203A Appendix E and using the impact from the MCAAV to determine risk acceptability. The Protection Effectiveness is determined depending on the type (technical or non-technical) and category (preparation means, window of opportunity, or execution means) that the Security Measure falls into in accordance with RTCA DO-356A/ED-203A Appendix E. The acceptability of a risk with respect to the Severity of the Threat and Mission Objective Impact is determined using two separate Risk Acceptability Matrices provided by DTAES 8. DTAES 8 advises using Protection Effectiveness vs. Likelihood when calculating security risk.

2.6A.6 Security Development

1. **Security Architecture and Measures.** Security Measures are planned and applied in cases where the Security Risk Assessment of a given Threat Scenario resulted in an unacceptable risk. Development of Security Measures is an optimization problem where many factors need to be considered (cost, ease of implementation, level of Protection Effectiveness offered, etc.). Security SMEs from DTAES 8 can offer guidance and reference documentation for effective Security Measures that can be applied to aviation systems.

2. **Security Architecture Principles.** When developing the security architecture of a system, it is recommended to consider and apply, where possible, the following Security Architecture Principles that are defined in DO-356A/ED-203A:

a. Defence-in-Depth;

b. Integrity of Connected Equipment;

c. Continuing Airworthiness;

d. Prevent Bypass of Security Barriers;

e. Keep Security Architecture as Simple as Possible;

f. Detection and Restoration;

g. Attack Path Refinement at System Level;

h. Consider Security Process Specifics;

i. Minimize External Interfaces;

j. Disable All Unused Interfaces;

k. Independence and Isolation;

l. Ensure Proper Error Handling;

m. Least Privilege; and

n. Control Access to Connections.

3. **Security Verification and Validation.** Security Verification and Validation ensures that Security Measures work as expected and it is not possible for them to be bypassed. Some Security Measures require sophisticated tests to verify the absence of vulnerabilities. The security test activities required for each Security Measure can be determined using the Security Assurance Levels (SALs) assigned as described in DO-356A/ED-203A.

4. **Security Guidance.** The purpose of the Security Guidance activity is to provide documentation describing the integration, operation and maintenance requirements for Security Measures. A complete list of the recommended security guidance to be developed can be found in DO-326A/ED-202A, supplemented by DO-356A/ED-203A, DO-355A/ED-204A, DO-392/ED-206 and RCMAP, or obtained from security SMEs in DTAES 8.

PART 2
CERTIFICATION PROCESSES

CHAPTER 7 — AIR VEHICLE – PERFORMANCE AND HANDLING

2.7.1 Introduction and Scope

1. This chapter identifies the airworthiness requirements, standards and associated guidance acceptable to the Technical Airworthiness Authority (TAA) for air vehicle performance and handling. Air vehicle performance and handling constitute a group of aeronautical specialties or topics focused on the aerodynamics, flight dynamics, performance, flight controls, flying qualities/characteristics, icing, and stores/weapons carriage/separation of aircraft.

2. The scope of this chapter, however, does not include standards and requirements for aeroelasticity (flutter) and aerodynamic loads (which are covered in Part 2, Chapter 8 – Structural Integrity of this manual), nor ground resonance and stores/weapons carriage/separation (the latter is detailed in Part 2, Chapter 9 – Armament and Stores Integration). This chapter only considers the impact of these specialties on aircraft vehicle performance and handling.

3. The chapter also provides guidance on the establishment of a certification basis for initial type design approval, or subsequent design changes, which impact air vehicle performance and handling. Recognizing that DND acquires and operates a mix of military and civil pattern aircraft, both military and civil airworthiness requirements and standards are provided. The TAA (DTAES 7-5 – Flight Sciences) specialists should be consulted in the planning stages for any projects that involve the specialties mentioned above.

2.7.2 Civil Certification Requirements and Airworthiness Design Standards for Air Vehicle Performance and Handling

1. DND/CAF aircraft operated in a role identical to a civil-operator, and/or derived from civil pattern aircraft will normally be certified using a baseline civil airworthiness code. The TAA has approved the following civil airworthiness codes for the development of a certification basis for DND/CAF aircraft designs:

   a. Transport Canada, Civil Aviation (TCCA) Airworthiness Manual (AWM);

   b. Federal Aviation Administration (FAA) U.S. Title 14 Code of Federal Regulations (14 CFR); and

   c. European Union Aviation Safety Agency (EASA) Certification Specifications (CSs).

2. Figure 2-7-1 and Figure 2-7-2 illustrate the civil certification requirements applicable, to varying degrees, to air vehicle performance and handling for fixed and rotary wing aircraft, respectively, which are deemed acceptable by the TAA for use in the development of a certification basis for DND/CAF aircraft. For the purpose of this chapter, all airworthiness codes (AWM/14 CFR/CSs) listed in Figure 1-2-1 are applicable in Figure 2-7-1 and Figure 2-7-2. The applicant may propose alternate equivalent airworthiness design standards to the TAA for consideration and approval.

NOTE

The civil certification requirements and airworthiness design standards listed in Figure 2-7-1 and Figure 2-7-2 focus only on transport category aeroplanes and rotorcraft, respectively. Normal category aeroplanes and rotorcraft may also be applicable but are not listed in this chapter, as the certification basis for DND/CAF aircraft using civil airworthiness codes typically falls under transport category.

3. The airworthiness design standards used for defining the means/method of compliance for civil certification requirements are commonly embedded directly in the certification requirements provided in the airworthiness code, included in the Acceptable Means of Compliance (AMC) (normally in the CSs), or are in the advisory material published by the respective Airworthiness Authority. Figure 2-7-1 and Figure 2-7-2 also include applicable

airworthiness design standards from advisory material, for use and consideration by the applicant. Further guidance material can be found in Figure 2-7-6.

Civil Certification Requirements and Airworthiness Design Standards for Fixed Wing Aircraft (AWM 525, 14 CFR 25, CS-25)			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
General	25.21	Proof of compliance	AC 25-7D Chapter 3.1
	25.23	Load distribution limits	
	25.25	Weight limits	
	25.27	Center of gravity limits	
	25.29	Empty weight and corresponding center of gravity	
	25.31	Removable ballast	AC 25-7D Chapter 3.5
	25.33	Propeller Speed and Pitch Limits	AC 25-7D Chapter 3.6
Performance	25.101	Performance – General	AC 25-7D Chapter 4.1
	25.103	Stall speed	AC 25-7D Chapter 8
	25.105	Takeoff	AC 25-7D Chapter 4.2
	25.107	Takeoff Speeds	AC 25-7D Chapter 4.2
	25.109	Accelerate - Stop Distance	AC 25-7D Chapter 4.3
	25.111	Takeoff Path	AC 25-7D Chapter 4.4
	25.113	Takeoff Distance and Takeoff	AC 25-7D Chapter 4.5
	25.115	Takeoff Flight Path	AC 25-7D Chapter 4.6
	25.117	Climb: General	AC 25-7D Chapter 4.7
	25.119	Landing Climb: All-Engines-Operative	AC 25-7D Chapter 4.8
	25.121	Climb: OEI	AC 25-7D Chapter 4.9
	25.123	En Route Flight Paths	AC 25-7D Chapter 4.10
	25.125	Landing	AC 25-7D Chapter 4.11
Flight Characteristics	25.143	Controllability and maneuverability	AC 25-7D Chapter 5.1
	25.145	Longitudinal control	AC 25-7D Chapter 5.2
	25.147	Directional and lateral control	AC 25-7D Chapter 5.3
	25.149	Minimum control speed	AC 25-7D Chapter 5.4
	25.161	Trim control	AC 25-7D Chapter 6.1
	25.171	Stability: General	AC 25-7D Chapter 7.1
	25.173	Static longitudinal stability	AC 25-7D Chapter 7.2
	25.175	Demonstration of static longitudinal stability	AC 25-7D Chapter 7.2
	25.177	Static Lateral Stability	AC 25-7D Chapter 7.3
	25.181	Dynamic Stability	AC 25-7D Chapter 7.4
	25.201	Stalls: Stall Demonstration	AC 25-7D Chapter 8
	25.203	Stall Characteristics	AC 25-7D Chapter 8
	25.207	Stall Warning	AC 25-7D Chapter 8

Figure 2-7-1 (Sheet 1 of 2) Civil Certification Requirements and Airworthiness Design Standards for Fixed Wing Aircraft

Civil Certification Requirements and Airworthiness Design Standards for Fixed Wing Aircraft (AWM 525, 14 CFR 25, CS-25)			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Ground and Water Handling Characteristics	25.231	Longitudinal stability and control	AC 25-7D Chapter 9.2
	25.233	Directional stability and control	AC 25-7D Chapter 9.3
	25.235	Taxiing condition	AC 25-7D Chapter 9.4
	25.237	Wind velocities	AC 25-7D Chapter 9.5
	25.239	Spray Characteristics, Control and Stability on Water	AC 25-7D Chapter 9.6
Miscellaneous Flight Requirements	25.251	Vibration	AC 25-7D Chapter 10.1
	25.253	High speed characteristics	AC 25-7D Chapter 10.2
	25.255	Out-of-trim characteristics	AC 25-7D Chapter 10.3
	25.672	Stability augmentation, automatic, and power-operated systems (Design and Construction: Control Systems)	
Icing	25.1419	Icing protection	AC 25-25A AC 20-73A
Operating Limitations	25.1503	Airspeed limitations: general	
	25.1505	Maximum operating limit speed	
	25.1507	Maneuvering Speed	
	25.1511	Flap Extended Speed	
	25.1513	Minimum control speed	
	25.1515	Landing gear speed	
	25.1516	Other speed limitations	
	25.1517	Rough air speed, VRA	
	25.1519	Weight, center of gravity, and weight distribution	
	25.1525	Kinds of operations	
	25.1531	Maneuvering flight load factors	
	25.1533	Additional operating limitations	
	25.1563	Airspeed placard	

Figure 2-7-1 (Sheet 2 of 2) Civil Certification Requirements and Airworthiness Design Standards for Fixed Wing Aircraft

Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft (AWM 529, 14 CFR 29, CS-29)			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
General	29.21	Proof of compliance	AC 29-2C 29.21
	29.23	Load distribution limits	
	29.25	Weight limits	AC 29-2C 29.25

Figure 2-7-2 (Sheet 1 of 3) Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft

Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft (AWM 529, 14 CFR 29, CS-29)			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
General (Cont)	29.27	Center of gravity limits	AC 29-2C 29.27
	29.29	Empty weight and corresponding center of gravity	AC 29-2C 29.27
	29.31	Removable ballast	AC 29-2C 29.31
	29.33	Propeller speed and pitch limits	AC 29-2C 29.33
Performance	29.45	Performance: General	AC 29-2C 29.45
	29.49	Performance at minimum operating speed	AC 29-2C 29.49
	29.51	Takeoff data: general	AC 29-2C 29.51
	29.53	Takeoff: Category A	AC 29-2C 29.53
	29.55	Takeoff decision point (TDP): Category A	AC 29-2C 29.55
	29.59	Takeoff path: Category A	AC 29-2C 29.59
	29.60	Elevated heliport takeoff path: Category A	AC 29-2C 29.59A
	29.61	Takeoff distance: Category A	AC 29-2C 29.61
	29.62	Rejected takeoff: Category A	AC 29-2C 29.62
	29.63	Takeoff: Category B	AC 29-2C 29.63
	29.64	Climb: General	AC 29-2C 29.64
	29.65	Climb: All engines operating	AC 29-2C 29.65
	29.67	Climb: One engine inoperative (OEI)	AC 29-2C 29.67
	29.75	Landing: General	AC 29-2C 29.75
	29.77	Landing Decision Point (LDP): Category A	AC 29-2C 29.77
	29.79	Landing: Category A	AC 29-2C 29.79
	29.81	Landing distance: Category A	AC 29-2C 29.81
	29.83	Landing: Category B	AC 29-2C 29.83
	29.85	Balked landing: Category A	AC 29-2C 29.85
	29.87	Height-velocity envelope	AC 29-2C 29.87
Flight Characteristics	29.141	Flight Characteristics: General	AC 29-2C 29.141
	29.143	Controllability and maneuverability	AC 29-2C 29.143
	29.151	Flight controls	AC 29-2C 29.151
	29.161	Trim control	AC 29-2C 29.161
	29.171	Stability: General	AC 29-2C 29.171
	29.173	Static longitudinal stability	AC 29-2C 29.173
	29.175	Demonstration of static longitudinal stability	AC 29-2C 29.175
	29.177	Static Lateral Stability	AC 29-2C 29.177
	29.181	Dynamic Stability	AC 29-2C 29.181
Ground and Water Handling Characteristics	29.231	Ground and Water Handling Characteristics: General	AC 29-2C 29.231
	29.235	Taxiing condition	AC 29-2C 29.235

Figure 2-7-2 (Sheet 2 of 3) Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft

Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft (AWM 529, 14 CFR 29, CS-29)			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Ground and Water Handling Characteristics (Cont)	29.239	Spray characteristics	AC 29-2C 29.239
	29.241	Ground resonance	AC 29-2C 29.241
Miscellaneous Flight Requirements	29.251	Vibration	AC 29-2C 29.251
	29.672	Stability augmentation, automatic, and power-operated systems (Design and Construction: Control Systems)	
Icing	29.1419	Icing protection	AC 29-2C 29.1419 AC 20-73A
Operating Limitations	29.1503	Airspeed limitations: general	
	29.1505	Never-exceed speed	
	29.1509	Rotor speed	
	29.1517	Limiting height-speed envelope	
	29.1519	Weight and center of gravity	
	29.1525	Kinds of operations	
	29.1527	Maximum operating altitude	

Figure 2-7-2 (Sheet 3 of 3) Civil Certification Requirements and Airworthiness Design Standards for Rotary Wing Aircraft

2.7.3 Military Certification Requirements and Airworthiness Design Standards for Air Vehicle Performance and Handling

1. Any military operation involving the use of civil-certified aircraft, or the addition of a special fitment of military equipment to an aircraft that has already been certified to civil requirements and standards (i.e., armament and stores), may be subjected to additional military certification requirements or special conditions to ensure that an acceptable level of safety is achieved for the aircraft when operated in the harsher military environment. Furthermore, aircraft designed for military purposes will use military design and certification requirements. The TAA has approved the following military airworthiness codes for the development of a certification basis for DND/CAF aircraft:

   a. U.S. Department of Defense (DoD) – Military-Handbook (MIL-HDBK)-516 – Airworthiness Certification Criteria;

   b. European Defence Agency (EDA) – European Military Airworthiness Certification Criteria (EMACC) (also available internally, within DND, at AEPM RDIMS #1374982); and

   c. United Kingdom (UK) Defence Standard (DEF STAN) 00-970.

2. Figure 2-7-3 provides a list of MIL-HDBK-516C and EMACC military certification criteria that are applicable to air vehicle performance and handling, to varying degrees, and are deemed acceptable by the TAA for use in developing a certification basis for DND/CAF aircraft. The applicant may propose alternate equivalent airworthiness design standards (such as DEF STAN 00-970) to the TAA for consideration and approval.

3. The military airworthiness codes and certification requirements do not typically include the airworthiness standards or means/method of compliance within the certification requirement. Therefore, Figure 2-7-3 also provides relevant standards that may be used in defining the methods of compliance for the certification requirement. Note that the military airworthiness codes may identify additional recommended standards to be used with the certification

requirements. Further standards and guidance material can be found in Figure 2-7-7. Applicants may propose alternative or supplemental standards or means/methods of compliance for review and approval by the TAA.

Military Certification Requirements and Airworthiness Design Standards			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Performance	6.3	Aerodynamics and Performance	Not a Requirement
	6.3.2	Performance information	MIL-STD-3013 MIL-DTL-7700 MIL-PRF-63029 MIL-DTL-85025 ADS-10-SP ADS-40-SP 14 CFR 25 14 CFR 29
	6.3.3	Performance limits	MIL-STD-1797 MIL-STD-3013 MIL-DTL-7700 MIL-DTL-85025 MIL-PRF-63029 ADS-10-SP ADS-40-SP 14 CFR 25 14 CFR 29
Flight Characteristics/ Flying Qualities	6.1	Flying Qualities	Not a Requirement
	6.1.1	Preliminary steps in application of flying qualities	Not a Requirement
	6.1.1.1	Determining operational missions	MIL-STD-1797 4.1.1 ADS-33-PRF 3.1.1, 3.1.3 14 CFR 27.143
	6.1.1.2	Determining applicable flight phases	MIL-STD-1797 4.1.2 ADS-33-PRF 3.1.1, 3.1.3, 3.11 14 CFR 23.143, 25.143
	6.1.1.3	Defining air vehicle states	MIL-STD-1797 4.1.3 ADS-33-PRF 3.1.6 MIL-HDBK-516C 6.1.1.3.1-6.1.1.3.8
	6.1.1.4	Defining the regions of handling	MIL-STD-1797 4.1.4
	6.1.1.5	Modelling, simulation, analysis tools and databases	MIL-STD-1797 Tables I-III MIL-STD-3022 14 CFR 60
	6.1.2	Primary flying qualities	MIL-STD-1797 5.1 ADS-33-PRF 3.1 MIL-HDBK-516C 6.1.2.1-6.1.2.4

Figure 2-7-3 (Sheet 1 of 4) Military Certification Requirements and Airworthiness Design Standards

Military Certification Requirements and Airworthiness Design Standards			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Flight Characteristics/ Flying Qualities (Cont)	6.1.3	Flying qualities in degraded environmental conditions	MIL-STD-1797 5.1.2 ADS-33-PRF 3.1.3, 3.2.2
	6.1.3.1	Flying qualities in icing conditions	14 CFR 23.1419, 25.21(g), 27.1419, 29.1419 MIL-STD-1797 5.1.2 ADS-33-PRF 3.1.3, 3.2.2
	6.1.4	Control margin	MIL-STD-1797 5.1.3 JSSG-2001B 3.3.11.1.3
	6.1.5	General flying qualities	Not a Requirement
	6.1.5.1	Approach to dangerous conditions	MIL-STD-1791 5.2.1 ADS-33-PRF 3.1.15
	6.1.5.2	Buffet	MIL-STD-1797 5.2.1.2
	6.1.5.3	Release of stores	MIL-STD-1797 5.2.1.3
	6.1.5.4	Effects of armament delivery and special equipment	MIL-STD-1797 5.2.1.4
	6.1.5.5	Failures	MIL-STD-1797 5.2.1.5 ADS-33-PRF 3.1.14, 3.7, 3.10.2 14 CFR 23.145, 23.147, 23.149, 23.672, 23.691, 23.701 14 CFR 25.147, 25.149, 25.671, 25.672, 25.701 14 CFR 27.141, 27.143, Appendix B VII SAS
	6.1.5.6	Pilot-in-the-loop oscillations	MIL-STD-1797 5.2.1.6 ADS-33-PRF 3.1.16
	6.1.5.7	Residual oscillations	MIL-STD-1797 5.2.1.7 ADS-33-PRF 3.1.17
	6.1.5.8	Ride qualities	MIL-STD-1797 5.2.1.8
	6.1.6	Longitudinal flying qualities	Not a Requirement
	6.1.6.1	Longitudinal response to the pitch controller	MIL-STD-1797 5.2.2.1 14 CFR 23.143, 23.145, 23.153, 23.155, 23.173, 23,175, 23.181 14 CFR 25.143, 25.145, 25.173, 25.181 14 CFR 27.173, 17.175, Appendix B IV MIL-HDBK-516C 6.1.6.1.1-6.1.6.1.8
	6.1.6.2	Longitudinal response to the designated flight path controller	MIL-STD-1797 5.2.2.2

Figure 2-7-3 (Sheet 2 of 4) Military Certification Requirements and Airworthiness Design Standards

Military Certification Requirements and Airworthiness Design Standards			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Flight Characteristics/ Flying Qualities (Cont)	6.1.7	Lateral-directional flying qualities	MIL-STD-1791 5.2.3 ADS-33-PRF 3.4.9, 3.4.10 MIL-HDBK-516C 6.1.7.1-6.1.7.13 EMACC 6.1.7.1-6.1.7.13
	6.1.8	Cross-axis responses	MIL-STD-1797 5.2.4 ADS-33-PRF 3.3.9, 3.4.5 MIL-HDBK-516C 6.1.8.1-6.1.8.6
	6.1.9	High angle-of-attack	MIL-STD-1797 5.2.5 MIL-HDBK-516C 6.1.9.1-6.1.9.6
	6.1.12	Characteristics of the primary flight control system	Not a Requirement
	6.1.13	Characteristics of the secondary flight control system	Not a Requirement
	6.1.14	Rotorcraft unique criteria	Included in EMACC, 516C included as sub paras
	6.1.14.1	Translational rate response-type	ADS-33-PRF 3.3.12
	6.1.14.2	Response to collective controller	ADS-33-PRF 3.3.10.1, 3.3.10.3
	6.1.14.3	Equilibrium characteristics	ADS-33-PRF 3.3.1
	6.1.14.4	Position hold	ADS-33-PRF 3.3.11
	6.1.14.5	Rotor revolutions per minute (RPM) governing	ADS-33-PRF 3.3.10.4, 3.4.3.3
	6.1.14.6	Torque response	ADS-33-PRF 3.3.10.2
	6.1.14.7	Slope landing and takeoff characteristics	
	6.1.14.8	Ground operation	ADS-33-PRF 3.9.1, 3.9.2, 3.9.3
	6.1.14.9	External slung loads	ADS-33-PRF 3.10
	6.1.14.10	Water landing	ADS-33-PRF 3.9.4.1
	6.1.14.11	Autorotation	ADS-33-PRF 3.4.5.1.3, 3.7.2, 3.7.3
Ship Helicopter Operating Limits (SHOL)	6.1.10	Shipboard operations	MIL-STD-1797 5.2.6 RTO-AG-300 MIL-HDBK-516C 6.1.10.1-6.1.10.18
Stores Carriage and Separation	17.2.2	Safe separation	MIL-STD-1289 MIL-HDBK-244 MIL-HDBK-1763
	17.2.5	Store induced environments	MIL-STD-1289 MIL-HDBK-1763 MIL-STD-8591 ADS-44-HDBK
	17.2.6	Safe store operations	MIL-HDBK-244 MIL-STD-1289 MIL-HDBK-1763

Figure 2-7-3 (Sheet 3 of 4) Military Certification Requirements and Airworthiness Design Standards

Military Certification Requirements and Airworthiness Design Standards			
Category	**Requirement**	**Description**	**Means/Method of Compliance**
Stores Carriage and Separation (Cont)	17.2.7	Store configurations	TAM Part 2, Chapter 7

Figure 2-7-3 (Sheet 4 of 4) Military Certification Requirements and Airworthiness Design Standards

2.7.4 Associated Publications and Standards

1. The references identified in Figure 2-7-4 through Figure 2-7-7 are associated with the various air vehicle performance and handling aspects of the DND/CAF aircraft. While Figure 2-7-4 and Figure 2-7-5 provide a list of the civil and military airworthiness codes, respectively, associated with the design, construction, and in-service usage of air vehicle performance and handling, Figure 2-7-6 and Figure 2-7-7 identify additional airworthiness design standards, and guidance material.

Civil Airworthiness Codes		
Regulator or Organization	**Number**	**Title**
EASA	CS-25 CS-29	Large Aeroplanes Large Rotorcraft
TCCA	Chapter 525 Chapter 529	Transport Category Aeroplanes Transport Category Rotorcraft
FAA	14 CFR Part 25 14 CFR Part 29	Airworthiness Standard: Transport Category Aeroplanes Airworthiness Standard: Transport Category Rotorcraft

Figure 2-7-4 Civil Airworthiness Codes Related to Air Vehicle Performance and Handing

Military Airworthiness Codes		
Regulator or Organization	**Number**	**Title**
UK MoD	DEF STAN 00-970 Part 7	Design and Airworthiness Requirements of Service Aircraft Part 7 Rotorcraft
U.S. DoD	MIL-HDBK-516C	Department of Defense Handbook – Airworthiness Certification Criteria
EDA	EMACC 3.1	European Military Airworthiness Certification Criteria Handbook

Figure 2-7-5 Military Airworthiness Codes Related to Air Vehicle Performance and Handling

Civil Airworthiness Standards and Guidance		
Regulator or Organization	**Number**	**Title**
FAA	AC 20-73A AC 25-7D AC 25-25A	Aircraft Ice Protection Flight Test Guide for Certification of Transport Category Airplanes Performance and Handling Characteristics in Icing Conditions

Figure 2-7-6 (Sheet 1 of 2) Civil Airworthiness Standards and Guidance Related to Air Vehicle Performance and Handling

Civil Airworthiness Standards and Guidance		
Regulator or Organization	**Number**	**Title**
FAA (Cont)	AC 25-28	Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions
	AC 25-31	Takeoff Performance Data for Operations on Contaminated Runways
	AC 25-32	Landing Performance Data for Time-of-Arrival Landing Performance Assessments
	AC 25.335-1A	Design Dive Speed
	AC 25.629-1B	Aeroelastic Stability Substantiation of Transport Category Airplanes
	AC 29-2C	Certification of Transport Category Rotorcraft
	AC 91-74B	Pilot Guide: Flight in Icing Conditions

Figure 2-7-6 (Sheet 2 of 2) Civil Airworthiness Standards and Guidance Related to Air Vehicle Performance and Handling

Military Airworthiness Standards and Guidance		
Regulator or Organization	**Number**	**Title**
NATO	RTO-AG-300	Volume 22 – Helicopter/Ship Qualification Testing
U.S. DoD	MIL-HDBK-244A	Guide to Aircraft Stores Compatibility
	MIL-HDBK-1763	Department of Defense Handbook – Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures
	MIL-HDBK-1791	Department of Defense Handbook – Designing for Internal Aerial Delivery in Fixed Wing Aircraft
	MIL-HDBK-1797	Department of Defense Handbook – Flying Qualities of Piloted Aircraft
	MIL-STD-810	Environmental Engineering Considerations and Laboratory Test
	MIL-STD-1289D	Department of Defence Standard Practice – Airborne Stores, Ground Fit and Compatibility Requirements
	MIL-A-8591H	Military Specification: Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase), General Design Criteria
	MIL-A-8860B	Military Specification: Aircraft Strength and Rigidity, General Specification for
	MIL-A-8861B	Military Specification: Airplane Strength and Rigidity – Flight Loads
	MIL-A-8863C	Military Specification: Airplane Strength and Rigidity, Ground Loads for Navy Acquired Airplanes
	MIL-A-8865(B)	Military Specification: Airplane Strength and Rigidity, Flight Loads
	MIL-A-8870	Military Specification: Airplane Strength and Rigidity – Vibration, Flutter and Divergence
	MIL-F-8785C	Flying Qualities of Piloted Airplanes
	MIL-I-8671D	Installation of Droppable Stores and Associated Release Systems
	MIL-T-7743F	General Specification for Testing, Store Suspension and Release Equipment

Figure 2-7-7 (Sheet 1 of 2) Military Airworthiness Standards and Guidance Related to Air Vehicle Performance and Handling

Military Airworthiness Standards and Guidance		
Regulator or Organization	**Number**	**Title**
U.S. DoD (Cont)	ADS-10-SP	Aeronautical Design Standard – Standard Practice – Air Vehicle Technical Description
	ADS-20-HDBK	Aeronautical Design Standard – Handbook – Armament and Fire Control System Survey for Army Aircraft
	ADS-27A-SP	Aeronautical Design Standard – Standard Practice – Requirements for Rotorcraft Vibration Specifications, Modelling and Testing
	ADS-33E-PRF	Aeronautical Design Standard – Performance Specification – Handling Qualities for Military Rotorcraft
	ADS-40A-SP	Aeronautical Design Standard – Standard Practice – Air Vehicle Flight Performance Description
	ADS-45-HDBK	Aeronautical Design Standard – Handbook – Data and Test Procedures for Airworthiness Release for U.S. Army Helicopter Armament Testing (Guns, Rockets, Missiles)
	ADS-51-HDBK	Aeronautical Design Standard – Handbook – Rotorcraft and Aircraft Qualification Handbook

Figure 2-7-7 (Sheet 2 of 2) Military Airworthiness Standards and Guidance Related to Air Vehicle Performance and Handling

2.7.5 Guidance Information – General

1. The guidance information provided in this section aims to aid the applicant in selecting applicable military or civil airworthiness codes, certification requirements, and airworthiness standards to be used in developing a compliance matrix for design changes or initial type certification.

2. Additional guidance information may be available. Applicants may consult with the TAA staff whenever required.

2.7.6 Guidance Information – Military Airworthiness Code

1. The certification criteria in the EMACC mirror the U.S. DoD MIL-HDBK-516. However, the EMACC also provides cross-references to the relevant sections of the EASA CSs, the UK DEF STAN 00-970 and the NATO STANAGs. It is, therefore, recommended that the applicant consult the EMACC as a primary source for determining appropriate certification requirements and airworthiness design standards.

2. The applicant should also be aware that military airworthiness codes (MIL-HBDK-516C and EMACC) may only provide the certification criteria/requirements. The applicant should identify applicable airworthiness standards in the methods of compliance.

2.7.7 Guidance Information – Cold Weather Operations

1. **Flight in icing and ice protection.** When certification for flight in icing is required, this is typically done using the civil certification requirements, which include FAR 2X.1419 (even MIL-HDBK-516C, para 6.1.3.1, refers to 14 CFR 25.21[g] or 14 CFR 2X.1419). This ensures a minimum level of safety for flight in icing (e.g., the capacity of 45 min flight in icing and in a holding pattern). This certification does not imply indefinite flight in icing.

2. **Aircraft Ice Protection (AC 20-73).** Advisory circular AC 20-73 offers guidance to type certificate and supplemental type certificate applicants on methods of compliance with the ice protection requirements of Title 14 of the Code of Federal Regulations (14 CFR) parts 23, 25, 27, 29, 33, and 35. It also provides guidance for aircraft type certificate holders on how to maintain the airworthiness of the aircraft when operating in an icing environment. Tables 2, 3 and 4 of AC 20-73 contain certification requirements related to flight into icing conditions.

3. **Contaminated runways.** The following references (two FAA ACs and two EASA AFM-related requirements) are considered relevant by the TAA for the contaminated runway topic.

a. **AC 25-31** – Take-off Performance Data for Operations on Contaminated Runways;

b. **AC 91-79A** – Mitigating the Risks of a Runway Overrun Upon Landing;

c. **CS 25.1591** – Performance Information for Operations with Contaminated Runway Surface Conditions and associated **AMC 25.1591** – The derivation and methodology of performance information for use when taking-off from slippery wet and contaminated runways; and

d. **CS 25.1592** – Performance information for assessing the landing distance and associated **AMC 25.1592** – The derivation and methodology of performance information for use when landing on slippery wet and contaminated runways to support the dispatch of a flight, and landing assessment performance at the time of arrival in all runway surface conditions.

4. Establishing crosswind limits for take-off and landing on contaminated runways is part of what should be included in the AFM. For example, AMC 25.1592 states that "[…] the applicant should provide to operators recommendations or guidelines for crosswind landings, including the maximum recommended crosswinds, for the RWYCCs for which landing-distance data is provided.[…]" An example of the expected AFM guidelines was found online, at https://safetyfirst.airbus.com/landing-on-contaminated-runways/ (Landing on contaminated runways | Safety First).

5. **Anti-icing and de-icing fluids.** For cold weather operations, it is expected that the aircraft be certified to use SAE AMS 1424K Type I and SAE AMS 1428G Type II and IV fluids.

6. Guidance is available to help shape the testing required to confirm that take-off flight characteristics are not adversely affected by the pre-flight application of anti-icing fluids. The Federal Aviation Administration (FAA) Policy Statement at (available internally, within DND, at AEPM RDIMS #1979124) is a relevant reference regarding the approval of usage of anti-icing fluids on airplanes certificated under 14 CFR 23 and 14 CFR 25. The Aerospace Recommended Practice ARP 6852 issued by SAE International regarding the methods and processes for evaluation of the aerodynamic effects of anti-icing fluids (available internally, within DND, at AEPM RDIMS #1870358) is also an important source of information, as it provides guidance and recommended practices on the subject.

7. CS 25.1597 and AMC 25.1597 (draft available internally, within DND, at RDIMS AEPM #2187978, as they have not been implemented in EASA CS-25 at the time of publication of this chapter) present requirements affected by ground de-icing/anti-icing fluids, as well as detailed means of compliance.

2.7.8 Guidance Information – Uncrewed Aircraft Systems

1. The following NATO STANAGs were developed to establish certification requirements specifically for Uncrewed Aircraft Systems (or UAVs, according to the old NATO terminology):

a. STANAG 4671 (based on 14 CFR 23) for large fixed-wing UAS;

b. STANAG 4702 for small rotary-wing UAS;

c. STANAG 4703 for light fixed-wing UAS; and

d. STANAG 4746 for large rotary-wing UAS.

2.7.9 Guidance Information – Certification by Analysis

1. Certification by analysis (CbA) is an analysis-based means of compliance for aircraft certification. CbA can include numerical methods such as computational fluid dynamics (CFD), wind tunnel and/or other ground-based testing results, and other simulation and modelling techniques. A Guide for Aircraft Certification by Analysis (also available internally, within DND, at RDIMS AEPM #2270967), produced by NASA, provides excellent information for applicants considering CbA as a means of compliance.

2. The American Institute of Aeronautics and Astronautics (AIAA) community of interest has recommended the following practices for CbA:

a. Documentation of the flight modelling analysis, including management of the analysis configuration, model inputs, version control of analysis processes and data, etc.;

b. Verification that the model was implemented as intended and produces results as expected;

c. Verification that the model was applied correctly for the specific analysis used for the showing of compliance;

d. Validation of the model against real world data;

e. Justification that the flight modelling analysis proposed is adequate for the compliance application; and

f. An overall applicability confidence assessment, which, if deemed sufficient, demonstrates that the compliance to the certification requirement is achieved with the same level of confidence as if compliance had been shown based on flight testing.

3. The NASA guide for CbA identifies the following challenges for CbA to be considered by the applicant, if they wish to use CbA as a means of compliance:

a. Developing and applying methods for comprehensive verification of tools for single and multiple discipline analysis, including estimation of numerical uncertainties for representative cases;

b. Obtaining validation data for specific full-scale applications with sufficient knowledge of test articles and measurements to estimate model form uncertainties;

c. Demonstrating appropriate techniques for estimating changes in uncertainty from a relevant validation data set to an application problem;

d. Creating efficient uncertainty quantification methodologies and standards applicable to certification metrics including both aleatory and epistemic uncertainties appropriately; and

e. Establishing standards for communicating and interpreting uncertainties in general, but specifically with respect to regulations.

4. For use of CbA as a means of compliance, the applicant may wish to consult with the TAA for further information, or, internally, within DND, refer to RDIMS AEPM #1955042.

2.7.10 Guidance Information – Stores Carriage and Separation

1. For extensive guidance on stores carriage and separation, refer to Part 2, Chapter 9.

2.7.11 Guidance Information – Flight Characteristics/Flying Qualities (To be promulgated)

2.7.12 Guidance Information – Ship Helicopter Operating Limits (To be promulgated)

2.7.13 Guidance Information – Performance (To be promulgated)

PART 2
CERTIFICATION PROCESSES

CHAPTER 8 — STRUCTURAL INTEGRITY

2.8.1 Introduction

1. This chapter sets out the standards for airworthiness and associated guidance material acceptable to the Technical Airworthiness Authority (TAA) for air vehicle structural design. This chapter further defines general design standards and associated guidance material for the qualification of military air vehicle structure to ensure the aircraft system is capable of safely and effectively performing its military role and function. This chapter has been written to take into account that the DND acquires and operates a mix of military and civil pattern aircraft. Additionally, this chapter provides a starting point for the establishment of a certification basis for air vehicle design changes.

2. Aircraft structure includes the airframe (fuselage, wing and empennage), all load bearing elements of the landing gear, the control system and control surfaces, drive system including gearboxes and rotor systems and any other load carrying member subjected to aerodynamic or inertial loading.

3. The structural design performance and verification requirements for the airframe are derived from operational and maintenance needs. The airframe structure is required to safely and effectively provide the capability to sustain all loading actions resulting from aerodynamic, inertial and ground or water forces applied throughout the entire design-operating envelope for which the aircraft has been designed.

4. A standardized terminology for structure does not exist throughout the civil and military communities. Items of the structure may be referred to as “Primary Structure”, “Class I Structure”, “Safety of Flight Structure”, “Structurally Significant Items” or any other term referring to structure, the failure of which would cause direct loss of the aircraft or, if left undetected, would lead to the loss of the aircraft. The Structural Integrity of a design can only be established when all such items are identified, assessed and recorded in documents that are maintained and accessible to Structural Integrity specialists.

5. Civil Regulations, such as the U.S. Title 14 Code of Federal Regulations (14 CFR, also known as FARs) and TCCA’s Canadian Airworthiness Manual (AWM, also known as CARs), provide a solid foundation for aircraft that are used primarily in a role identical or very similar to an airline operation. However, aircraft required to operate in a harsher military environment may be subjected to unique load conditions. Aircraft which are designed specifically for military operations must be assessed using military unique requirements, such as those provided in the UK MoD DEF STAN 00-970 or the U.S. DoD JSSG-2006.

6. Notwithstanding the general guidance provided in 1.4.3, the requirements of both DEF STAN 00-970 and JSSG-2006 are considered equally acceptable for aircraft structural design.

7. The term DEF STAN 00-970 – Part XX is used to mean DEF STAN 00-970 – Part 1, Part 3, Part 5, Part 7, Part 9, Part 13 and Part 15, as appropriate, in this chapter. Similarly, the terms 14 CFR Part XX, Certification Specification (CS)-XX and AWM 5XX correspond to 14 CFR Parts 23 through 29, CS-23 through 29 and CAR AWM Chapters 523 through 529, issued by the FAA, EASA and TCCA, respectively.

2.8.2 Acceptable Standards for Aircraft Structure

1. The following airworthiness designs standards presented in Figure 2-8-1 through Figure 2-8-4 are applicable to DND/CAF Aircraft Structure to varying degrees.

2. Any military operation involving the use of civil-certified aircraft, or the addition of a special fitment of military equipment to an aircraft that has already been certified to civil standards, might require the application of supplementary military design standards or special conditions to ensure that an acceptable level of safety is achieved for the aircraft when operated in the harsher military environment. The source of the supplementary requirements or special conditions will be the military standards outlined as follows.

3. Aircraft operated in a role identical to that of a civil operator will normally be certified using a baseline civilian standard.

4. The following requirements shall apply to all new aircraft acquisitions and, where applicable, to the repair or modification of in-service aircraft.

General Airworthiness Design Standards	
1.	**MANDATORY.** Repair schemes shall not have details that have been shown to be hazardous, unreliable, or are known to have short fatigue or damage tolerant lives.
2.	**MANDATORY.** All primary and secondary structural repairs and modifications shall incorporate durability and damage tolerance principles.
3.	**MANDATORY.** In situations where shot peening is required for life enhancement, rotary flap peening shall not be considered as an acceptable process to be applied to DND/CAF aircraft structures.
4.	**MANDATORY.** Spot welds or brazing are prohibited unless authorized by a recognized structural specialist.
5.	**MANDATORY.** Welding of 2000 or 7000 series aluminium alloys is prohibited.

Figure 2-8-1 General Airworthiness Design Standards Related to Aircraft Structure

Military Airworthiness Design Standards	
UK Military	
1.	**DEF STAN 00-970,** Design and Airworthiness Requirements for Service Aircraft
U.S. Military	
1.	**JSSG-2006,** Joint Service Specification Guide, Aircraft Structures
2.	**MIL-A-8860B (AS),** Airplane Strength and Rigidity, General Specification for
3.	**MIL-A-8861B (AS),** Airplane Strength and Rigidity, Flight Loads
4.	**MIL-A-8862 (AS),** Airplane Strength and Rigidity, Landing and Ground Handling Loads
5.	**MIL-A-8863C (AS),** Airplane Strength and Rigidity, Ground Loads for Navy Acquired Aircraft
6.	**MIL-A-8865 (ASG),** Airplane Strength and Rigidity, Miscellaneous Loads
7.	**MIL-A-8866C (AS),** Airplane Strength and Rigidity, Reliability Requirements, Repeated Loads, Fatigue and Damage Tolerance
8.	**MIL-A-8867C (AS),** Airplane Strength and Rigidity, Ground Tests
9.	**MIL-A-8870 (AS),** Airplane Strength and Rigidity, Flutter and Divergence
10.	**MIL-A-83444 (USAF),** Airplane Damage Tolerance Requirements
11.	**MIL-HDBK-516,** Airworthiness Certification Criteria
12.	**MIL-HDBK-1763,** Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures
13.	**MIL-HDBK-810,** Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
14.	**MIL-HDBK-1290A,** Light Fixed and Rotary-Wing Aircraft Crash Resistance
15.	**MIL-HDBK-1530,** Aircraft Structural Integrity Program (ASIP)
16.	**MIL-STD-1568D,** Materials and Processes for Corrosion Prevention and Control in Aerospace Weapons Systems
17.	**MIL-STD-3063,** Rotorcraft Structural Integrity Program (RSIP)
18.	**WL-TR-94-4052/3/4/5/6,** U.S. DoD Damage Tolerance Handbook

Figure 2-8-2 Military Airworthiness Design Standards Related to Aircraft Structure

Civil Airworthiness Design Standards	
1.	**CS-23,** Certification Specifications for Normal, Utility, Aerobatic and Commuter Category Aeroplanes
2.	**CS-25,** Certification Specifications for Large Aeroplanes
3.	**CS-27,** Certification Specifications for Small Rotorcraft
4.	**CS-29,** Certification Specifications for Large Transport Rotorcraft
5.	**AC 21-25,** Approval of Modified Seats and Berths
6.	**14 CFR 23,** Normal, Utility, Acrobatic and Commuter Category Airplanes
7.	**AC 23.629-1,** Means of Compliance with Title 14 CFR, Part 23, paragraph 23.629, Flutter
8.	**AC 23-13,** Fatigue, Fail-Safe, and Damage Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Category Airplanes
9.	**AC 23-15,** Small Airplane Certification Compliance Program
10.	**AC 23-19,** Airframe Guide for Certification of Part 23 Airplanes
11.	**14 CFR 25,** Transport Category Airplanes
12.	**AC 25.1529-1,** Instructions for Continued Airworthiness of Structural Repairs on Transport Airplanes
13.	**AC 25.491-1,** Taxi, Takeoff and Landing Roll Design Loads
14.	**AC 25.562-1,** Dynamic Evaluation of Seat Restraint Systems and Occupant Protection
15.	**AC 25.613-1,** Material Strength Properties and Material Design Values
16.	**AC 25.629-1,** Aeroelastic Stability Substantiation of Transport Category Airplanes
17.	**AC 25-17,** Transport Aircraft Cabin Interiors Crashworthiness Handbook
18.	**AC 25-22,** Certification of Transport Airplanes Mechanical Systems
19.	**AC 25-571,** Damage Tolerance and Fatigue Evaluation of Structure
20.	**14 CFR 27,** Normal Category Rotorcraft
21.	**AC 27-1,** Certification of Normal Category Rotorcraft
22.	**14 CFR 29,** Transport Category Rotorcraft
23.	**AC 29-2,** Certification of Transport Category Rotorcraft
24.	**AC 43-4A,** Corrosion Control for Aircraft
25.	**AC 91-56,** Continuing Structural Integrity Program for Large Transport Category Airplanes
26.	**AC 91-82,** Fatigue Management Programs for In-Service Issues
27.	**AC 120-73,** Damage Tolerance Assessment of Repairs to Pressurized Fuselages
28.	**MMPDS-2023,** Metallic Materials Properties Development and Standardization
29.	**ESDU 00932,** Metallic Materials Data Handbook (MMDH)
30.	**CMH-17,** Composite Materials Handbook 17
31.	**AWM 523,** Normal, Utility, Aerobatic and Commuter Category Aeroplanes
32.	**AWM 525,** Transport Category Aeroplanes
33.	**AWM 527,** Normal Category Rotorcraft.
34.	**AWM 529,** Transport Category Rotorcraft

Figure 2-8-3 Civil Airworthiness Design Standards Related to Aircraft Structure

General Airworthiness Design Standards	
NATO	
1.	**AIR STD 20/18C,** Environmental Test Methods for Aircraft Stores Suspension and Release Equipment
2.	**AIR STD 20/20C,** Standardized Data List for Interoperability Studies and Certification of Aircraft Stores
3.	**AIR STD 20/23B,** Safety Design Requirements for Airborne Dispenser Weapons

Figure 2-8-4 (Sheet 1 of 2) General Airworthiness Design Standards Related to Aircraft Structure

General Airworthiness Design Standards	
4.	**AIR STD 25/57,** Technical Criteria for the Transport of Cargo by Helicopter
5.	**AECTP 100,** Environmental Guidelines for Defence Materiel
6.	**STANAG 2418,** Equipment design or modification should give consideration to enhancing the equipment's combat effectiveness by minimizing its vulnerability to battle damage and simplifying its battle damage repair
7.	**STANAG 3441,** Design of Aircraft Stores
8.	**STANAG 3898,** Aircraft Stores Interface Manual
9.	**STANAG 3950,** Helicopter Design Criteria for Crew Crash Protection and Anthropometric Accommodation

Figure 2-8-4 (Sheet 2 of 2) General Airworthiness Design Standards Related to Aircraft Structure

2.8.3 Guidance Information – UK Military

1. DEF STAN 00-970 is the foundation document for the certification and qualification of UK MoD aircraft and is the most comprehensive requirements document available for the design of military aircraft. Design requirements are well established and are supported by a large volume of guidance materiel embedded as leaflets on very specific requirements.

2. DEF STAN 00-970, Issue 1, December 1983, was released in two volumes, Volume 1 – Aeroplanes and Volume 2 – Rotorcraft. In recent years, DEF STAN 00-970 has undergone a major re-structure and re-write. The current version of DEF STAN 00-970 is in nine parts, as follows:

- Part 0: Guidance;
- Part 1: Fixed Wing;
- Part 3: Small Civil Type Aircraft;
- Part 5: Large Civil Type Aircraft;
- Part 7: Rotorcraft;
- Part 9: UAVs;
- Part 11: Engines;
- Part 13: Military Common Fit Equipment; and
- Part 15: Items with no military-specific purpose.

3. The current effort to re-align the structure of the DEF STAN to something similar to the 14 CFR/CS structure will facilitate the application of the DEF STAN requirements to aircraft that have been civil certified but are being used in a military rather than a civil-type role.

4. The creation of Part 9 is the first available standard on UAVs. While NATO is presently working up a UAV System Airworthiness Requirements (USAR) document, this part of the DEF STAN provides valuable information until such time as the USAR is ready for release. Furthermore, the creation of Part 13 for "Military Common Fit Equipment" provides a unique source of standards for such things as NVG, Reconnaissance pods, launchers, aero medical equipment and other specific role equipment.

5. Of special note is the UK MoD requirement regarding structural deformation under load: "Until the Design Proof Load is reached, no Grade A items shall sustain deformations detrimental to airworthiness: Moving parts essential to safety shall function satisfactorily. After removal of the design proof load, no effects of loading shall remain that might result in subsequent maintenance, repair or replacement." Design Proof Load is defined as "the product of the design limit load and the proof factor, which shall normally be 1.125."

2.8.4 Guidance Information – U.S. Military

1. The JSSG is a "guide" that establishes the structural performance and verification requirements for the airframe. Supplemental information is required to complete the specification before it can be used as a standard. A very positive aspect of this document is the supplementary information provided in the Appendix A. For each requirement, the guide provides a rationale for the requirement, guidance material and lessons learned. The guide further provides information on the means and methods for verifying that the requirements have been met. Rationale, guidance and lessons learned are also provided for the verification paragraphs.

2. The U.S. JSSG-2006 establishes the structural performance and verification requirements for the airframe for U.S. DoD aircraft acquisitions. This document applies to metallic and non-metallic air vehicle structures which includes the fuselage, wing, empennage, landing gear, structural elements of the control systems, control surfaces, radomes, antennas, engine mounts, nacelles, pylons, in-flight refuelling mechanisms, carrier related apparatus/devices, structural operating mechanisms and structural provisions for equipment, payload, cargo (if applicable), personnel, and any other item that is considered necessary to be included.

3. In conjunction with JSSG-2006, MIL-HDBK-516 – Airworthiness Certification Criteria establishes the airworthiness certification criteria to be used in the determination of airworthiness of all U.S. DoD aircraft. Both JSSG-2006 and MIL-HDBK-516 are guidance documents.

4. MIL-STD-1530C – Aircraft Structural Integrity Program – provides a comprehensive summary for ensuring that all the necessary information is available to substantiate and certify the structural integrity of aircraft structure. MIL-STD-1530C is mandatory for all USAF aircraft but is not applicable to USN or U.S. Army aircraft. Even so, this MIL-STD provides source information for the creation of a checklist of those items that should be addressed prior to the certification of the aircraft structure for any aircraft.

5. The documents referenced above, JSSG-2006 and MIL-HDBK-516, provide considerable guidance when making an assessment regarding the feasibility of certifying an aircraft structure. The former also provides information based on lessons learned from previous acquisition programs. Unfortunately, JSSG-2006 does not provide very much in the way of specific structural integrity requirements. During the 1990s, the U.S. Military underwent significant effort to reduce the degree to which new aircraft projects over-specified their requirements. Many of the existing Military Specifications were deleted and new "Mil-Prime" specifications evolved. The JSSG series of documents is the latest generation of these latter types of specifications.

6. Supplementing the JSSG, MIL-HDBK-516 provides guidance for the airworthiness certification of U.S. DoD aircraft. Section 5 of this handbook is applicable directly to aircraft structure. Other aspects of certification of interest to the structures specialists such as material, manufacturing, crashworthiness, etc, can be found in other sections of the handbook. MIL-HDBK-516, Section 5 – Structures, makes direct reference to JSSG-2006 in many areas but also refers the U.S. Army Aeronautical Design Standard (ADS) 29 – Structural Design Criteria for Rotary Wing Aircraft.

7. By comparison to the specific requirement regarding structural deformations at 2.8.3.5, the USAF and the U.S.N require that "detrimental deformations, including delaminations, shall not occur at or below 115 percent design limit loads". This requirement is slightly more severe than the similar requirement from the UK MoD.

2.8.5 Guidance Information – AWM/14 CFR/CSs

1. Civil Regulations provide a good benchmark against which structural integrity requirements can be assessed to ensure that all the necessary requirements are being included. For aircraft that are being used in an identical manner as would be expected of a civil commercial operation, these regulations (as described in 1.2.4), should be considered to be full and sufficient with the exception that in-service monitoring requirements, as defined in TAM, Part 3, Chapter 4, will need to be added.

2. Aircraft designed to meet civil requirements may also be used for military-unique operations. In these circumstances, the impact of the military unique operation on the Durability and Damage Tolerance of the structure will require careful evaluation. The importance of meeting the TAM requirement for in-service monitoring cannot

be over-emphasised. MIL-STD-1530 and the U.S. DoD Damage Tolerant Handbook may be used to assist in determining the adequacy of the proposed design.

3. Associated with civilian standards are numerous and comprehensive guidance documents issued by the FAA in the form of Advisory Circulars (AC). These ACs provide an explanation of the specific paragraphs applicable to the subject of the AC along with a rationale for the rule and means and methods of compliance. It is understood that, if the guidance material provided in the AC is followed, then compliance with the standard can be expected. EASA has published its Certification Standards (CS) in two books. Book One contains the design standards, while Book Two provides the guidance material. Both books are published together.

4. When dealing with aircraft designed and manufactured to meet U.S. DoD requirements, UK MoD requirements or civil requirements, care must be taken to ensure that the unique service requirements for Durability and Damage Tolerance are fully understood. The original design usage must be well defined and understood. A full assessment of the impact that the intended military operation will have, in comparison to the baseline operation for which the aircraft was designed, must be undertaken to ensure that the requirements of TAM Part 3, Chapter 4 can be met, and each fleet must implement an in-service monitoring program acceptable to the TAA. In this context, MIL-STD-1530C is considered an acceptable standard applicable to DND-registered aircraft. All aircraft on the DND aircraft register are expected to have an Aircraft Structural Integrity Program that reflects the requirements established in MIL-STD-1530C.

5. The DND/CAF is an integral member of a number of international working parties whose sole concern is ensuring that the design of military products conform to internationally recognized standards. The primary purpose of these international standards is to ensure the interoperability of equipment being procured by various allied countries when required to interact during military missions involving an international composite force. The primary sources of these agreements are NATO, under whose auspices NATO STANAGs are issued, and the AFIC that issues Air Standards and Advisory Publications (as described in 1.4.3.3).

2.8.6 Associated Publications and Standards

1. The source references provided in Figure 2-8-5 are associated with the design, construction, maintenance and in-service usage and monitoring of aircraft structure.

Regulator or Organization	Number	Title
Air Force Interoperability Council (AFIC)	AIR STD AM 4076	Technical Criteria for the Transport of Cargo by Helicopter
Allied Environmental Conditions and Test Publications (AECTP)	AECTP 100	Environmental Guidelines for Defence Materiel
EASA	CS-23	Certification Specifications for Normal, Utility, Aerobatic and Commuter Category Aeroplanes
	CS-25	Certification Specifications for Large Aeroplanes
	CS-27	Certification Specifications for Small Rotorcraft
	CS-29	Certification Specifications for Large Transport Rotorcraft
ESDU	ESDU 00932	Metallic Materials Data Handbook (MMDH)
FAA	AC 21-25	Approval of Modified Seats and Berths
	AC 23.629-1	Means of Compliance with Title 14 CFR, Part 23, paragraph 23.629, Flutter

Figure 2-8-5 (Sheet 1 of 3) Associated Publications and Standards Related to Aircraft Structure

Regulator or Organization	Number	Title
FAA (Cont)	AC 23-13	Fatigue, Fail-Safe, and Damage Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Category Airplanes
	AC 23-15	Small Airplane Certification Compliance Program
	AC 23-19	Airframe Guide for Certification of Part 23 Airplanes
	AC 25.1529-1	Instructions for Continued Airworthiness of Structural Repairs on Transport Airplanes
	AC 25.491-1	Taxi, Takeoff and Landing Roll Design Loads
	AC 25.562-1	Dynamic Evaluation of Seat Restraint Systems and Occupant Protection
	AC 25.613-1	Material Strength Properties and Material Design Values
	AC 25.629-1	Aeroelastic Stability Substantiation of Transport Category Airplanes
	AC 25-17	Transport Aircraft Cabin Interiors Crashworthiness Handbook
	AC 25-22	Certification of Transport Airplanes Mechanical Systems
	AC 25-571	Damage Tolerance and Fatigue Evaluation of Structure
	AC 27-1	Certification of Normal Category Rotorcraft
	AC 29-2	Certification of Transport Category Rotorcraft
	AC 43-4A	Corrosion Control for Aircraft
	AC 91-56	Continuing Structural Integrity Program for Large Transport Category Airplanes
	AC 91-82	Fatigue Management Programs for In-Service Issues
	AC 120-73	Damage Tolerance Assessment of Repairs to Pressurized Fuselages
	14 CFR Part 23	Normal, Utility, Acrobatic and Commuter Category Airplanes
	14 CFR Part 25	Transport Category Airplanes
	14 CFR Part 27	Normal Category Rotorcraft
	14 CFR Part 29	Transport Category Rotorcraft
	MMPDS 2023	Metallic Materials Properties Development and Standardization
	CMH-17	Composite Materials Handbook 17
NATO	STANAG 2418	Battle Damage Repair Policy (not ratified by Canada)
	STANAG 3441	Design of Aircraft Stores
	STANAG 3898	Aircraft Stores Interface Manual
	STANAG 3950	Helicopter Design Criteria for Crew Crash Protection and Anthropometric Accommodation
TCCA	AWM Chapter 523	Normal, Utility, Aerobatic and Commuter Category Aeroplanes
	AWM Chapter 525	Transport Category Aeroplanes
	AWM Chapter 527	Normal Category Rotorcraft
	AWM Chapter 529	Transport Category Rotorcraft
UK MoD	DEF STAN 00-970	Design and Airworthiness Requirements for Service Aircraft
U.S. DoD	MIL-A-8860B (AS)	Airplane Strength and Rigidity, General Specification for
	MIL-A-8861B (AS)	Airplane Strength and Rigidity, Flight Loads

Figure 2-8-5 (Sheet 2 of 3) Associated Publications and Standards Related to Aircraft Structure

Regulator or Organization	Number	Title
U.S. DoD (Cont)	MIL-A-8862 (AS)	Airplane Strength and Rigidity, Landing and Ground Handling Loads
	MIL-A-8863C (AS)	Airplane Strength and Rigidity, Ground Loads for Navy Acquired Aircraft
	MIL-A-8865 (ASG)	Airplane Strength and Rigidity, Miscellaneous Loads
	MIL-A-8866C (AS)	Airplane Strength and Rigidity, Reliability Requirements, Repeated Loads, Fatigue and Damage Tolerance
	MIL-A-8867C (AS)	Airplane Strength and Rigidity, Ground Tests
	MIL-A-8870 (AS)	Airplane Strength and Rigidity, Flutter and Divergence
	MIL-A-83444 (USAF)	Airplane Damage Tolerance Requirements
	MIL-HDBK-516	Airworthiness Certification Criteria
	MIL-HDBK-1763	Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures
	MIL-STD-810	Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
	MIL-STD-1290A	Light Fixed and Rotary-Wing Aircraft Crash Resistance
	MIL-STD-1530	Aircraft Structural Integrity Program (ASIP)
	MIL-STD-1568D	Materials and Processes for Corrosion Prevention and Control In Aerospace Weapons Systems
	MIL-STD-3063	Rotorcraft Structural Integrity Program (RSIP)
	JSSG-2006	Aircraft Structures
	WL-TR-94-4052/3/4/5/6	U.S. DoD Damage Tolerance Handbook

Figure 2-8-5 (Sheet 3 of 3) Associated Publications and Standards Related to Aircraft Structure

PART 2
CERTIFICATION PROCESSES

CHAPTER 9 — ARMAMENT AND STORES INTEGRATION

2.9.1 Introduction and Scope

1. This chapter sets out the airworthiness certification requirements, associated standards and means/method of compliance deemed acceptable by the Technical Airworthiness Authority (TAA) in certifying the safe carriage and release of aircraft armament and stores on DND/CAF aircraft, including Uncrewed Aircraft Systems (UAS). This chapter also includes advisory material applicable to the design, integration and qualification of aircraft armament and stores.

2. The information in this chapter is applicable to the clearance of all types of stores, as defined in the Glossary. The definitions of most of the terms included in this chapter are adopted by DND's Director General Aerospace Equipment Program Management (DGAEPM) and the TAA to define the certification and qualification requirements for armament and stores integration.

2.9.2 Certification Requirements and Means/Methods of Compliance

1. The certification requirements and their associated Means/Methods of Compliance listed in Figure 2-9-1 are deemed acceptable by the TAA for use in developing the certification basis from military airworthiness certification criteria for the safe carriage and release of aircraft armament and stores.

2. Applicants may propose alternate or supplemental certification requirements. However, these must be reviewed and approved by the TAA.

NOTE

Any reference to MIL-HDBK-516 in this chapter is based on version C of the document, in effect when this Change of the ADSM was published.

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
4.5	**Operator's and maintenance manual/technical orders**		
4.5.1	**Procedures and limitations.** Verify that processes are in place to identify and document normal and emergency procedures, limitations, restrictions, warnings, cautions and notes.	TAM Part 2, Chapter 7	Flight Sciences
5.1	**Mass Properties**		
5.5.2	**Weight and Center of Gravity.** Verify that center of gravity margins are properly defined to handle aerodynamic, center of gravity, and inertia changes resulting from fuel usage, store expenditure, asymmetric fuel and store loading, fuel migration at high angle of attack and roll rates, and aerial refuelling, and release of external sling loads, and air drop of internal cargo.	MIL-HDBK-516C, 5.5.2	Flight Sciences

Figure 2-9-1 (Sheet 1 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
6.1	**Flying Qualities**		
6.1.5.3	**Release of Stores.** Verify that release of stores has been defined and assessed for safety of flight.	MIL-STD-1797, 5.2.1.3	Flight Sciences
6.1.5.4	**Effects of armament delivery and special equipment.** Verify that effects of armament delivery and special equipment have been defined and assessed for safety of flight.	MIL-STD-1797, 5.2.1.4	Flight Sciences
12.1	**Electrical Power Generation System**		
12.1.1	**Power quantity.** Verify that sufficient power is available to meet the power requirements during all modes of operation, mission profiles, failure conditions and malfunction recovery procedures. Verification of sufficient power requires consideration of all sources and includes evaluating battery rate(s) of discharge.	MIL-HDBK-454 MIL-STD-464 MIL-PRF-21480 MIL-E-7016 14 CFR XX.1351 – XX.1363	Electrical
12.1.6.1	**Lithium batteries.** Verify that, if Lithium batteries are employed, the batteries safely operate when supplied MIL-STD-704 power. Verify that adequate charging methods and checks are provided and installation provisions for the batteries are safe.	NAVSEATM-S9310-AQ-SAF-010 MIL-STD-704 MIL-HDBK-704 14 CFR XX.1351 – XX.1363	Electrical
13.1	**Component/subsystem E3 qualification**		
13.1.2	**Non-flight-critical/non-safety-critical equipment requirements.** Verify that all non-flight-critical and non-safety-critical equipment comply with the conducted and radiated emissions and susceptibility requirements (including external electromagnetic environments), and do not affect the safe operation of flight-critical and safety-critical equipment.	MIL-STD-461, section 5 RTCA/DO-160, sections 18-21	E3
13.2	**System-level E3 qualification**		
13.2.3	**Compatibility of air system with electromagnetic environment.** Verify that the air system is electromagnetically compatible with its intended external radio frequency (RF) electromagnetic environment.	MIL-STD-464, 5.3 SAE ARP 5583, sections 5 and 7	E3
13.2.4	**Lightning effects.** Verify that the air system has met all requirements for lightning, either direct (physical) or indirect (electromagnetic) effects and that any potential for ignition of fuel vapors is eliminated.	MIL-STD-464, 5.5 SAE ARP 5412	E3

Figure 2-9-1 (Sheet 2 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
13.2.7c	**Hazards of electromagnetic radiation to Ordnance – HERO.** Verify that sources of electromagnetic radiation pose no Hazard of Electromagnetic Radiation to Ordnance.	MIL-STD-464, 5.1, 5.5 and 5.9.3 SAE ARP 5583, sections 5 and 7	E3
14.2	**Safety Design Requirements**		
14.2.5	**Human factors.** Verify that all aspects of human factors are addressed, and unacceptable human factors safety issues/risks are resolved in the design process.	MIL-STD-882 MIL-STD-1472 SAE ARP 4761 SAE ARP 4754	Human Factors
15.	**Computer Systems and Software**		
15.2.4	**Critical discrepancies.** Verify that safety critical hardware and software discrepancies identified are safely corrected or mitigated.	JSSG-2008 MIL-STD-882 RTCA DO-178 FAA AC 20-115C	Avionics
15.2.6	**Safety interlocks.** Verify that interlocks provide safe engagement and disengagement of air system modes for flight and ground operations.	JSSG-2008 MIL-HDBK-244 ADS-62-SP ADS-65-HDBK	Avionics Air Weapons
15.3.4	**Environmental qualification.** Verify that all hardware processing elements are capable of safely operating within planned operational environments.	JSSG-2005 JSSG-2008 MIL-STD-810 MIL-STD-1796 RTCA DO-160	Avionics
17.1	**Gun/rocket integration and Interface**		
17.1.1	**Gun/rocket induced environments.** Verify that environment induced by gun/rocket operation is compatible with the air vehicle's limitations for muzzle blast and overpressure, recoil, vibroacoustics, cooling, egress, human factors, and loads of the air vehicle.	MIL-HDBK-244, 5.1.9.1, 5.1.9.2, 5.1.9.2.4, 5.1.10	Air Weapons
17.1.2	**Gas and plume hazards.** Verify that gun/rocket gases and plume do not create safety of flight hazards for the air vehicle and aircrew.	MIL-HDBK-516C, 17.1.2	Air Weapons
17.1.3	**Gas impingement.** Verify that munitions gas impingement does not cause unacceptable erosion of air vehicle structure/skin or any other flight essential systems.	MIL-HDBK-244 ADS-44-HDBK ADS-62-SP ADS-65-HDBK	Air Weapons
17.1.4	**Explosive gas accumulations.** Verify that the gun/rocket gas ventilation/purge system prevents accumulation of any explosive gas mixture.	MIL-HDBK-244	Air Weapons

Figure 2-9-1 (Sheet 3 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
17.2	**Stores Integration**		
17.2.1	**Stores Clearance.** Verify that the stores/ air vehicle interface does not create unsafe conditions during ground and flight operations.	MIL-STD-1289 MIL-HDBK-1763 MIL-STD-8591 STANAG 3899 ADS-44-HDBK ADS-45-HDBK	Air Weapons Flight Sciences
17.2.2	**Safe separation.** Verify that the stores separate safely from the air vehicle throughout the air vehicle/store launch or jettison flight envelope.	MIL-STD-1289 MIL-HDBK-244 MIL-HDBK-1763	Flight Sciences
17.2.3	**Store, suspension and release equipment structural integrity.** Verify that the store or suspension and release equipment and air vehicle are structurally capable of operating safely in the air vehicle/store carriage flight envelope.	MIL-HDBK-1763, Test 131 MIL-STD-8591	Flight Sciences Structures
17.2.4	**Electrical Interfaces.** For all required store configurations, verify that electrical interfaces do not cause unsafe stores operation or interactions with the air vehicle.	MIL-HDBK-244 MIL-STD-1760 SAE AS 5726	Air Weapons
17.2.5	**Store induced environments.** Verify that the environment induced by the stores on the air vehicle, and by the air vehicle on the store during carriage and launch/separation/jettison for the cleared usage, does not adversely affect safety of flight of the air vehicle.	MIL-STD-1289 MIL-HDBK-1763 MIL-STD-8591 ADS-44-HDBK	Air Weapons Flight Sciences
17.2.6	**Safe store operations.** Verify that the stores operations do not adversely affect any safety aspect of the flight control of the air vehicle.	MIL-HDBK-244 MIL-STD-1289 MIL-HDBK-1763	Flight Sciences
17.2.7	**Store configurations.** Verify that all stores configurations for the air vehicle are documented in the flight manuals.	TAM Part 2, Chapter 7	Flight Sciences
17.2.8	**Malfunctioning stores.** Verify that malfunctioning stores can be turned off or released if required to protect the air vehicle.	MIL-HDBK-244 MIL-STD-1760 for the electrical/logical interface	Air Weapons
17.2.9	**Lost link.** Verify that a lost-link condition during a weapons engagement is considered and hazards are minimized and/or mitigated.		Air Weapons

Figure 2-9-1 (Sheet 4 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
17.3	**Laser Integration**		
17.3.1	**Crew exposure.** Verify that the aircrew and maintenance personnel are not exposed to laser radiation (direct and reflected) in excess of maximum permissible exposure limits in order to ensure safe conditions.	MIL-STD-1425 MIL-HDBK-828 AR 11-9 AFOSH STD 48-139 ANSI Z136.1 21 CFR Part 1040	Air Weapons Human Factors
17.3.2	**Induced environment.** Verify that the induced environment resulting from laser operation is compatible with the air vehicle's limitations for vibroacoustics, thermal loads, and structural loads of the air vehicle.	MIL-STD-1425 MIL-HDBK-828 AR 11-9 AFOSH STD 48-139 ANSI Z136.1 21 CFR Part 1040	Air Weapons Structures
17.3.3	**Chemical exhaust.** Verify that laser chemical and exhaust gases do not create safety of flight hazards for the air vehicle.	MIL-STD-1425 MIL-HDBK-828 AR 11-9 AFOSH STD 48-139 ANSI Z136.1 21 CFR Part 1040	Air Weapons
17.3.4	**Operation and direction.** Verify that a means is provided for the crew and maintenance personnel to determine when the laser is operating and discern the direction of the beam.	MIL-STD-1425 MIL-HDBK-828 AR 11-9 AFOSH STD 48-139 ANSI Z136.1 21 CFR Part 1040	Air Weapons Human Factors
17.3.5	**Latching.** Verify that laser operation and direction is controllable only by the crew and maintenance personnel and does not latch on (radiating).	MIL-STD-1425 MIL-HDBK-828 AR 11-9 AFOSH STD 48-139 ANSI Z136.1 21 CFR Part 1040	Air Weapons Human Factors
17.3.6	**Airframe contact.** Verify that the laser beam cannot unintentionally contact any part of the airframe, rotor system, or payload/stores.	MIL-STD-1425 ADS-62-SP ADS-65-HDBK	Air Weapons
17.4	**Safety Interlocks.** Verify that appropriate safety lockout and interlocks are in place to assure that unsafe armament and/or store operation does not take place.	MIL-HDBK-244 ADS-62-SP ADS-65-HDBK	Air Weapons

Figure 2-9-1 (Sheet 5 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
20.1	**Air transportability and airdrop**		
20.1.1	**Air vehicle structure.** Verify that the air vehicle structure can support all loads (internal or external, as applicable) imposed by the transported items during operational usage.	JSSG-2000: 3.1.7.2 JSSG-2001: 3.4.5, 3.4.6 MIL-HDBK-516: Section 5	Structures
20.1.2	**Clearances.** Verify that clearance exists for aircrew, support personnel and passengers during flight-critical and ground and flight emergency functions.	JSSG-2000: 3.1.7.2 JSSG-2001: 3.4.5, 3.4.6 MIL-STD-1472	Human Factors Occupant Safety
20.1.5	**Restraint system function during aerial delivery operations.** Verify that the aircraft cargo restraint system meets the restraint specifications for the aircraft and also permits conduct of cargo delivery operations (e.g., air transport, combat offload, airdrop). The restraint system may be required to be compatible with standard DoD cargo and restraint systems.	JSSG-2000: 3.1.7.2 JSSG-2001: 3.4.5, 3.4.6 MIL-STD-1791 MIL-A-8865	Structures
20.1.8	**Cargo Compartment Dimensions.** Verify that cargo compartment dimensions allow enough room to load, transport, and/or airdrop required items safely.	JSSG-2009: Appendix J MIL-STD-1791	Air Weapons (via ASSB)
20.1.9	**Cargo or CG movement in flight.** Verify that air vehicle flight safety is not hazardously affected by movements in CG of airdrop loads or by load and CG movement experienced during external load operations.	JSSG-2009: Appendix J MIL-STD-1791	Flight Sciences
20.1.10	**Personnel airdrop system structure.** Verify that air vehicle personnel airdrop systems can withstand the loads imposed by personnel during airdrop and possible malfunctions of personnel airdrop equipment.	JSSG-2009: Appendix J ASC-TM-ENE-77-1	Structures
20.1.11	**Towed jumper retrieval capability.** Verify that the air vehicle provides the capability to safely recover a towed jumper.	Flight testing results demonstrate the capability exists for a single aircrew member (unless otherwise specified) to readily retrieve a maximum weight towed mannequin plus the maximum towed parachute bag(s) minus one, using the onboard equipment	Flight Sciences

Figure 2-9-1 (Sheet 6 of 7) Military Certification Requirements for Armament and Stores Integration

Military Certification Requirements for Armament and Stores Integration (Source: MIL-HDBK-516C)			
Requirement	**Description**	**Means/Method of Compliance**	**Finding Authority**
20.1.13	**Cargo Jettison Capability.** Verify for airdrop or jettisonable cargo, that the loaded items can be safely jettisoned during flight.	JSSG-2009, Appendix J MIL-STD-1791	Flight Sciences
EASA CS-XX.1319	**Cyber Security**		
EASA CS-XX.1319	**Equipment, systems and network information protection** 1. Aeroplane equipment, systems and networks, considered separately and in relation to other systems, must be protected from intentional unauthorized electronic interactions (IUEIs) that may result in adverse effects on the safety of the aeroplane. Protection must be ensured by showing that the security risks have been identified, assessed and mitigated as necessary. 2. When required by paragraph (a), the applicant must make procedures and Instructions for Continued Airworthiness (ICA) available that ensure that the security protections of the aeroplane's equipment, systems and networks are maintained.	DO-326A/ED-202A DO-356A/ED-203A DO-355A/ED-204A AMC 20-42	Cybersecurity

Figure 2-9-1 (Sheet 7 of 7) Military Certification Requirements for Armament and Stores Integration

ANNEX A

ARMAMENT AND STORES INTEGRATION QUALIFICATION REQUIREMENTS AND NOTES ON BEST PRACTICES

NOTE

The term "Stores Clearance" has been superseded by the term "Armament and Stores Integration" in all weapon certification and qualification activities. While the two terms may be considered synonymous, Stores Clearance is now considered a subset of Armament and Stores Integration, as detailed in Chapter 17 of MIL-HDBK-516C.

2.9A.1 Armament and Stores Integration Organizational Responsibilities

1. **DTAES 6 Avionics System Engineering.** Provides airworthiness certification and qualification support, engineering and technical advice on avionics, electrical systems, human factors, system safety, software and electronic hardware engineering, laser integration and electromagnetic environmental effects (E3).

2. **DTAES 7 Aeronautical Engineering.** Provides airworthiness certification and qualification support, engineering and technical advice on flight sciences, aircraft structures and flight manuals.

3. **DTAES 8 Air Warfare Engineering.** DTAES 8 provides airworthiness certification and qualification support, engineering and technical advice on air weapons engineering, range safety, air weapons effectiveness, armament and stores integration and aircraft cybersecurity. DTAES 8-4 is the specific sub-section responsible for the stores clearance part of armament and stores integration and for aircraft-to-store interactions. Within the DTAES 8 team, there is also a number of TAA-authorized individuals who may perform airworthiness functions related to the certification of the safe carriage and release of aircraft stores.

4. **Directorate of Ammunition and Explosives Management and Engineering (DAEME)**. DAEME is responsible for the lifecycle management of all ammunition, explosives and ordinance. DAEME is the chair of the Ammunition Safety and Suitability Board (ASSB), responsible for introduction of ammunition and explosives into service. This includes phase reports on requirements for testing (Phase 1) and acceptance (Phase 2). The conclusion of the process is a recommendation for release to service of the ammunition or explosive. The processes conducted by the ASSB are independent and separate from airworthiness processes, and a DAEME recommendation for release to service does not imply approval to use the ammunition or explosive on board aircraft.

5. **Project Management Office (PMO)**. Normally responsible as the Applicant submitting a request to the TAA for a Type Certificate for new DND/CAF aircraft and thus is responsible for the initiation of the armament and stores integration activities, as part of the type certification process. The PMO is also responsible for applying to DAEME to obtain any required S3 assessments from the ASSB for the armament and stores covered by the initial certification.

6. **Weapon System Management (WSM) Organization.** Normally responsible for the initiation of the armament and stores integration process when introducing a new capability or design change on existing platforms. The WSM may be an Applicant submitting a request to the TAA for certification of an out-of-scope design change. They may also be a client organization for the DTAES engineering support sections during the development, integration and certification of the stores-related design change. The WSM is also responsible for applying to DAEME to obtain any required S3 assessments from the ASSB.

2.9A.2 Introducing Ammunition and Explosives (A&E) into Service

1. Organizations involved with the acquisition, A&E certification under the Explosives Act and qualification of armament and stores on military aircraft must ensure A&E items with energetic materials follow the ASSB process before being introduced into service.

2. In accordance with Defence Administrative Order and Directive (DAOD) 3002-1, A&E items are not authorized for service use until receipt of an ASSB validation and subsequent acceptance for service use by the appropriate authority. In accordance with DAOD 3002-0, this authority is normally a level one (L1) advisor, or delegate. For the

purpose of ensuring compliance with the Explosives Act, the introduction to service and certification of A&E must be done in accordance with C-09-005-007/TS-001 – *Ammunition and Safety Manual*, Volume 7, which builds upon the regulatory requirements laid out in DAOD 3002-0 and DAOD 3002-1. This process, including the S3 assessment, is managed and controlled by the DAEME organization.

3. The S3 assessment process applies to energetic stores (i.e., containing explosives and propellant), but inert bomb bodies are also included. The purpose of this process is to assess the impact on the system capabilities, integration and standardization of the stores on the weapon system as a whole. For stores common to multiple platforms, this process should include an assessment for each of the impacted fleets. Moreover, an assessment should be completed separately and independently for each store. However, should an assessment apply to more than one store, it may be referenced, instead of repeated. The S3 assessment assists the ASSB in providing relevant authorities with an impartial appraisal of, and advice on, the S3 of A&E items or independent weapon system components containing energetic materials. The advice includes a risk assessment and recommendations concerning conditions of service.

NOTE

The ASSB and its related S3 Assessment covers aspects that impact Airworthiness Certification, Qualification and Logistics. More specifically, the aspects that touches on Qualification and Airworthiness Certification will not be apparent until the S3 process is completed and the ASSB reports the findings and recommendations.

4. Normally, ammunition is inducted into service through the ASSB approval process, which consists of two phases:

a. **Phase 1** – This phase defines the introduction to service safety levels assurance analysis requirements. The resulting decision defines, assesses and approves the S3 qualification program for the A&E under consideration, for DND/CAF service use, with respect to its declared Life Cycle Environmental Profiles (LCEP); and

b. **Phase 2** – This phase involves the execution of the required data collection, including testing and analysis, to ensure that the qualification requirements identified in Phase 1 are met. The decision resulting from Phase 2 assesses available data, makes findings and recommendations with respect to S3 for the A&E, and approves the S3 qualification program for the A&E under consideration for DND/CAF service use.

5. The ASSB approval process can result in one of the following outputs:

a. **Technical Letter (TL)** – Assesses the S3 of non-DND/CAF A&E in limited use condition, such as trials and demonstrations, conducted by DND/CAF personnel or using DND/CAF resources. The requirements will also apply to in-service DND/CAF ammunitions, trials or demonstration outside the approved conditions;

b. **Extraordinary Decision (EX)** – Assesses the S3 of non-DND/CAF A&E in limited use conditions arising from DND/CAF UORs, or in-service DND/CAF A&E under consideration for service, if the timely completion of an ASSB decision, or Amendment to meet the requirement, is not feasible;

c. **Class Decision** – Assesses the S3 A&E normally available for non-military use that should not see a LCEP exceeding those already deemed safe and suitable by a competent authority;

d. **Decision Amendment** – Evaluates circumstances or data affecting findings and recommendations made in a Phase 2 or Class decision, or a previous amendment, to revise them as appropriate. This could include significant changes to the ammunition or explosives themselves, weapons, launchers or transport platforms (for the A&E), or changes to the LCEP; and

e. **Engineering Assessment (EA)** – Evaluates circumstances or data not affecting findings and recommendations made in a Phase 2 or Class decision, or a previous amendment.

6. To introduce A&E into the RCAF, the operational community (normally the Directorate of Air Requirements or Fighter Capability Office) initiate a Statement of Requirements (SOR) or Statement of Capability Deficiency (SOCD), to be further actioned by DAEME and appropriate fleet WSMs. New A&E items can also be introduced through a PMO, in conjunction with the introduction of a new weapon system or platform. In fewer cases, such as product improvement/obsolescence replacement, this will be done by an assigned DAEME Project Manager (PM), with WSM support. Normally, DAEME will assign a QATA, who is supported by PMO, WSM and DTAES, to complete S3 activities in order to achieve A&E certification to comply with the Explosives Act. Once the A&E certification requirements have been met, specific authorization is required for carriage on-board or use by DND/CAF aircraft; this is achieved by PMO, WSM, DTAES and RCAF staff performing activities to certify and qualify A&E items to obtain Technical and Operational Airworthiness Clearance (TAC and OAC). To address limited use of ammunition, for example as often required by Canadian Joint Operations Command (CJOC) or other operational organizations for trials, or to meet Unforecasted Operational Requirements, Armament and Stores Integration processes are typically arranged through WSMs, with input from the operational community.

7. **Acceptance Into Service (AIS)**. AIS is the process by which a given branch of the CAF (the CA, the RCAF or the RCN) is ready to accept given A&E items for service use, once the ASSB/S3 work is completed, while at the same time formally addressing and accepting ASSB decisions and recommendations. AIS is mandatory, and it constitutes a condition for DAEME to release the A&E for use. Normally, AIS is achieved by means of a letter signed by the L1 of a given CAF branch. However, for Air A&E, the ASSB findings are necessary, but not sufficient to certify A&E on air platforms, due to airworthiness certification requirements. Thus, for Air A&E, AIS can be accomplished in one of the following three ways:

a. **Full Acceptance into Service,** after Phase 2 ASSB (or, in some cases, with EXs, when it takes an extended period of time to complete Phase 2). This AIS can be obtained through the release of a (Provisional) Operational Airworthiness Clearance ([P]OAC) that must refer to the (Provisional) Technical Airworthiness Clearance ([P]TAC), both of which have to be provided to DAEME 3. The A&E can then be released for use;

b. **Limited and/or Temporary Acceptance into Service, for TLs, EXs and EAs.** For this AIS, Specific Purpose Flight Permits (SPFPs) and Experimental Flight Permits (EFPs) are sufficient, after the SPFSs and EFPs have been provided to DAEME 3; and

c. **UOR and current operations requirements.** This AIS is obtained after a CJOC letter of acceptance, which refers to applicable SPFPs, has been provided to DAEME 3.

NOTE

While the induction process of the ammunition entering service concludes with the ASSB, it does not result in an approval for carriage on board, or for use by DND/CAF aircraft, which requires a specific authorization, as part of the airworthiness certification and qualification processes.

8. It is also important to distinguish the Air A&E certification/S3 risk assessment process used to introduce A&E into service from the Airworthiness risk assessment process. While Airworthiness risk assessments are focused on ensuring an Acceptable Level of Safety (ALOS), the Project Approval Directive (PAD) governs DND's Project Approval Process (PAP) and requires S3 assessments as part of an overarching process called Type Classification. The latter includes performance, procurement Integrated Logistics Support (ILS) and production requirements. Further, some munitions, such as those requested under a UOR (as mentioned in 2.9.5.5), are not type classified and are accepted for limited use without AIS. DTAES 8 Armament and Stores Integration SMEs are responsible to interpret and adapt the S3 risk into airworthiness/operational risk.

2.9A.3 Aircraft Stowage (Stores)

1. The on-board stowage of ammunition and explosives (A&E) on RCAF aircraft is an Armament and Stores Integration concern if the stores are required to be accessible for deployment from inside the aircraft during flight. This ready-use requirement normally necessitates the removal of the explosives/stores from their original shipping packaging and placing them in some type of storage rack, box, launching system or container inside the aircraft

cabin. For most aircraft fleets, the most common items meeting this requirement are various types of air launched ready-use pyrotechnics. If simply being transported from one location to another (i.e., carried in the aircraft but used on the ground), A&E are considered as cargo and are therefore governed by Transportation of Dangerous Goods (TDG) regulations and standards.

2. In most cases, the addition of a storage system is a design change and therefore is accomplished through the in-service design change or part of the original certification process. The DTAES 8 Stores Clearance SME is often requested, by either the WSM or DTAES 3 as applicable, to assist with provision of A&E related requirements for the Certification Basis for the storage system.

3. Also, stowage of stores must undergo A&E Certification under the ASSB and related S3 assessment process, as the type of storage, the A&E stowed and their configuration and flight environment have an impact on Safety and Suitability form Service.

4. As no specific standards exist for the stowage and transport of A&E that are accessed during flight, the approach for the Armament and Stores Integration of on-board storage racks, boxes, etc., is through analysis of available standards and regulations to determine the criteria which should be considered for inclusion in the Certification Basis. Some of the things that should be considered are listed in the following paragraphs:

a. **Are the stores cleared for use on the aircraft?**

(1) Confirm through a review of the AOIs, Armament and Stores documentation and airworthiness approval documentation that all stores have an airworthiness approval and ASSB reports for the aircraft. Only stores actually launched from the aircraft in flight require an airworthiness approval and ASSB. As many older fleets rely on ‘grandfathering’ of stores clearance from previous aircraft, the original TAC documents for the aircraft may prove helpful.

b. **Are the stores compatible with each other for storage/transportation?**

(1) Refer to A-LM-117-001/FP-001 – *Transportation of Dangerous Goods (TDG) by Canadian Forces Aircraft* for A&E compatibility requirements. To determine A&E compatibility, refer to C-74-300-D01/TA-000 – *Ammunition and Explosives Technical Information - Logistical Data* for applicable Hazard Classification Codes (HCC) for individual items. This is normally covered by the ASSB.

(2) Additionally, the RCAF *Flight Operations Manual (FOM)*, Part 7 contains waivers from the TDG regulations for carriage of specific combinations of A&E on RCAF aircraft for many operational missions (SAR, Tactical Aviation, Special Operations, etc.) in the form of Standing Authority.

c. **Has the box/rack/container been structurally engineered for occupant safety/crashworthiness?** (Contains all stores, remains affixed to the aircraft)

(1) It should be confirmed that a structural analysis of the storage system has been carried out prior to making an airworthiness approval recommendation for a storage box.

(2) The stowage system must be designed to comply with applicable requirements for structural integrity, internal and external loads, crash loads, etc. A structures specialist should be consulted and may require input and/or analysis of store.

(3) It may also require input to accessibility and storage of stores.

d. **Are the stores restrained from movement within the storage container during flight?**

(1) Review design to ensure stores are physically restrained and separated from each other during all flight regimens.

e. **Has EMC, EMI, Bonding and Grounding of the storage system been addressed?**

(1) Refer to MIL-STD-464 for requirements.

(2) May require input and/or analysis from avionics/electrical specialists.

(3) Ammunition Safety and Suitability Board (ASSB) assessments are a good source of E3 hazard information for individual stores to aid in determining requirements.

f. **Have Human Factors considerations been addressed?** (Weight, size and ease of access)

(1) Confirm a Human Factors analysis of the storage system has been carried out.

g. **Is a hazard labelling on exterior of container and/or storage system required?**

(1) A-LM-117-001/FP-001 requires labelling of containers containing dangerous goods to indicate the primary and secondary hazards of the materials contained. On advice from 1 Cdn Air Div, for security reasons, the word "Explosives" is no longer to be placed on the outside of containers, nor is it appropriate to include the HCC label. A fire class symbol should be displayed on the container.

h. **Are all cabin safety considerations satisfied?** (i.e., Firefighting, crashworthiness, emergency evacuation, breathing apparatus available if applicable, etc. See Part 4, Section D of A-LM-117-001/FP-001 for applicable standard)

i. **Do aircraft publications include instructions for installation/removal procedures, inspection and repair of the container, emergency procedures and weight and balance data?** If no, then the publications should contain applicable requirements.

5. If the store being considered is in doubt for its clearance, contact DTAES SMEs for approval of the store prior to use on the aircraft.

2.9A.4 Qualification Requirements – Weapons Effectiveness and Ballistics

1. System qualification during initial acquisition or design change must consider system effectiveness beyond safe carriage and release. This may include, without being limited to, ballistics, weapons effectiveness, safe escape, handling, storage, range safety and other environmental considerations.

2. There are currently no recognized standards against which weapon effectiveness is assessed. That being said, system effectiveness is usually assessed based on the degree to which the system achieves the desired effect. A common reference used to study ballistics and weapons effectiveness is *Weaponeering: Conventional Weapon System Effectiveness*, by Morris R. Driels (Copyright © 2013 by the American Institute of Aeronautics and Astronautics, Inc.).

3. Ballistics is usually correlated to weapons effectiveness. Accuracy evaluation/verification and results (Circular Error Probable [CEP], dispersion and range biases) for all aircraft/stores configurations should be included in accordance with MIL-HDBK-1763, Test 290, for all delivery modes and the aircraft Operational Flight Program (OFP) used. Algorithms and flow field separation coefficients should be identified, if used. Ballistic accuracy can be reported and measured, in accordance with MIL-HDBK-1763, Paras 4.1.4.12.1 through 12.7, based on the following primary considerations, among others:

a. **Store behaviour on separation.** Forces imparted to the store on separation can impact the trajectory of the store after separation.

b. **Store accuracy.** There are two specific flight regimes that are considered:

(1) Full flight trajectory. This includes separation dynamics and specific aircraft and store configurations.

(2) Free stream ballistics. This is the trajectory, aerodynamic and ballistic behaviour of the store after separation from the aircraft.

2.9A.5 Qualification Requirements – Air Weapons Range Safety

1. DTAES 8-4 acts as the authority for air weapons range safety templating on behalf of the Canadian Army Doctrine and Training Centre (the authority for all CAF ranges). This includes all stores deployed from an aircraft. Weapons Danger Zone (WDZ) templates are constructed by DTAES 8-4 to be employed by range managers, range safety authorities and operators by using two approaches:

a. **Probabilistic.** This methodology models the actual behaviour of a weapon and incorporates the probability of failure. It can account for the local terrain and weapon range design, and can make a direct estimate of the risk to the public, CAF personnel and materiel. Although involving higher levels of inherent risk, probabilistic WDZs can be more practically contained in established training areas and is the preferred methodology, where possible.

b. **Deterministic.** This methodology involves identifying a series of potential hazard sources and estimating their effects in the worst case, irrespective of their likelihood of occurrence and independent of weapon range design or local geography. By design, these WDZs are very conservative. The requirements of a deterministic WDZ can also be met by application of Maximum Energy Boundaries (MEB) to a weapon. The MEB is calculated as the maximum possible range (in all directions) that a weapon can travel under ideal conditions accounting for all variables in the launch-to-impact sequence.

2. DTAES 8-4 conducts periodic reviews of ranges to approve and renew range licenses for the employment of air weapons. Reviews of authorized templates are part of this process. As such, new air weapons, or novel methods of employments must be qualified by DTAES 8-4, including the development of templates prior to their authorization for local employment.

2.9A.6 Qualification Requirements – Safe Escape

1. Safe Escape data and procedures provide protection for the releasing aircraft, and any other platforms that might be operating in conjunction with the releasing aircraft, to an acceptable level of risk. DTAES 8-4 is the SME for safe escape risk mitigation procedures and modelling. There are no current standards for the development of Safe Escape information to meet the acceptable risk levels defined by the Operational Airworthiness Authority. There are differences in acceptable risk levels for safe escape among the nations (and services) from which the DND/CAF receives safe escape information. As such, it is incumbent upon the TAA and the OAA to rely on DTAES 8-4's independent analysis with regards to DND/CAF risk tolerances.

2.9A.7 Qualification Requirements – Handling and Environmental Considerations

1. Required conditions and preferred conditions for handling and environmental effects are normally documented as part of the induction into service by the ASSB. They can be reiterated, or further restricted, as part of the airworthiness certification or qualification process.

2.9A.8 Qualification Requirements – Aircraft Cybersecurity Certification, IT Security and Cyber Mission Assurance (CMA)

1. The preferred method for addressing the Aircraft Cybersecurity Certification, IT Security and Cyber Mission Assurance (CMA) of the aircraft weapon system is the Harmonized Assessment of Cybersecurity Risk (HACR) process. The HACR process utilizes the acceptable means/methods of compliance to aircraft cybersecurity requirements, IT Security policies and standards and industry best practices to support the achievement of Aircraft Cybersecurity Certification, IT Security and CMA.

2. While Aircraft Cybersecurity Certification requirements must be considered for certification of the weapon system to ensure safe operation, the CMA requirements incorporated into the HACR process must be considered to obtain an Authority to Operate (ATO) from DTAES, the Security Authority for Aerospace Systems. Applicants should liaise with DTAES 8 prior to project initiation to establish the certification, IT Security and CMA requirements

for cybersecurity. More information on the HACR process and best practices can be found in Part 2, Chapter 6, Annex A of this manual.

2.9A.9 Associated Publications and Standards

Regulator or Organization	Number	Title
DND/CAF	DAOD 3002-0	Ammunition and Explosives
	DAOD 3002-1	Certification of Ammunition and Explosives
	C-09-005-007/TS-001	Ammunition and Safety Manual, Volume 7
	C-09-005-001/TS-000	Ammunition and Explosives Safety Manual, Volume 1
	C-07-010-011/TP-000	Canadian Forces Air Weapons Ranges
	AF9000+ Procedure EMT04.019	CF Air-Ground Weapon System Ballistic Activities
	C-05-005-001/AG-002	Airworthiness Design Standards Manual, Part 2, Chapter 4
	A-LM-117-001/FP-001	Transportation of Dangerous Goods (TDG) by Canadian Forces Aircraft
NATO	AIR STD 20/21C	Airborne Stores Ground Fit and Compatibility Criteria
	STANAG 4297, AOP–15	Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces
	STANAG 3558	Location of Electrical Connectors for Aircraft Stores
	STANAG 3575	Aircraft Stores Ejectors Racks
	STANAG 3726	Bail (Portal) Lugs for The Suspension of Aircraft Stores
	STANAG 3898	Aircraft Stores Interface Manual (ASIM)
	STANAG 3899	Ground Fit and Compatibility Criteria
	STANAG 7068	Aircraft/Stores Certification Process
	STANAG 7081	Standard Rail for Launch of 0-68 Kilogram (0-150 Pound) Missiles from Helicopters
Society of automotive Engineers (SAE)	SAE AS 50881	Wiring, Aerospace Vehicle
UK MoD	DEF STAN 00-970	Certification Specifications for Airworthiness
U.S. DoD	MIL-HDBK-244A	Guide to Aircraft Stores Compatibility
	MIL-HDBK-1763	Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures
	MIL-HDBK-1797	Flying Qualities of Piloted Aircraft
	MIL-STD-244	Guide to Aircraft/Stores Compatibility
	MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
	MIL-STD-464	Electromagnetic Effects, Requirements for Systems
	MIL-STD-704	Characteristics and Utilization of Aircraft Electric Power
	MIL-STD-794F	Procedures for Packaging Parts and Equipment
	MIL-STD-810	Environmental Engineering Considerations and Laboratory Test

Figure 2-9A-1 (Sheet 1 of 2) Associated Publications and Standards Related to Armament and Stores Integration

Regulator or Organization	Number	Title
U.S. DoD (Cont)	MIL-STD-882	System Safety
	MIL-STD-1289D	Airborne Stores, Ground Fit and Compatibility Requirements
	MIL-STD-1472	Department of Defense Design Criteria Standard: Human Engineering
	MIL-STD-1760	Aircraft/Store Electrical Interconnection System
	MIL-A-8591H	Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase), General Design Criteria
	MIL-A-8860B	General Specification for Aircraft Strength and Rigidity
	MIL-A-8861B(AS)	Airplane Strength, Rigidity and Flight Loads
	MIL-A-8863C	Airplane Strength, Rigidity and Ground Loads for Navy Acquired Airplanes
	MIL-A-8866C	Airplane Strength and Rigidity Reliability Requirements, Repeated Loads, Fatigue and Damage Tolerance
	MIL-A-8870	Airplane Strength and Rigidity, Vibration, Flutter and Divergence
	MIL-C-6781B	Control Panel: Aircraft Equipment, Rack of Console Mounted
	MIL-E-704A	Characteristics and Utilization of Aircraft Electric Power
	MIL-E-7016	Analysis of Electrical Load and Power Source Capacity
	MIL-E-7080	Electric Equipment Aircraft Selection
	MIL-F-8785C	Flying Qualities of Piloted Airplanes
	MIL-I-8671D	Installation of Droppable Stores and Associated Release Systems
	MIL-T-7743F	General Specification for Testing, Store Suspension and Release Equipment
Reference Manual	Morris R. Driels	Weaponeering: Conventional Weapon System Effectiveness
Radio Technical Commission for Aeronautics (RTCA)/European Organization for Civil Aviation Equipment (EUROCAE)	DO-326A/ED-202A	Airworthiness Security Process Specification
	DO-356A/ED-203A	Information Security Guidance for Continuing Airworthiness
	DO-355A/ED-204A	Airworthiness Security Methods and Considerations
	DO-391/ED-201A	Aeronautical Information System Security Framework Guidance
	DO-392/ED-206	Guidance for Security Event Management

Figure 2-9A-1 (Sheet 2 of 2) Associated Publications and Standards Related to Armament and Stores Integration

PART 2
CERTIFICATION PROCESSES

CHAPTER 10 — NON-DESTRUCTIVE TESTING

2.10.1 Introduction

1. This chapter describes the minimum safety standards and best practices for the airworthiness approval of a full range of Non-Destructive Testing (NDT) inspection activities.

2. NDT is the term used to describe the testing, inspection or examination of any material, component or assembly by means that do not affect its future serviceability. Typical NDT methods include visual examination, liquid penetrant testing (PT), magnetic particle testing (MT), radiographic testing (RT), ultrasonic testing (UT) and eddy current testing (ET).

2.10.2 Philosophy of NDT

1. The philosophy of Non-Destructive Testing for CAF aircraft is summed up as follows:

a. NDT methods range from relatively simple to highly complex in principle. Success in their use, however, depends heavily upon the intelligent application and discriminating interpretation of the results. NDT inspections are not easily applied remedies to all maintenance problems, but they can be instrumental in assuring high quality standards in aircraft if they are integrated into the entire spectrum of aircraft inspection activity from design to final phase-out.

b. Caution must be exercised so that too great an emphasis is not placed on the capabilities of NDT without full realization of the attendant limitations. Blind faith in any one of a number of routine NDT methods could lead to an inspection failure, with possible catastrophic results, and place the particular method into disrepute.

c. NDT should be taken into consideration in the design of any new aircraft structure; it should be used to increase the assurance that the quality of materials is maintained at a consistently high level and thus increase the factor of safety by excluding indefinite design quality factors. Aircraft design teams should ensure that aircraft structures and electrical, hydraulic and other systems are so designed that subsequent NDT inspections can be carried out with reasonable access to critical areas. Designing for inspectability of sophisticated equipment is as important as designing for static strength, fatigue resistance and ease of manufacturing.

d. In the initial stages of new aircraft development it is often very difficult to obtain information on areas of possible weakness in any proposed structure. In any aircraft design team there is an inherent reluctance to admit that their particular design has any weak points. In fairness it should be pointed out that, on the drawing board, the design may well appear to be satisfactory, i.e., all computed stress figures are verifiable; however, only the translation of the design into a structure that will be subjected to actual stress can pinpoint the particular weak points of the structure.

e. NDT should be utilized extensively during the structural, fatigue and vibration tests to aid inspection of the material under test. From the results obtained, the periodicity of inspections can be initially scheduled and many of the techniques developed can be used for these inspections. This also applies to aircraft power plants.

f. NDT should be applied on the production line, at various stages in the construction of an airframe or engine, to check the quality of workmanship. The main considerations are: presence of foreign bodies, i.e., tools, loose objects, etc; riveting checks, to ensure quality of holes and correct pick-up of blind rivets; and alignment checks to ensure that butting members do not override. Much of the experience gained in these latter stages can form the basis of maintenance techniques. In many cases, referring to original radiographs, etc can make valuable comparison checks.

g. The first group of aircraft from a production line needs to keep ahead of the rest of the fleet in terms of flying hours, number of landings, etc. Therefore, these aircraft which may form a part of the “Lead the Fleet” concept should be used to develop NDT techniques for future inspections on that aircraft type and they should be examined in greater depth than the rest of the fleet, both during construction and after, since any defects found could be representative of the whole fleet. Aircraft belonging to other nations may also contribute to establishing NDT requirements for Canadian Armed Forces aircraft.

h. NDT should be applied to the routine maintenance of aircraft since routine maintenance can be an expensive item. With the use of NDT techniques much of the time-consuming dismantling of structures for visual examination can be eliminated or, where visual inspection is essential, its sensitivity can be increased by the use of various NDT methods. There are many recorded examples of ultrasonic or radiographic inspections locating defects that were otherwise impossible to find where strip down would have put the aircraft out of service completely or resulted in a totally unacceptable downtime. After a period of time, rationalization of the complete NDT package applied to a specific aircraft should be carried out to ensure an economic application of NDT methods. The rationalization should be carried out considering defect data available and should recommend addition or deletion of present techniques, new areas of inspection and inspection periodicity.

i. One important aspect of the regular use of NDT on an aircraft is the information obtained on crack propagation. It is possible to follow the progress of a small crack in a secondary structure and, with the security obtained by frequent comparison checks, enable the aircraft to keep flying until a repair can be carried out at the earliest convenient time or during a planned Inspection.

j. The experience to date in the use of NDT at all stages in the life of an aircraft has fully justified the expenditures for complex NDT equipment with the resultant economics, and the assurance of a better end-product. Armed with this experience, NDT will increase in status and application in the future.

k. The performance of NDT on aircraft will be carried out, as far as it is economically possible, by Service personnel at all levels of maintenance, either at the Aircraft Maintenance organizations at Canadian Armed Forces Wings or the Aerospace Telecommunications Engineering Support Squadron (ATESS).

l. The performance of NDT requires skilled personnel in the field; therefore, all NDT performed on aircraft must be done by personnel suitably qualified in the particular method of NDT being applied.

m. The purpose of NDT technique development is to produce a written set of instructions that specify the optimum manner in which parts, assemblies or materials are to be inspected to establish the absence or presence of defects.

2.10.3 Application

1. The purpose of NDT application is to establish the presence or absence of defects in parts, assemblies or materials. NDT application may be effected by utilizing general inspection procedures which may be applied to an entire part or assembly and do not require a written NDT technique or by utilizing NDT techniques which define specific areas to be inspected. Discontinuities found as a result of the application of NDT must be investigated to establish whether they are defects. Such investigations will normally utilize at least one other NDT method of inspection, further disassembly or destructive testing.

2. The application of NDT during first and second line aircraft maintenance is normally performed by CAF NDT specialists at the ATESS NDT Centre, or the wing NDT Area Facilities (AFs). Aircraft maintenance personnel who have been qualified to perform a limited number of NDT inspections may be utilized at locations which are remote from NDTAFs, or which cannot be visited regularly by ATESS or NDTAF specialists. DND contracted NDT specialists normally perform the application of NDT during third line maintenance.

3. The application of NDT to CAF aircraft is managed by DTAES 7 staff. NDT inspections must be carried out in accordance with approved and authorized techniques.

NOTE

An acceptable means of compliance for technique development is the DGAEPM AF 9000 Procedure, EMT04.023/b-02 "Non-Destructive Testing Technique Development, Amendment, Approval and Implementation". For one-time inspections such as special inspections the application of NDT may be carried out in accordance with written instructions contained in inspection directives or leaflets issued by the applicable Aircraft Engineering Officer (AEO).

2.10.4 Definitions

1. The definition of NDT terms used in this ADSM has the meanings assigned below:

a. **Discontinuity.** This is the interruption in the normal physical structure or configuration of a part, such as laps, cracks, seams, inclusions or porosity. A discontinuity may or may not affect the usefulness of a part.

b. **NDT Technique.** This is the formal written instruction describing the procedure to be followed and the equipment required in order to perform a specific NDT inspection. Ultrasonic, radiographic, eddy current, magnetic particle and liquid penetrant inspections are carried out in accordance with NDT Techniques. DND contractors must carry out NDT inspections in accordance with approved DND NDT Techniques.

2.10.5 Standards

1. The following orders, specifications, and standards are acceptable for engineering, maintenance and administrative practices applicable to the NDT of Canadian Armed Forces aircraft and equipment.

	Civil Airworthiness Design Standards
1.	**Annual Book of ASTM Standards,** Section 3 - Metals Test Methods and Analytical Procedures, Volume 3.03 - NDT Testing
2.	**CAN/CGSB 48.9712-2000,** CGSB Qualification and Certification of Personnel
3.	**NAS 410,** Certification and Qualification of Non Destructive Testing Personnel
4.	**NTIAC DB-97-02,** Non-Destructive Evaluation (NDE) Capabilities Data Book
5.	**AWS Structural Welding Codes** (D1.1 – Steel, D1.2-90 – Aluminium)
6.	**SAE AMS 2644,** Inspection Material, Penetrant

Figure 2-10-1 Civil Airworthiness Design Standards Related to NDT

2.10.6 Guidance Information – Rationale for Standards

1. **Annual Book of ASTM Standards, Section 3 – Metals Test Methods and Analytical Procedures, Volume 3.03 – NDT Testing (latest version).** This volume covers the latest standards on non-destructive testing of engineering materials, structures, and assemblies to detect flaws and characterize materials properties. Subjects include the following:

a. Radiography – Reference radiograph standards, which when accompanied by ASTM's standard radiograph plates, are used to illustrate the type and degrees of discontinuities that may be found in castings and welds. Others detail the procedures required for proper radiographic examination.

b. Magnetic Particle and Liquid Penetrant Examination – test methods, practices, and reference photographs examine minimum requirements and various techniques.

c. Ultrasonic – practices for performing ultrasonic examination of tubing, weldments, and other materials.

d. Electromagnetic – standards detail procedures to follow when performing electromagnetic (eddy current) examination of ferrous and nonferrous metals, and in particular, various tubular products.

e. Other headings in this volume include infrared methods, leak testing, acoustic emission, NDT agencies, and metals sorting and identification.

2. **CAN/CGSB – 48.9712-2000 – CGSB Qualification and Certification of Personnel.** This standard establishes a system for the qualification and certification, by a certification body, of personnel to perform industrial NDT using any of the five traditional methods (eddy current, liquid penetrant, magnetic particle radiographic and ultrasonic testing).

2.10.7 Associated Publications and Standards

1. Related material may be found in the standards and publications listed in Figure 2-10-2.

Regulator or Organization	Number	Title
American Society of Mechanical Engineers (ASME)		Boiler and Pressure Vessel Code, Section V
American Society for Non-Destructive Testing (ASNT)		Non-Destructive Testing Handbook Series (latest edition)
American Society for Testing and Materials (ASTM)	Annual Book of Standards, Section 3	Metals Test Methods and Analytical Procedures, Volume 3.03 - NDT Testing
American Welding Society (AWS)	D1.1 – Steel, D1.2-90	Structural Welding Code - Aluminium
Canadian General Standards Board (CGSB)	CAN/CGSB 48.2-92	Spot Radiography of Welded Butt Joints in Ferrous Metals
	CAN/CGSB 48.3-92	Radiographic Testing of Steel Castings
	CAN/CGSB 48.5-95	Manual on Industrial Radiography
	CAN/CGSB 48.14-M86	Advanced Manual for Eddy Current Test Method
	CAN/CGSB 48.16-92	Radiographic Inspection of Aircraft Structures
Canadian Government Publications	Safety Code 34	Radiation Protection and Safety for Industrial X-Ray Equipment
DND/CAF	C-06-020-001/AM-001	Test Equipment Calibration Policy
	C-77-005-001/AM-000	Canadian Forces Radiac Equipment
	D-12-020-001/SF-001	Specification for Quality Control of NDT (Aircraft, Missile, and Related Equipment Applications)
	D-49-020-001/SF-001	NDT Specification for HMC Ships
	D-49-020-001/SF-002	NDT Specification for Shipboard Equipment Non-Combatant Ships
	DAOD 4002-0	Nuclear Technology Regulation and Control
	DAOD 4002-1	Nuclear and Ionizing Radiation Safety
	CFMO Volume 2, Chapter 41-02	CF Medical Orders X-Ray Safety Precautions

Figure 2-10-2 (Sheet 1 of 2) Associated Publications and Standards Related to NDT

Regulator or Organization	Number	Title
DND/CAF (Cont)	MSICF 8000-114	CF Medical Services Instructions, Physical Hazards Surveillance Programme
ISO	ISO 10012-1	Quality Assurance Requirements for Measuring Equipment
National Aviation Standard (NAS)	410	Certification and Qualification of Non Destructive Testing Personnel
Nondestructive Testing Information Analysis Center (NTIAC)	DB-97-02	Non-Destructive Evaluation (NDE) Capabilities Data Book
SAE	AMS 2644	Inspection Material, Penetrant
U.S. DoD	MIL-HDBK-1823	Non-Destructive Evaluation System, Reliability Assessment
	MIL-STD-1530B	Aircraft Structural Integrity Program (ASIP)
	MIL-STD-1537	Electrical Conductivity Test for Measurement of Heat Treatment of Aluminium Alloys, Eddy Current Method
	MIL-STD-2154	Inspection, Ultrasonic, Wrought Metals, Process for
	R-02-020-001/AM-000	Non-Destructive Inspection Methods
	-	Handbook for Damage Tolerant Design

Figure 2-10-2 (Sheet 2 of 2) Associated Publications and Standards Related to NDT

PART 2
CERTIFICATION PROCESSES

CHAPTER 11 — SYSTEMS AND EQUIPMENT TESTABILITY

2.11.1 Introduction

1. Operational availability is directly affected by equipment reliability, maintainability, and logistic support. Testability is a design characteristic, which describes the ability to determine an item's status and to isolate faults within an item in an accurate and timely manner. Testability directly affects maintainability. By designing testability features into systems, faults can be detected before catastrophic failure and appropriate replacement parts can be positioned to effect timely maintenance.

2. Mechanical fault detection systems typically monitor excessive vibrations, wear debris (generated in oil-wetted systems) and temperatures and pressures against predetermined limits. Avionics fault detection systems typically monitor voltages, operating temperatures, signal outputs, system performance and results from built in tests (BIT). Software fault detection systems monitor the accuracy of data and failures in processes.

3. COTS systems are preferred and in many cases are the only systems available to CAF project staff for acquisition. Test capabilities and system interfaces that are part of the original design can enhance equipment testability features. The Technical Authority (TA) for the system or equipment can in concert with the OEM, build upon these testability characteristics by developing a testability strategy for the weapon system and making it integral to system requirements during development and integration.

2.11.2 Standards

1. The following testability standards are acceptable to the TAA.

	Military Airworthiness Design Standards
1.	**MIL-HDBK-2165,** Testability Handbook for Systems and Equipment
2.	**DEF STAN 00-42,** Reliability and Maintainability (R&M) Assurance Guide Part 4, Testability

Figure 2-11-1 Military Airworthiness Design Standards Related to System and Equipment Testability

2.11.3 Guidance Information – System Testability

1. MIL-HDBK-2165, although not strictly a standard, prescribes a standard approach to testability program planning, establishment of diagnostic concepts and testability (including BIT) requirements, testability and test design and assessment and requirements for conducting testability reviews. DEF STAN 00-42 reflects current applications for testability.

2. System testability is considered to be an integral part of the maintainability program. It is important to interlink reliability, maintainability and availability with testability to ensure consistency between them. When specifying the requirements for system test the following should be specified:

   a. FDR (Failure Detection Rate) – the percentage of total number of failures that should be indicated.

   b. FAR (False Alarm Rate) – indication of a failure where no failure exists, such as operator error or test deficiency.

   c. The indenture level (i.e., Line Replaceable Unit (LRU) to which a specified percentage of failures should be isolated), derived from the maintenance concept.

d. 100 per cent of safety critical systems should be continuously monitored, failures detected and indicated at the time of occurrence.

3. Excessive testability requirements can be a source of increased cost and project delay. For example, detection of failures in crew lighting would not be considered critical and may not be subject to testability due to the level of effort required. Conversely, testability features are vital for the failure detection of flight-critical components, such as rotor blades, to enable flight and ground crew to determine their condition more accurately and easily. DEF STAN 00-42 provides guidance on strategies for failure detection. It recommends the creation of a fault list and proposes that faults be evaluated using practical methods of detection, e.g., Inspection and Self-Test.

4. System Test can be accomplished by various methods. Traditionally, sub-systems had self-contained BIT that required initiation by operational or maintenance personnel and provided a Go/No-Go indication. BIT was limited to avionics and was not available for system integration. Systems integration can improve testability by integrating and monitoring mechanical and avionic systems from start-up and throughout operations; it can also add testability or fault filtering features into the mission systems. Improvements to system testability can also be realized through the development of Level 5 Interactive Electronic Technical Manuals (IETMs). They can integrate faultfinding into electronic technical publications that can be updated throughout the service life of the system rather than relying on system-specific support and test equipment.

2.11.4 Associated Publications and Standards

1. The following publications (Figure 2-11-2) provide information on how testability can be integrated into a reliability and maintainability program.

Regulator or Organization	Number	Title
NATO	ARMP-4	Guidance for Writing NATO R&M Requirements Documents
UK MoD	DEF STAN 00-42	Reliability and Maintainability (R&M) Assurance Guide Part 4, Testability
	DEF STAN 00-60	Application of Integrated Logistics Support
U.S. DoD	MIL-STD-1388	Logistic Support Analysis
	MIL-HDBK-2165	Testability Handbook for Systems and Equipment

Figure 2-11-2 Associated Publications and Standards Related to System and Equipment Testability

PART 2
CERTIFICATION PROCESSES

CHAPTER 12 — FUELS, LUBRICANTS AND HYDRAULIC FLUIDS

2.12.1 Introduction

1. This chapter identifies the airworthiness design standards and associated guidance accepted by the Technical Airworthiness Authority (TAA) for military and civil aircraft fuels, lubricants and hydraulic fluids. It has been written to consider that DND acquires and operates a mix of military and civil pattern aircraft. Because of its focus, this chapter is a good starting point in defining a certification basis for design changes related to fuels, lubricants and hydraulic fluids.

2.12.2 Scope

1. This chapter provides fuel, lubricants and hydraulic fluids design standards and advisory material.

2. This chapter is also meant to complement Part 3, Chapter 10 – Propulsion Systems. The engine manufacturer generates the bulk of the data required under Part 3, Chapter 10. Substantiation of changes to fuels or powerplant lubricants usually requires assessing the impact of the changes on the performance and operating limitations of the powerplant.

3. This chapter is also meant to complement Part 3, Chapter 11 – Aircraft Fuel Systems. Substantiation of changes to fuels usually requires assessing the impact of the changes on the performance and operating limitations of the fuel systems, including compatibility with the materials used in the fuel system and effects on the fuel system instrumentation (such as dielectric/density relationship).

4. This chapter is also meant to complement Part 3, Chapter 18 – Aerospace Rigid Tubing. Substantiation of changes to fuels, lubricants or hydraulic fluids usually requires assessing the impact of the changes on the performance and operating limitations of the tubing that serves to transport and route the fluid, including compatibility with the materials used, and operating conditions.

5. Substantiation of changes to hydraulic fluids usually requires assessing the impact of the changes on the performance and operating limitations of the hydraulic systems, including compatibility with the materials used in the hydraulic system. No current ADSM chapter exists specifically on hydraulic systems.

6. Quality Engineering Test Establishment (QETE) 3-3 is the Technical Authority for aviation fuels, lubricants and hydraulic fluids standards as delegated through the AEPM – QETE Service Level Agreement (SLA). DTAES 7-7 and 7-8 provide airworthiness certification support and engineering support regarding these fluids and their use in RCAF aircraft.

2.12.3 Fuel-Related Airworthiness Requirements

1. Figure 2-12-1 through Figure 2-12-4 provide a list of the military and civil airworthiness standards and requirements, as well as relevant advisory material and informational reports that pertain to the certification of aviation fuels.

Military Airworthiness Requirements – Fuels
General
1. **C-82-005-001/AM-004,** Technical Reference for Fuels, Lubricants and Associated Products
2. **C-82-010-007/TP-000,** Maintenance Procedures – Quality Control of Aviation and Ground Fuels and Lubricants

Figure 2-12-1 (Sheet 1 of 2) Military Airworthiness Requirements Related to Fuels

Military Airworthiness Requirements – Fuels
3. **C-82-010-007/TP-000,** Quality Control of Aviation and Ground Fuels and Lubricants
4. **D-82-002-007/SG-001,** Technical Requirements for Process Control in Production, Quality Control and Delivery of Aviation Fuels
5. **MIL-HDBK-516C,** U.S. Department of Defense Handbook – Airworthiness Certification Criteria, para 8.3.3 (Compatibility with approved fuels) and 19.1.5 (Environmental effects)
6. **EMACC Handbook,** section 8.3.3 (Compatibility with approved fuels) and 19.1.5 (Environmental effects)
Fuel Specifications (Canadian, UK MoD, U.S. DoD, NATO)
1. **CAN/CGSB-3.24,** Aviation Turbine Fuel (Military grades F-34, F-37 and F-44)
2. **DEF STAN 91-86,** UK MoD – Turbine Fuel, Aviation Kerosene Type: High Flash Type, Containing Fuel System Icing Inhibitor
3. **DEF STAN 91-87,** UK MoD – Turbine Fuel, Aviation Kerosene Type, Containing Fuel System Icing Inhibitor
4. **DEF STAN 91-90,** UK MoD – Gasoline, Aviation: Grades 80/87, 100/130 and 100/130 Low Lead. Joint Service Designation: AVGAS 80, AVGAS 100 and AVGAS 100LL
5. **DEF STAN 91-91,** Turbine Fuel, Aviation Kerosene Type, Jet A-1 NATO Code: F-35, Joint Service Designation: AVTUR
6. **DEF STAN 05-50,** Methods for Testing Fuels, Lubricants and Associated Products
7. **DEF STAN 05-52,** UK MoD – Markings for the Identification of Fuels, Lubricants and Associated Products
8. **MIL-DTL-5624,** Detail Specification, Turbine Fuel, Aviation, Grades JP-4 and JP-5
9. **MIL-DTL-83133,** Detail Specification, Turbine Fuel, Aviation Kerosene Type, JP-8, and JP-8+100
10. **MIL-STD-3004,** Quality Assurance/Surveillance for Fuels, Lubricants and Related Products
11. **STANAG/AFLP-3747,** Guide Specifications (minimum quality standards) for Aviation Turbine Fuels (F-24, F-27, F-34, F-35, F-37, F-40 and F-44)

Figure 2-12-1 (Sheet 2 of 2) Military Airworthiness Requirements Related to Fuels

Civil Airworthiness Requirements – Fuels
Certification Requirements – General (AWM 523)
1. **523.863,** Flammable fluid fire protection
2. **523.1521 (d),** Fuel grade or designation
3. **523.1522,** Auxiliary Power Unit Limitations
4. **523.1583,** Operating Limitations
Certification Requirements – General (14 CFR 23/CS-23)
1. **23.2325 (g),** Fire Protection
2. **23.2430,** Fuels Systems
3. **23.2620 (a)(1),** Airplane operating limitations
Certification Requirements – Transport Category Aircraft and all Rotorcraft (14 CFR/AWM/CS-25, -27, -29)
1. **xx.863,** Flammable fluid fire protection
2. **xx.951-1001,** Fuel Systems and Components
3. **xx.1185,** Flammable Fluids
4. **xx.1521,** Powerplant limitations
5. **xx.1522,** Auxiliary Power Unit Limitations
6. **xx.1583 (b)(1),** Operating Limitations
Certification Requirements – Other (CFR)
1. **33.7 (b)(2) and (c)(2),** Engine ratings and operating limitations (Fuel)

Figure 2-12-2 (Sheet 1 of 2) Civil Airworthiness Requirements Related to Fuels

Civil Airworthiness Requirements – Fuels	
2.	**91.9,** Civil aircraft flight manual, marking, and placard requirements

Figure 2-12-2 (Sheet 2 of 2) Civil Airworthiness Requirements Related to Fuels

Military Airworthiness Guidance Material – Fuels	
NATO Publications	
1.	**STANAG/AFLP-1110,** Allowable deterioration limits for NATO armed forces fuels, lubricants and associated products
2.	**STANAG/AFLP-1135 (C-82-005-001/AM-002),** Interchangeability of fuels, lubricants and associated products used by the armed forces of the North Atlantic Treaty nations
3.	**STANAG/AFLP-3149,** Minimum quality surveillance for fuels
4.	**NATO STO Technical Report TR-AVT-225,** Military User's Guide for the Certification of Aviation Platforms on Synthetic Jet Fuels
Methods of Compliance – General (for specific paras, consult MIL-HDBK-516C para 8.3.3)	
1.	**JSSG-2007,** U.S. DoD Joint Services Specification Guide, Engines, Aircraft, Turbine
2.	**JSSG-2009,** U.S. DoD Joint Services Specification Guide, Air Vehicle Subsystems
3.	**MIL-HDBK-510,** U.S. Department of Defense Handbook, Aerospace Fuels Certification

Figure 2-12-3 Military Airworthiness Guidance Material Related to Fuels

Civil Airworthiness Guidance Material – Fuels	
Fuel Specifications	
1.	**ASTM D910,** Standard Specification for Aviation Gasolines (Includes 100LL)
2.	**ASTM D1655,** Standard Specification for Aviation Turbine Fuels (Includes Jet A/A-1)
3.	**ASTM D6227,** Standard Specification for Grade UL82 and UL87 Unleaded Aviation Gasoline
4.	**ASTM D6615,** Standard Specification for Jet B Wide-Cut Aviation Turbine Fuels
5.	**ASTM D7223,** Standard Specification for Aviation Certification Turbine Fuel
6.	**ASTM D7547,** Standard Specification for Unleaded Aviation Gasoline
7.	**ASTM D7566,** Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons
8.	**ASTM D7592,** Standard Specification for Specification for Grade 94 Unleaded Aviation Gasoline Certification and Test Fuel
9.	**CAN/CGSB-3.23,** Aviation Turbine Fuel, Kerosene Type
10.	**GB6537,** No 3 Jet Fuel [People's Republic of China]
11.	**GOST 10227,** Jet Fuels Specifications [Russia]
FAA Publications	
1.	**AC 20-24D,** Approval of Propulsion Fuels, Additives, and Lubricating Oils
2.	**AC 20-29B,** Use of Aircraft Fuel Anti-Icing Additives
3.	**AC 20-43C,** Aircraft Fuel Control
4.	**AC 20-125,** Water in Aviation Fuels
5.	**AC 23.1521-1,** Type Cert of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines
6.	**AC 23.1521-2,** Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines
7.	**AC 33.47-1,** Detonation Testing in Reciprocating Aircraft Engines
8.	**AC 91-33A,** Use of Alternate Grades of Aviation Gasoline for Grade 80/87, and Use of Automotive Gasoline

Figure 2-12-4 (Sheet 1 of 2) Civil Airworthiness Guidance Material Related to Fuels

Civil Airworthiness Guidance Material – Fuels
9. **Special Airworthiness Information Bulletin (SAIB) NE11-56,** Engine Fuel and Control – Semi-Synthetic Jet Fuel
10. **TSO-C77b,** APU TSO Approval Minimum Qualification Standards
EASA Publications
1. **CS-23/25/27/29 Book 2,** Acceptable Means of Compliance
Consensus Standard Aerospace Recommended Practices and Information Reports
1. **ASTM F3264-17,** Standard Specification for Normal Category Aeroplanes Certification
2. **ASTM D4054,** Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives
3. **ASTM D6424,** Standard Practice for Octane Rating Naturally Aspirated Spark Ignition Aircraft Engines
4. **ASTM D6812,** Standard Practice for Ground-Based Octane Rating Procedures for Turbocharged/ Supercharged Spark Ignition Aircraft Engines
5. **CRC Report No. 635,** Handbook of Aviation Fuel Properties
6. **DO-160C Section 11,** Fluids Susceptibility
7. **SAE AIR 7484,** Guidance on the Impact of Fuel Properties on Fuel System Design and Operation

Figure 2-12-4 (Sheet 2 of 2) Civil Airworthiness Guidance Material Related to Fuels

2.12.4 Guidance – Fuel Airworthiness Requirements and Aircraft Design Specifications

1. The Royal Canadian Air Force (RCAF) uses two types of aviation fuel: aviation gasoline (AVGAS), which is primarily used in reciprocating or piston engine aircrafts, and aviation turbine fuel (jet fuel), which is primarily used in gas turbine engines.

2. A list of approved fluids (e.g., fuels), along with the applicable design operating limitations, shall be provided in the Approved Flight Manual (AFM) and the Type Certificate Data Sheet (TCDS) in accordance with the TAM, Part 2, Chapter 1, Section 2. Typically, approved fuels can be categorized as follows:

a. fuels that are authorized for continuous unrestricted operation (e.g., primary fuels);

b. fuels that impose operational restrictions on the aircraft. These fuels may be used only if no primary fuels are available (e.g., restricted fuels); and

c. fuels that may be used for a minimum time when a primary fuel is not available, and an urgent need exists. Pilot approval may be required before servicing, in addition to operational restrictions on the aircraft (e.g., emergency fuels).

2.12.5 Guidance Information – Fuel Specifications

1. To ensure interoperability requirements are met, the standard aviation fuels for the RCAF are codified in North Atlantic Treaty Organization (NATO) standardizing agreements. To this effect, NATO member nations agree to the use of STANAG 1135, which covers fuels and other non-aviation fluids. Within STANAG 1135, a list of NATO codes is provided for various fuel types, which are further defined via minimum quality standards identified in the guide specifications (e.g., STANAG 3747).

2. Interoperability between participating nations for each codified product is ensured by providing a guide specification, which represents the minimum quality standards for that NATO code (F-27, F-34, F-44, etc.). Thus, each participating nation is allowed to maintain their own national specification, so long as the minimum requirements of the guide specification are still met. Furthermore, national specifications cannot include additives, unless approved in the guide specification. For example, the guide specification for F-34 aviation turbine fuel is the NATO STANAG 3747. When compared to the guide specification and other national specifications, Canada's F-34 military grade aviation turbine fuel specification (CGSB-3.24) has a more stringent requirement with regards to the Fuel System Icing Inhibitor (FSII) additive content to reflect lower temperature operability requirements. Despite

this technical difference, it is still considered interchangeable with other national specifications listed under the F-34 NATO code in NATO STANAG 1135. The implications are that, if the technical requirements specify a NATO code (e.g., F-34) or a NATO guide specification (STANAG 3747), then this would include all F-34 national specifications listed in NATO STANAG 1135. If the technical requirements only specify one national specification (e.g., CGSB-3.24), then only that specification satisfies the requirements.

3. For materiel acquisition and support (MA&S) of aerospace systems, the NATO guide specifications (STANAG 3747) should be preferred, noting in requirements documentation that common alternative identifiers (e.g., JP-8, Jet A-1) may be used at some locations (the specifications associated with these alternative identifiers should not be preferred as reference specifications). National specifications meeting the NATO guide specification requirements are used for procurement in respective nations (e.g., procured in Canada under CGSB specifications).

4. The NATO standards are revised annually by the Naval, Army and Aviation Fuels and Lubricants Working Parties. Canada's Head of Delegation for the Aviation Fuels and Lubricants Working Party is the RCAF Senior Technical Authority for Fuels and Lubricants at the QETE (QETE 3).

2.12.6 Guidance Information – Fuel Certification and Approvals

1. Civil aircraft engines are normally certified by the national civil aviation authority in the country of manufacture, leading to engine Type Certification. The engine Type Certificate lists the fuel specifications approved by the OEM for use in the type. The certifying authority does not directly regulate fuel standards, but instead participates in the industry-led specification change and approval process (e.g., through ASTM or CGSB). For DND aircraft, the approach is similar. However, DND Type Certificates are issued only at the aircraft level, incorporating the engine design. Canadian military specification fuel is governed by a CGSB-issued standard. However, in some countries, including the U.S. and UK, military specification fuel is controlled by the defence department (e.g., by MIL-SPECs and DEF STANs, respectively).

2. MIL-HDBK-510 provides comprehensive guidance on the evaluation, approval and certification of aviation fuels and fuel additives. Consideration is given to safety of operation, performance, durability, survivability, material compatibility, environmental impact, safety and health. This document also covers the interchangeability aspect of military aviation fuels to provide enhanced compatibility between aviation requirements and those of support equipment and vehicles.

3. AC 20-24D Advisory Circular provides guidance applicable to adding fuels and oils as powerplant operating limitations. It also provides guidance on fuel and lubricating oil certification plans, as well as specifications and standards that cover propulsion fuels and lubricating oil.

2.12.7 Lubricants

1. Figure 2-12-5 through Figure 2-12-8 provide a list of the military and civil airworthiness standards, as well as advisory material and informational reports that pertain to the certification of aviation lubricants.

	Military Airworthiness Design Standards – Lubricants
1.	**C-82-005-001/AM-004,** Technical Reference for Fuels, Lubricants and Associated Products
2.	**C-82-010-007/TP-000,** Quality Control of Aviation and Ground Fuels and Lubricants
3.	**C-05-005-008/AM-000,** Aerospace Oil Analysis Program Maintenance Policy
4.	**MIL-HDBK-516C,** U.S. Department of Defense Handbook – Airworthiness Certification Criteria, para 7.2.4.1.9, 7.2.4.1.11-13, 7.3.2.5, 7.3.2.11-13, 8.6.15, and 19.1.5
5.	**EMACC Handbook,** sections 7.2.4.1.9, 7.2.4.1.11-13, 7.3.2.5, 7.3.2.11-13, 8.6.15, and 19.1.5
6.	**DEF STAN 05-52,** UK MoD – Markings for the identification of fuels, lubricants and associated products
7.	**DEF STAN 05-50,** Methods for Testing Fuels, Lubricants and Associated Products

Figure 2-12-5 (Sheet 1 of 2) Military Airworthiness Design Standards Related to Lubricants

Military Airworthiness Design Standards – Lubricants	
8.	**MIL-PRF-23699,** Performance specification: lubricating oil, aircraft turbine engine, synthetic base, NATO code number O-156
9.	**MIL-L-6082,** Lubricating Oil, Aircraft Piston Engine (Non-Dispersant Mineral Oil)
10.	**MIL-L-22851,** Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant)
11.	**MIL-STD-3004,** Quality Assurance/Surveillance for Fuels, Lubricants and Related Products

Figure 2-12-5 (Sheet 2 of 2) Military Airworthiness Design Standards Related to Lubricants

Civil Airworthiness Requirements – Lubricants	
Certification Requirements – General (AWM 523)	
1.	**523.863,** Flammable fluid fire protection
2.	**523.1011-1027,** Oil Systems
3.	**523.1521,** Powerplant limitations
4.	**523.1522,** Auxiliary Power Unit Limitations
5.	**523.1583,** Operating Limitations
Certification Requirements – General (14 CFR 23/CS-23)	
1.	**23.2325 (g),** Fire Protection
2.	**23.2425,** Powerplant operational characteristics
3.	**23.2620 (a)(1),** Airplane operating limitations
Certification Requirements – Transport Category Aircraft and all Rotorcraft (14 CFR/AWM/CS-25, -27, -29)	
1.	**xx.863,** Flammable fluid fire protection
2.	**xx.951-1027,** Oil Systems
3.	**3. xx.1041-1049,** Cooling
4.	**xx.1185,** Flammable Fluids
5.	**xx.1521,** Powerplant limitations
6.	**xx.1522,** Auxiliary Power Unit Limitations
7.	**xx.1583 (b)(1),** Operating Limitations
Certification Requirements – Other (CFR)	
1.	**33.7 (b)(3) and (c)(3),** Engine ratings and operating limitations (Oil)
2.	**91.9,** Civil aircraft flight manual, marking, and placard requirements

Figure 2-12-6 Civil Airworthiness Design Standards Related to Lubricants

Military Airworthiness Guidance Material – Lubricants	
NATO Standardization Agreement	
1.	**STANAG 1135,** Interchangeability of fuels, lubricants and associated products used by the armed forces of the North Atlantic Treaty nations
2.	**STANAG 1110,** Allowable deterioration limits for NATO armed forces fuels, lubricants and associated products
Methods of Compliance – General (for specific paras, consult MIL-HDBK-516C para 8.3.3)	
1.	**JSSG-2007,** U.S. DoD Joint Services Specification Guide, Engines, Aircraft, Turbine
2.	**JSSG-2009,** U.S. DoD Joint Services Specification Guide, Air Vehicle Subsystems

Figure 2-12-7 (Sheet 1 of 2) Military Airworthiness Guidance Material Related to Lubricants

Military Airworthiness Guidance Material – Lubricants
3. **MIL-HDBK-275,** U.S. Department of Defense Handbook – Guide for selection of lubricant fluids and compounds for use in flight vehicles and components

Figure 2-12-7 (Sheet 2 of 2) Military Airworthiness Guidance Material Related to Lubricants

Civil Airworthiness Guidance Material – Lubricants
FAA Advisory Circulars 1. **AC 20-24D,** Approval of Propulsion Fuels, Additives, and Lubricating Oils
FAA Technical Standing Orders 1. **TSO-C77b,** APU TSO Approval Minimum Qualification Standards
EASA Acceptable Means of Compliance 1. **CS-23/25/27/29 Book 2,** Acceptable Means of Compliance
Consensus Standard Aerospace Recommended Practices and Information Reports 1. **ASTM F3264-17,** Standard Specification for Normal Category Aeroplanes Certification 2. **DO-160C Section 11,** Fluids Susceptibility 3. **SAE AIR 6056,** Gas Turbine Engine Lubricant Specifications: Current Technical Review and Future Direction 4. **SAE AIR 5433,** Lubricating Characteristics and Typical Properties of Lubricants Used in Aviation Propulsion and Drive Systems 5. **SAE AMS 3057,** Lubricant, Semi-Fluid, for Aircraft Gearboxes 6. **SAE ARP 1400B,** Recommended Practices for Lubricating Oil Filters, General Aviation Reciprocating Engine (Piston Type) Aircraft 7. **SAE ARP 5824,** Recommended Solid Film Lubricants for Fluid System Components 8. **SAE ARP 6179,** Evaluation of Gas Turbine Engine Lubricant Compatibility with Elastomer O-Rings 9. **SAE ARP 6255,** Aviation Lubricant Tribology Evaluator (ALTE) Method to Determine the Lubricating Capability of Gas Turbine Lubricants 10. **SAE AS 5780,** Specification for Aero and Aero Derived Gas Turbine Engine Lubricants 11. **SAE J1 899,** Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant) 12. **SAE J1 966,** Lubricating Oils, Aircraft Piston Engine (Non-Dispersant Mineral Oil)

Figure 2-12-8 Civil Airworthiness Guidance Material Related to Lubricants

2.12.8 Guidance Information – Lubricants

1. AC 20-24D Advisory Circular provides guidance applicable to adding fuels and oils as powerplant operating limitations. It also provides guidance on fuel and lubricating oil certification plans as well as specifications and standards that cover propulsion fuels and lubricating oil.

2. MIL-HDBK-275 provides comprehensive guidance on the uses and limitations of lubricants for various aerospace applications. The handbook covers U.S. Military Specification lubricants including greases, oils, hydraulic fluids, damping fluids, lubricating compounds and solid film lubricants.

3. STANAG 1135 provides a list of the various fuels, oil and hydraulic fluid specifications used by each NATO member country, and the interchangeability and compatibility between them.

4. SAE AS 5780 provides basic physical, chemical and performance limits for gas turbine engine lubricating oils. This specification also covers test methods and requirements for quality conformance.

2.12.9 Hydraulic Fluids

1. Figure 2-12-9 through Figure 2-12-12 provide a list of the military and civil airworthiness standards, as well as advisory material and informational reports that pertain to certification of aviation hydraulic fluids. The primary hydraulic fluid for RCAF aircraft is MIL-PRF-87257 due to its wide range of operating temperatures and low flammability characteristics. Properties of MIL-PRF-87257 are found in C-82-005-001/AM-004 and U.S. Military Performance Specification MIL-PRF-87257C. Some aircraft have approved alternate and/or emergency hydraulic fluids, which would be identified in the fleet's Aircraft Flight Manual or Aircraft Operating Instructions.

Military Airworthiness Design Standards – Hydraulic Fluids	
1.	**C-82-005-001/AM-004,** Technical Reference for Fuels, Lubricants & Associated Products
2.	**C-82-010-007/TP-000,** Quality Control of Aviation and Ground Fuels and Lubricants
3.	**C-13-010-000/AM-001,** Requirements for Hydraulic Fluid Cleanliness and Related Environmental Control at Military and Contractor Facilities
4.	**C-05-010-012/AM-000,** Prevention of Contamination in Hydraulic Systems Maintenance Policy
5.	**MIL-HDBK-516C,** U.S. Department of Defense Handbook – Airworthiness Certification Criteria, para 6.2.3, 6.2.10, 8.1
6.	**EMACC Handbook,** sections 6.2.3, 6.2.10, 8.1
7.	**DEF STAN 05-50,** Methods for Testing Fuels, Lubricants and Associated Products
8.	**DEF STAN 05-52,** UK MoD – Markings for the identification of fuels, lubricants and associated products
9.	**DEF STAN 91-35,** Hydraulic Fluid, Petroleum: Emulsifying, Anti-Wear Joint Service Designation: OX-30
10.	**ADS-69-PRF,** Aeronautical Design Standard: Performance Specification, Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance
11.	**MIL-DTL-17111,** Fluid Power Transmission
12.	**MIL-H-5440H,** Hydraulic systems, aircraft, design and installation requirements, For
13.	**MIL-H-8775D,** Military Specification: Hydraulic System Components, Aircraft and Missiles, General Specification, For
14.	**MIL-STD-5522,** Test Requirements and Methods for Aircraft Hydraulic and Emergency Pneumatic Systems
15.	**MIL-PRF-5606,** Hydraulic fluid, petroleum base; aircraft, missile, and ordnance
16.	**MIL-PRF-46170,** Hydraulic fluid, rust inhibited, fire resistant, synthetic base
17.	**MIL-PRF-46176,** Brake Fluid Silicone Automotive
18.	**MIL-PRF-83282,** Hydraulic fluid, fire resistant, synthetic, hydrocarbon base; aircraft
19.	**MIL-PRF-87257C,** Hydraulic Fluid Fire Resistant Low Base

Figure 2-12-9 Military Airworthiness Design Standards Related to Hydraulic Fluids

Civil Airworthiness Design Standards – Hydraulic Fluids	
Certification Requirements – General (CAR 523)	
1.	**523.863,** Flammable fluid fire protection
2.	**523.1435,** Hydraulic Systems
Certification Requirements – General (CFR 23/CS 23)	
1.	**23.2325 (g),** Fire Protection
Certification Requirements – Transport Category Aircraft and Rotorcraft (CFR/CAR/CS 25,27,29)	
1.	**xx.863,** Flammable fluid fire protection
2.	**xx.1435,** Hydraulic Systems
3.	**xx.1185,** Flammable Fluids

Figure 2-12-10 (Sheet 1 of 2) Civil Airworthiness Design Standards Related to Hydraulic Fluids

Civil Airworthiness Design Standards – Hydraulic Fluids
Certification Requirements – Other (CFR)
1. **91.9,** Civil aircraft flight manual, marking, and placard requirements

Figure 2-12-10 (Sheet 2 of 2) Civil Airworthiness Design Standards Related to Hydraulic Fluids

Military Airworthiness Guidance Material – Hydraulic Fluids
NATO Standardization Agreements
1. **STANAG 1110,** Allowable deterioration limits for NATO armed forces fuels, lubricants and associated products
2. **STANAG 7093,** Guide Specification for NATO Land System Automotive Fluids
3. **STANAG 1135,** Interchangeability of fuels, lubricants and associated products used by the armed forces of the North Atlantic Treaty nations
Methods of Compliance – General (for specific paras, consult MIL-HDBK-516C)
1. **JSSG-2008,** Department of Defense Joint Service Specification Guide: Vehicle Control and Management System
2. **JSSG-2009,** U.S.DoD Joint Services Specification Guide, Air Vehicle Subsystems
3. **MIL-HDBK-275,** U.S. Department of Defense Handbook – Guide for selection of lubricant fluids and compounds for use in flight vehicles and components

Figure 2-12-11 Military Airworthiness Guidance Material Related to Hydraulic Fluids

Civil Airworthiness Guidance Material – Hydraulic Fluids
FAA Advisory Circulars
1. **AC 25.1435-1,** Hydraulic System Certification Tests and Analysis
FAA Technical Standing Orders
1. **TSO-C47,** Pressure Instruments-Fuel, Oil, and Hydraulic
2. **TSO-C75,** Hydraulic Hose Assemblies (JTSO-2C75)
EASA Acceptable Means of Compliance
1. **CS-23/25/27/29 Book 2,** Acceptable Means of Compliance
Consensus Standard Aerospace Recommended Practices and Information Reports
1. **ASTM F3264-17,** Standard Specification for Normal Category Aeroplanes Certification
2. **DO-160C Section 11,** Fluids Susceptibility
3. **SAE AIR 81,** Importance of Physical and Chemical Properties of Aircraft Hydraulic Fluids
4. **SAE AIR 737,** Aerospace Hydraulic and Pneumatic Specifications, Standards, Recommended Practices, and Information Reports
5. **SAE AIR 810,** Degradation Limits of Hydrocarbon-Based Hydraulic Fluids, MIL-PRF-5606, MIL-PRF-83282, and MIL-PRF-87257 Used in Hydraulic Test Stands
6. **SAE AIR 1362,** Aerospace Hydraulic Fluids Physical Properties
7. **SAE AIR 1899,** Aerospace Military Aircraft Hydraulic System Characteristics
8. **SAE AIR 5005,** Aerospace Commercial Hydraulic Systems
9. **SAE AIR 5358,** Landing Gear Shock Strut Hydraulic Fluid
10. **SAE ARP 1288,** Placarding of Aircraft Hydraulic Equipment to Identify Phosphate Ester Fluid Compatibility
11. **SAE ARP 1493,** Wheel and Hydraulically Actuated Brake Design and Test Requirements for Military Aircraft

Figure 2-12-12 (Sheet 1 of 2) Civil Airworthiness Guidance Material Related to Hydraulic Fluids

Civil Airworthiness Guidance Material – Hydraulic Fluids	
12.	**SAE ARP 4752,** Design and Installation of Commercial Transport Aircraft Hydraulic Systems
13.	**SAE ARP 24,** Determination of Hydraulic Pressure Drop
14.	**SAE AS 1241,** Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
15.	**SAE AS 5440,** Hydraulic Systems, Military Aircraft, Design and Installation, Requirements For
16.	**SAE AS 5586,** General Requirements for Hydraulic System Reservoirs
17.	**SAE AS 8775,** Hydraulic System Components, Aircraft and Missiles, General Specification For
18.	**SAE J 1703,** Motor Vehicle Brake Fluid

Figure 2-12-12 (Sheet 2 of 2) Civil Airworthiness Guidance Material Related to Hydraulic Fluids

2.12.10 Guidance Information – Hydraulic Fluids

1. AC 25-1435-1 Advisory Circular gives guidance for substantiating civil aircraft hydraulic systems.

2. ARP 4752, AS 5440 and AS 8775 provide guidelines for the design and certification of civil and military hydraulic systems.

3. MIL-HDBK-275 provides comprehensive guidance on the uses and limitations of lubricants for various aerospace applications. The handbook covers U.S. Military specification-controlled lubricants, including greases, oils, hydraulic fluids, damping fluids, lubricating compounds and solid film lubricants.

4. STANAG 1135 provides a list of the various fuel, oil and hydraulic fluid specification used by each NATO member country, and the interchangeability and compatibility between them.

PART 2
CERTIFICATION PROCESSES

CHAPTER 13 — MATERIAL SPECIFICATIONS AND STANDARDS

2.13.1 Introduction

1. This chapter provides guidance on material specifications and standards used for the airworthiness certification of metallics and composites. The scope of the chapter is limited to aircraft structures, engines, and systems, and focuses on mechanical, elevated temperature and fatigue properties.

2. To achieve Certification by Analysis (CbA), room temperature mechanical properties are required. These properties include tensile, compression, bearing, shear, fatigue, fracture toughness, elongation and elastic modulus and durability characteristics. The same properties should also be understood at elevated temperatures with the addition of creep and stress rupture characteristics.

3. Many material specifications have been established, published, and maintained by international standards organizations or government agencies, who catalogue material design values and prescribe manufacturing, test, and acceptance criteria. The intent of the guidance material provided in this chapter is to detail existing TAA-recognized sources for material standards and specifications.

4. For new materials and manufacturing processes, including novel technology, guidance is provided on acceptable processes to derive design values in support of certification.

2.13.2 Airworthiness Codes and Standards

1. The TAA-accepted airworthiness design standards and requirements related to materials are listed in Figure 2-13-1 to Figure 2-13-3.

Military Airworthiness Design Standards	
U.S. DoD	
1.	**MIL-HDBK- 516C, Chapter 4, Section 4.3.1,** Selection of Materials
2.	**MIL-HDBK- 516C, Chapter 4, Section 5.3.2,** Materials and Processes
UK MoD DEF STAN 00-970	
1.	Aligned with EASA CS following DEF STAN 00-970 transformation
EDA	
1.	**EMACC Handbook, Section 4.3.1,** Selection of Materials
2.	**EMACC Handbook, Section 5.3.2,** Materials and Processes
3.	**EMACC Handbook, Section 19.1.1,** Material Property Evaluation
4.	**EMACC Handbook, Section 19.1.2,** Material Property Certification

Figure 2-13-1 Military Airworthiness Design Standards Related to Materials

DND/CAF Ratified International Standards	
NATO STANAGs (for Uncrewed Aircraft Systems [UAS] only)	
STANAG 4761/AEP-4671 – UAV System Airworthiness Requirements (USAR)	
1.	**USAR.603,** Materials and Workmanship
2.	**USAR.605,** Fabrication Methods

Figure 2-13-2 (Sheet 1 of 2) DND/CAF Ratified International Standards Related to Materials

DND/CAF Ratified International Standards
3. **USAR.609,** Protection of Structure 4. **USAR.613,** Material Strength Properties and Design Values
STANAG 4703/AEP 83 – Light UAS Airworthiness Requirements 1. **ER.1.1,** Structures and materials
STANAG 4702/AEP 80 – Rotary Wing UAS Airworthiness Requirements 1. **USAR-RW.603,** Materials 2. **USAR-RW.605,** Fabrication Methods 3. **USAR-RW.609,** Protection of Structure 4. **USAR-RW.613,** Material Strength Properties and Design Values
STANAG 4746/AEP 89 – Unmanned Aerial Vehicle (UAV) Systems Airworthiness Requirements (USAR) for Light Vertical Take Off and Landing (VTOL) Aircraft 1. **ER 1.1,** Structures and Materials

Figure 2-13-2 (Sheet 2 of 2) DND/CAF Ratified International Standards Related to Materials

Civil Airworthiness Design Standards
TCCA 1. **AWM 52X.603,** Materials 2. **AWM 52X.605,** Fabrications Methods 3. **AWM 52X.609,** Protection of Structure 4. **AWM 52X.613,** Material Strength Properties and Material Design Values 5. **AWM 533.15,** Materials
FAA 1. **14 CFR 23.2260,** Materials and Processes 2. **14 CFR 2X.603,** Materials 3. **14 CFR 2X.605,** Fabrication Methods 4. **14 CFR 2X.609,** Protection of Structure 5. **14 CFR 2X.613,** Material Strength Properties and Material Design Values 6. **14 CFR 33.13,** Materials
EASA 1. **CS 23.2260,** Materials and Processes 2. **CS 2X.603,** Materials 3. **CS 2X.605,** Fabrications Methods 4. **CS 2X.609,** Protection of Structure 5. **CS 2X.613,** Material Strength Properties and Material Design Values 6. **CS-E 70,** Materials and Manufacturing Methods 7. **CS-E 90,** Prevention of Corrosion and Deterioration

Figure 2-13-3 Civil Airworthiness Design Standards Related to Materials

2. Generally, there is clear commonality among all standards listed in Figure 2-13-1 and Figure 2-13-2 with regards to material requirements (e.g., CS 2X.603 and FAR 2X.603 are harmonized). Typically, a given airworthiness code will state that material suitability must:

a. be established from experience or tests;

b. meet approved specifications to ensure their properties are as assumed in the design data; and

c. consider the environmental effects expected in service.

3. Furthermore, material strength requirements (CS 2X.613, FAR 2X.613, etc.) state that design values must be derived on a statistical basis, as follows:

a. A-Basis (or T99) design values are to be used for critical structure (i.e., non-redundant and for which failure would result in loss of structural integrity). A-basis values assure material strength with 99% probability and 95% confidence;

b. B-basis design values for all other types of structure, assure material strength with 90% probability and 95% confidence;

c. Material specifications for the above data must be acceptable to the regulator. The airworthiness code may list Metallic Materials Properties Development and Standardization (MMPDS), Military Handbooks (MIL-HDBK), or Engineering Science Data Unit (ESDU) 00932 Metallic Materials Data Handbook (MMDH) as the default specification; and

d. Lastly, other design values may be used if a selection of the material is made in which a specimen of each individual item is tested before use, and it is determined that the actual strength properties of that item will equal or exceed those used in design.

4. All standards contain requirements for material fabrication methods (CS 2X.605, FAR 2X.605, etc.) to ensure the properties necessary to produce consistently safe aerospace materials. Some fabrication methods require close control to achieve this objective. All TAA-approved standards require that manufacturing be performed under approved process specifications, and that each new fabrication method be substantiated by a test program that is representative of the application.

5. Finally, all standards require that structure be suitably protected against deterioration or loss of strength due to any cause, including weathering, corrosion, and abrasion (see, for example, CS 2X.609, FAR 2X.609, CS-E 90, etc.). The standard will list underpinning specifications that will enable compliance. For instance, MMPDS gives guidance on environmental considerations related to weather and compatibility with other materials.

2.13.3 Guidance Material

1. Extensive guidance exists to assist applicants to achieve compliance with material and design value requirements, as detailed in Figure 2-13-4:

Guidance Related to Material Requirements and Design Values	
1.	**FAA Advisory Circular (AC) 25.613-1,** Material Strength Properties and Material Design Values
2.	**FAA AC 23-20,** Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems
3.	**FAA AC 20-107B,** Composite Aircraft Structure
4.	**JSSG-2006,** Aircraft Structures
5.	**MIL-STD-1568D,** Materials and Processes for Corrosion Prevention and Control in Aerospace Weapon Systems
6.	**EASA AMC-20,** General Acceptable Means of Compliance for Airworthiness of Products, Parts, and Appliances

Figure 2-13-4 Guidance Related to Material Requirements and Design Values

2.13.4 Material Specifications and Standards

1. Despite the abundance of material specifications available to industry, many are now obsolete and ceased to be maintained. Two new specifications, the MMPDS (North American) and the ESDU MMDH 00932 (European),

have superseded others. TAA-accepted airworthiness codes contain acceptable means of compliance that will direct the applicant to material specifications and standards from either MMPDS or ESDU MMDH. There are some exceptions where legacy standards are still called out.

2. Figure 2-13-5 illustrates the link between the airworthiness code standard/requirement, the guidance material, and the underpinning material specifications and standards. In turn, each Material Specification and Standard (MSS) is supported by process and quality assurance standards (e.g., AMS, ASTM, SAE, etc.).

Region	NAA/MAA	Example Requirement	Guidance Material	MSS
North America	TCCA	52X.603, Materials	AC 25.613, Material Strength/ design values AC 23-20, Polymer Composites AC 20-107B, Composites	MMPDS
	FAA	52X.603, Materials		
	MIL-HDBK-516C	4.3.1, Selection of Materials	JSSG-2006 MIL-STD-1568 MIL-HDBK-1587 CMH-17 ADS-13	
Europe	CSs	CS 52X.603, Materials	AMC-20, Amendment 23	ESDU 00932 MMDH
	EMAAC	5.3.2, Materials and Processes	Guidance contained in EMAAC HDBK	
	DEF STAN 00-970	References out to CS for most requirements	Same as CS's plus: • MMAC • MASAAG Paper 124	

Figure 2-13-5 Airworthiness Code Requirements, Related Guidance and Material Specifications

3. TAA-recognized Material Specifications and Standards are listed in Figure 2-13-6. All the standards listed are actively maintained by the respective standards organization.

TAA-Recognized Extant Material Specifications and Standards
1. **MMPDS-2023,** Metallic Materials Properties Development and Standardization (available within DND at AEPM RDIMS #2271603)
2. **ESDU 00932 MMDH,** Metallic Materials Data Handbook (MMDH)
3. **CMH-17,** Composite Materials Handbook 17
4. **MIL-STD-1568D,** Materials and Processes for Corrosion Prevention and Control in Aerospace Weapons Systems (available on U.S. DoD ASSIST webpage, at: ASSIST-QuickSearch Basic Search)

Figure 2-13-6 Extant Material Specifications and Standards Recognized by the TAA

4. **Material Process Control and Quality Assurance Standards.** Each of the above listed material specifications and standards contain process and quality assurance standards used in the production of aerospace material (e.g., AMS, ASTM, SAE, etc.). Due to their significant number, these subordinate standards cannot be listed in this manual. Applicants should refer directly to the documentation referenced in Figure 2-13-6 for acceptable material production, inspection, testing and quality control standards.

5. **Use of Legacy Material Standards and Specifications.** As stated in Part 1, Chapter 2, due to the constant evolution and amendment of standards and specifications, it is always recommended that the latest standards and versions be used. However, situations may arise where it is impractical to use extant material specifications and standards, particularly when procuring or modifying aircraft designed to legacy standards. While it is true that

some airworthiness requirements (FAR 2X.613, MIL-HDBK-516C) still list cancelled or withdrawn sources of design values, and that even some guidance material may refer to legacy specifications (e.g., AC 25.613 lists MIL-HDBK-5 and -17, which were extant at the time of its publication, in June 2003 but are now cancelled), the applicant should understand any airworthiness delta between those and the extant standards before applying any legacy standards, and consult the TAA to agree on any proposed alternative standard. Figure 2-13-7 provides examples of common legacy standards.

Legacy Material Specifications and Standards	
1.	**MIL-HDBK-5,** Metallic Materials and Elements for Flight Vehicle Structure
	-MMPDS was published as a replacement, concomitant with the publication of MIL-HDBK-5J, on 31 Jan 2003
	-MIL-HDBK-5J is technically equivalent to MMPDS-01
	-MIL-HDBK-5J was cancelled by the USAF in March 2006
	-FAA AC 25.613-1 states that MMPDS data may be used in lieu of MIL-HDBK-5 data
2.	**Air Force-Navy-Commerce (ANC)-18,** Design of Wood Aircraft Structures
	-obsolete, has not been updated since June 1951
3.	**DEFSTAN 00-932,** Metallic Materials Data Handbook
	-withdrawn by UK MAA on 3 May 2020
	-superseded by ESDU 00932 MMDH
4.	**MIL-HDBK-17**
	-superseded by CMH-17 as of 17 Jun 2022
5.	**MIL-HDBK-1568 (USAF)**
	-superseded by MIL-STD-1568D as of 18 Jul 1996
6.	**MIL-HDBK-1587 (USAF)**
	-superseded by MIL-STD-1568D as of 18 Jul 1996

Figure 2-13-7 Legacy Material Specifications and Standards

2.13.5 Certification of New Metallic Materials

1. Existing standardized tests and statistical analysis methods should be used to establish material physical properties and design values for new materials not covered by material specification handbooks. Chapter 9 of the MMPDS specification provides extensive guidance on how new materials are proposed for addition to the Handbook. This guidance is also applicable to the process that the TAA would follow to approve new materials. ESDU 00932 has equivalent requirements and could also be used to successfully qualify new materials.

2. It should be noted that the airworthiness approval of new material is a complex and costly proposition, which requires a minimum of 100-299 coupons to be tested for each static property to be established, depending on the distribution of data achieved. At least 100 coupons are required if the data accords to a three-parameter Weibull distribution or a Pearson Type III distribution. Otherwise, a minimum of 299 samples are required. Furthermore, there are tightly controlled production standards to adhere to, as well as minimum lot number requirements across at least 10 production heats, casts, or melts. The sample population should also include material from differing producers, where available. All the above requirements are necessary to ensure the tested population is representative, and that any material anomalies are captured. Additionally, some materials have differing properties dependant on grain direction and sample thickness, which require further sampling. Elevated temperature curves are derived from testing at given temperatures, typically at 200-300 °F intervals, whereas cryogenic testing is normally conducted at -110 °F, -320 °F, and -423 °F.

3. Within MMPDS, Table 9.2.3. – *Summary of Required Testing Standards* provides a list of all the ASTM tests for material static, elastic, and fatigue properties.

4. Applicants should refer directly to MMPDS for guidance on material process, testing and analysis means to certify new metallic material. TAA specialists should be consulted for assistance with the development of test plans, should the applicant intend to propose other means of qualifying material.

2.13.6 Certification of New Advanced Materials

1. Unlike metallic materials, non-proprietary material specifications for composite materials have not historically been made public. However, the National Center for Advanced Materials Performance (NCAMP) aims to establish a source of non-proprietary material specifications and allowables for composite materials like that available for metallic materials. Currently, NCAMP has published design values for a small selection of advanced materials. Certification of structure utilizing these materials may be streamlined by adopting NCAMP data. NCAMP publishes composite material specifications and related non-proprietary data on the NCAMP webpage under the *Allowables and Specs* heading.

2. NCAMP has evolved from the previously FAA-led Advanced General Aviation Transport Experiments (AGATE). Material qualification methodology and design allowables for certain advanced materials are still published by AGATE and are available on the AGATE Database.

3. Note that design values provided by NCAMP only cover basic lamina and limited laminate data associated with the lower levels of the building block approach shown in Figure 2-13-8 (refer to CMH-17, FAA ACC 20-107B, or EASA AMC-20 for more details on the building block approach).

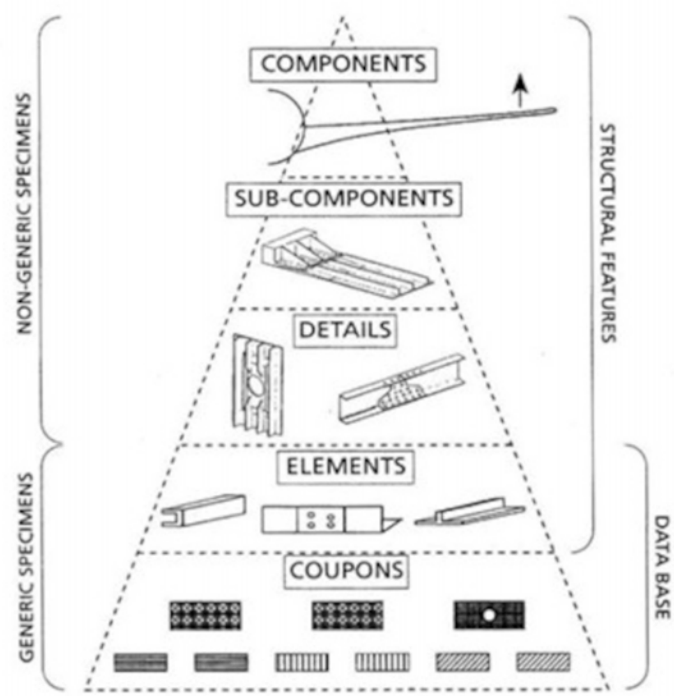

Figure 2-13-8 Schematic Diagram of Building Block Tests for a Fixed Wing (Source: FAA Advisory Circular AC20-107B)

4. Both the FAA and EASA accept composite specification and design values developed using the NCAMP process. The FAA memorandum FAA-AIR-100-2010-120-003 and the EASA Certification memorandum EASA CM-S-004 detail each respective regulator's acceptance of NCAMP processes and data.

5. Use of NCAMP data is acceptable to the TAA and will help alleviate some of the testing requirements for certification of new composite structure.

2.13.7 Novel Technology

1. Novel material processes, such as Additive Manufacturing (AM), have not attracted new airworthiness code requirements. Consequently, existing requirements must be applied to demonstrate the airworthiness of the material produced. In this way, certifying materials produced by novel technology is no different than certifying new materials, as described above. Two useful resources for applicants certifying AM parts have been promulgated by the UK MoD, as per Figure 2-13-9 below. TAA specialists should be consulted for AM certification approaches other than those listed in Figure 2-13-9.

Guidance Related to Additive Manufacturing
UK DoD
1. **Manual of Military Air System Certification (MMAC),** Chapter 7, Novel Technologies, Additive Manufacturing (AM)
2. **MASAAG Paper 124,** Guidance on the Qualification and Certification of Additive Manufactured Parts for Military Aviation

Figure 2-13-9 Guidance Related to Additive Manufacturing

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 1 — FLIGHT INSTRUMENTS, DISPLAYS AND CONTROLS (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 2 — AIRBORNE COMMUNICATION SYSTEMS

3.2.1 Introduction

1. This chapter sets out the certification requirements, standards, as well as means and methods of compliance considered acceptable by the Technical Airworthiness Authority (TAA) for the certification of Airborne Communication Systems used on crewed Department of National Defence (DND)/Canadian Armed Forces (CAF) aircraft.

2. For the purposes of this chapter, Airborne Communication Systems include the following systems, equipment, and their associated capabilities:

a. Aircraft Audio and Intercommunication Subsystems;

b. Very High Frequency (VHF);

c. Ultra High Frequency (UHF);

d. High Frequency (HF);

e. Satellite Communications; and

f. Aircraft Datalink Systems.

3. Program Management Offices (PMO)/Weapon System Managers (WSM), in conjunction with the Directorate Air Requirements (DAR) and the Operational Airworthiness Authority (OAA)/fleet, are responsible for determining the type of airborne communication systems that are operationally required for their aircraft. The operationally required communication equipment is typically divided into three categories:

a. equipment required to comply with airspace regulations and communicate with the appropriate Air Traffic Control (ATC) agency, in accordance with the National Defence Flying Orders (B-GA-100-001/AA-000);

b. equipment required to safely perform air-to-air refueling (when applicable); and

c. equipment required for CAF tactical/mission purposes.

4. This chapter addresses the airworthiness criteria applicable to the first two categories.

5. For aircraft with a civil certification basis, a specific equipage requirement for two-way radio communications systems is currently stated only in the airworthiness certification code for Transport Category Airplanes and Rotorcraft (i.e., 14 CFR, Part 25/29.1307). The requirement does not explicitly state the intended purpose or use of the two-way radio communications system. Historically, the intent of this paragraph has been the requirement to communicate with ATC and other aircraft. As a result, compliance to this requirement has been traditionally achieved by installing VHF radios. The crux of this matter is that a Transport Category Airplane/Rotorcraft may achieve Type Certification by equipping the aircraft with VHF radios only. This in no way implies that, to obtain airworthiness certification from an operational perspective, the Airplane/Rotorcraft only requires VHF Radios, since certain Operational Regulations/Requirements (e.g., operations along the North Atlantic Track system) may require additional equipage.

3.2.2 General

1. The minimum performance standards, advisory and guidance materials identified in this chapter are deemed acceptable by the TAA for the installation and certification of airborne communication systems. While Federal Aviation Administration (FAA) Technical Standard Orders (TSOs) are identified, equivalent Transport Canada, Civil Aviation (TCCA) CAN-TSOs and the European TSOs (ETSOs) of the European Union Aviation Safety Agency

(EASA) are also acceptable. In a few instances, the listed FAA TSOs are followed by an ETSO identified as ETSO-2C (e.g., FAA TSO-C169a/ETSO-2C169a). The rationale behind this pairing is that the FAA Minimum Operational Performance Standards (MOPS) and the EASA ETSO MOPS are not identical, or there is no equivalent FAA TSO.

2. The use of more recent versions of the standards and advisory material is recommended. Earlier versions of the standard or guidance material may be used, provided they are acceptable to the TAA.

3. This chapter supplements the applicable processes of Part 2 of this manual with guidance specific to airborne communication systems. Design changes that introduce or modify these systems must meet their certification basis, as detailed in Part 3, Chapter 2 of the Technical Airworthiness Manual (TAM).

4. The FAA/EASA/TCCA TSO will typically reference an industry standard (e.g., Society of Automotive Engineering SAE document) or Aviation Minimum Operational Performance Specification (e.g., RTCA MOPS or EUROCAE ED specification). When this is the case and a TSO is listed as an acceptable standard, the individual industry standard or aviation MOPS will not be identified separately.

5. The guidance in this chapter is not meant to be all encompassing, it focuses on the electronic aspects associated with the installation of Communication Systems, and its various sections and figures predominately represent those aspects. Naturally, other certification aspects for the equipment and its installation need to be considered (e.g., structural, electrical, lightning, High-Intensity Radiated Fields [HIRF], mechanical mounting, etc.). The certification basis must be assessed to determine what other airworthiness standards and requirements, if any, need to be addressed. This should include the development of a certification plan that clearly identifies the certification basis applicable to the entire installation. Consult the TAM (Part 2, Chapter 1– Initial Airworthiness, or Part 3, Chapter 2 – Design Changes) for further details on defining the certification basis associated with either a new design, or a design change, respectively.

6. The standards identified in the various Figures cover specific subsystem requirements. As such, they should not necessarily be considered as a complete set of standards when certifying subsystem components, or an entire communications system. For example, some datalink systems transmit using a VHF radio, while others use a satellite radio. If a VHF radio is intended for use by a system, then both datalink and VHF radio standards will have to be considered.

7. Although not specifically a technical airworthiness requirement, radiation hazards (RADHAZ) to personnel and combustibles when Radio Frequency emitters are operated on the ground also need to be considered. This is especially important when installing high energy transmitting communications equipment. For additional information, consult Part 2, Chapter 3 of this manual, which references the requirements and guidance on RF survey and survey procedures provided in C-55-040-001/TS-002, *Radio Frequency Safety Standards and Requirements*.

8. When the installed communication systems are used to process classified data, the process detailed in AF9000 procedure EMT09.056 – *EMSEC Security Risk Management for Tactical Air Platforms* of the Director General – Aerospace Equipment Program Management (DGAEPM) needs to be considered. It is recommended that DTAES 8 Subject Matter Experts (SMEs) be consulted early in the certification process.

9. The Human Factors evaluation will require that the Speech Intelligibility Standards contained in ANSI-S3.2 – *Method for Measuring the Intelligibility of Speech over Communications Systems*, be considered. For additional details related to the application of Human Factor aspects to certification projects, Part 2, Chapter 2 of this manual can be consulted.

3.2.3 Aircraft Installation Standards and Guidance

1. The aircraft installation airworthiness standards and guidance listed in Figure 3-2-1, Figure 3-2-2 and Figure 3-2-3 are acceptable for application to DND/CAF airborne communication systems.

NOTE

With respect to Figure 3-2-2, it is beneficial to understand the recent historical changes that 14 CFR Part 23 has undergone. In 2011, the FAA established an Aviation Rulemaking

Committee (ARC) to examine Part 23 airworthiness requirements. The ARC recommended that Part 23 be completely restructured and transition from traditional prescriptive regulations to performance-based regulations, underpinned by consensus standards. Therefore, with the publication of 14 CFR Part 23 amendment 23-64, dated August 30, 2017, the FAA moved from prescriptive-based regulations to performance-based regulations for Part 23 aircraft. EASA and TCCA did the same with the publication of performance-based regulations in EASA CS-23 amendment 5 dated 29 March 2017, and Airworthiness Manual Section 523-18 dated September 21, 2021, respectively. As a result, since the norm in the ADSM is to reference the most recent design standards, 14 CFR Part 23/EASA CS-23/TCCA AWM 523, paragraphs 1301 and 1309, are not included in this figure.

	Military Airworthiness Design Standards Related to Aircraft Installation
1.	**MIL-HDBK-516C, Airworthiness Certification Criteria 516C, Paragraph 8.7.1.5,** Communication system
2.	**MIL-HDBK-516C, Airworthiness Certification Criteria 516C, Paragraph 9.2.7,** Communication system
3.	**MIL-HDBK-516C, Airworthiness Certification Criteria 516C, Paragraph 9.8.3,** Intercom/public address system
4.	**MIL-HDBK-516C, Airworthiness Certification Criteria 516C, Paragraph 11.1.1.4,** Communications subsystem
5.	**MIL-STD-877,** Antenna Subsystems, Airborne, Criteria for Design and Location Of
6.	**MIL-STD-1472,** Human Engineering

Figure 3-2-1 Military Airworthiness Design Standards Related to Aircraft Installation

	Civil Airworthiness Design Standards Related to Aircraft Installation
1.	**14 CFR Part 25/27/29 / CS-25/27/29 / TCCA Airworthiness Manual Section 525/527/529,** 1301 Function and Installation
2.	**14 CFR Part 25/29 / CS-25/29 / TCCA Airworthiness Manual Section 525/529,** 1307 Airworthiness Standards: Miscellaneous Equipment
3.	**14 CFR Part 25/27/29 / CS-25/27/29 / TCCA Airworthiness Manual Section 525/527/529,** 1309 Equipment, Systems and Installation
4.	**14 CFR Part 25 / CS-25 / TCCA Airworthiness Manual Section 525,** 1423 Passenger Address
5.	**14 CFR Part 25/29 / CS-25/29 / TCCA Airworthiness Manual Section 525/529,** 1431 Electronic Equipment
6.	**14 CFR Part 23 / CS-23 / TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level System Requirements
7.	**14 CFR Part 23 / CS-23 / TCCA Airworthiness Manual Section 523,** 2505 Function and Installation
8.	**14 CFR Part 23 / CS-23 / TCCA Airworthiness Manual Section 523,** 2510 Equipment systems and installation

Figure 3-2-2 Civil Airworthiness Design Standards Related to Aircraft Installation

	Civil Advisory Circulars Related to Aircraft Installation
1.	**FAA AC 23-8C,** Flight Test Guide for Certification of Part 23 Airplanes
2.	**FAA AC 23 17C,** Systems and Equipment Guide for Certification of Part 23 Airplanes
3.	**FAA AC 23.1309-1E,** Equipment, Systems and Installations in Part 23 Aircraft
4.	**FAA AC 25 7D,** Flight Test Guide for Certification of Transport Category Airplanes
5.	**FAA AC 25.1309-1A,** System Design and Analysis

Figure 3-2-3 (Sheet 1 of 2) Civil Advisory Circulars Related to Aircraft Installation

Civil Advisory Circulars Related to Aircraft Installation	
6.	**FAA AC 27-1B,** Certification of Normal Category Rotorcraft
7.	**FAA AC 29-2C,** Certification of Transport Category Rotorcraft
8.	**EASA CS-ACNS Issue 4,** Certification Specification and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance
9.	**EASA AMC-20 Amendment 23,** General Acceptable Means of Compliance for Airworthiness of Products, Parts and Appliances (Specifically AMC sections: 20-9 and 20-10)

Figure 3-2-3 (Sheet 2 of 2) Civil Advisory Circulars Related to Aircraft Installation

3.2.4 Radio Licensing and Frequency Spectrum Management

1. Radio licensing and frequency spectrum management policies need to be considered during the planning and acquisition phases of a communication system project. The primary concerns are proper licencing, as well as the safe operation of the air vehicle while using the air-to-air and air-to-ground communication systems.

2. RCAF radio equipment must be licensed by DND's Frequency Spectrum Management (DFSM) through delegated authority from the Assistant Deputy Minister (ADM) Information Management (IM) Director General Information Management Operations (DGIMO), in compliance with the *Canadian Radio Communications Act*.

3. Frequency spectrum management enquires should be directed to ADM(IM) DFSM. Details and contact information about DFSM can be found internally, within DND, at: http://admim-smagi.mil.ca/en/it-services/radio-spectrum-space/spectrum.page.

4. DFSM's policy, standards for spectrum management, and instructions for obtaining spectrum supportability, licencing and frequency assignments for DND/CAF radio-frequency emitters are published in CFTO B-GT-D35-001/AG-000, *Management of the Radio Frequency Spectrum*. This publication is also referred to as DNDP35, and is available internally, within DND, at: http://admim-smagi.mil.ca/en/it-services/radio-spectrum-space/spectrum-management/dndp-35.page.

3.2.5 Aircraft Audio and Intercommunication Subsystems

1. The aircraft audio and intercommunications subsystems (i.e., microphones, headsets and intercoms) are used to improve the quality of speech transmissions, audio response and overall intelligibility of voice communications between aircrew, aircraft and ground stations. The military airworthiness design standards and the civil airworthiness design standards are identified in Figure 3-2-4 and Figure 3-2-5, respectively.

2. While certain manufacturers of headsets/helmets have obtained a TSO for their equipment, there is no specific technical airworthiness or operational requirement for headsets and/or helmets to be issued a TSO. The decision on whether or not procured headset/helmets need to have a TSO authorization is left to the PMO/WSM, in conjunction with DAR and the OAA/fleet.

Military Airworthiness Design Standards Related to Passenger Address Systems	
1.	**MIL-HDBK-173,** Audio Equipment

Figure 3-2-4 Military Airworthiness Design Standards Related to Passenger Address Systems

Civil Airworthiness Design Standards Related to Aircraft Audio and Intercommunications Systems and Equipment	
1.	**TSO C139a,** Aircraft Audio Systems and Equipment

Figure 3-2-5 (Sheet 1 of 2) Civil Airworthiness Design Standards Related to Aircraft Audio and Intercommunications Systems and Equipment

	Civil Airworthiness Design Standards Related to Aircraft Audio and Intercommunications Systems and Equipment
2.	**14 CFR Part 25.1423,** Airworthiness Standards: Transport Category Airplanes – Public Address System

Figure 3-2-5 (Sheet 2 of 2) Civil Airworthiness Design Standards Related to Aircraft Audio and Intercommunications Systems and Equipment

3.2.6 VHF Communication Subsystems

1. VHF communication systems for ATC purposes are capable of transmitting and receiving within the frequency range of 117.975 – 137.000 MHz. The civil airworthiness design standards related to this type of communication subsystems are identified in Figure 3-2-6.

2. For other applications, such as the communication requirements associated with the support of ground tactical forces, or interoperability with the North Atlantic Treaty Organization (NATO) and/or allies, the WSM/PMO should consider the following non-exhaustive list of documents: MIL-STD-188-200, *System Design and Engineering Standard*, MIL-STD-188-242, *Interoperability and Performance Standards for Tactical Single Channel Very High Frequency*, NATO STANAG 4204, *Technical Standards for Single Channel VHF Radio Equipment* and Air Standard ASCC 70/3, *Interoperability of Aircraft VHFAM and/or FM Multi-Frequency Transceiver Installations and Compatible Ground Radio Equipments*.

	Civil Airworthiness Design Standards Related to VHF Communication Systems and Equipment
1.	**TSO-C169a/ETSO-2C169a,** VHF Radio Communications Transceiver Equipment Operating within Radio Frequency Range 117.975 to 137.000 Megahertz
2.	**TSO-C160a,** VHF Data Link (VDL) Mode 2 Communication Equipment
3.	**TSO-C163a,** VHF Data Link (VDL) Mode 3 Communications equipment operating within the Frequency Range 117.975 -137.000 MHz
4.	**TSO-C128a/ETSO-2C128,** Minimum Operational Performance Standards for Devices that prevent Blocked Channels Used in Two-way Radio Communications Due to Unintentional Transmissions

Figure 3-2-6 Civil Airworthiness Design Standards Related to VHF Communication Systems and Equipment

3.2.7 UHF Communications Subsystems

1. UHF communications systems are capable of transmitting and receiving within the 225 MHz to 400 MHz frequency band. There are no civil airworthiness design standards specific to this equipment. Nevertheless, when a UHF communication system is installed and used for communications with the appropriate ATC agency, in accordance with the National Defence Flying Orders (B-GA-100-001/AA-000), or for air-to-air refueling, the UHF communication system cannot be considered Mission Equipment. As such, the certification strategy will need to address the intended function of the equipment, the associated failure modes and associated hazards, the proposed equipment level testing, as well as ground and airborne testing appropriate to the intended function. Otherwise, if the UHF equipment is only intended for military use, it can be considered as Mission Equipment and dealt with in accordance with TAA Advisory 2006-04 – Installation of Miscellaneous Non-Required Equipment. In case of doubt about whether the UHF communication system may be considered as Mission Equipment, the OAA and 1 Cdn Air Div will make the final decision, which must be documented in the Certification Plan.

2. The military design standards are identified in Figure 3-2-7. Typically, the radio capabilities and design criteria are identified in a Performance Description Document.

3. For other applications, such as the communication requirements associated with the support of ground tactical forces or interoperability with NATO and/or allies, the WSM/PMO should consider the following non-exhaustive list of documents: MIL-STD-188-200, *Quadripartite Standardization Agreement (QSTAG) 667 – Aircraft Communications Radio Set, UHF-AM* and Air Standard ASCC 70/4, *Interoperability of Aircraft Uhf Multi-Frequency Transceiver Installation and Compatible Ground Transmitters and Receivers*.

Military Airworthiness Design Standards Related to UHF Systems and Equipment	
1.	**STANAG 4205,** Technical Standards for Single Channel UHF Radio
2.	**STANAG 4246,** Communications Equipment Have Quick UHF Secure and Jam Resistant

Figure 3-2-7 Military Airworthiness Design Standards Related to UHF Systems and Equipment

3.2.8 HF Communication Subsystem

1. Airborne High Frequency (HF) communication systems for ATC purposes are capable of transmitting and receiving within the 1.5 MHz to 30 MHz radio frequency band. A Selective Calling (SELCAL) System may be used to provide visual and aural annunciation of a radio call intended for the aircraft. The SELCAL system is designed to operate with existing High Frequency (HF) and Very High Frequency (VHF) ground-to-air transmitters and receivers. However, for the most part, SELCAL is used in conjunction with HF radios due to the intrinsic background noise associated with HF radios. Monitoring the HF frequencies under these conditions would result in increased crew fatigue. The military standards and the civil airworthiness design standards specific to this equipment are identified in Figure 3-2-8 and Figure 3-2-9, respectively.

2. For other applications, such as the communication requirements associated with the support of ground tactical forces, or interoperability with NATO and/or allies, the WSM/PM should consider the following non-exhaustive list of documents: Air Standard ASCC 70/20, NATO STANAG 748, and MIL-STD-188-141/148/200/721.

Military Airworthiness Design Standards Related to HF Systems and Equipment	
1.	**STANAG 4203,** Technical Standards for Single Channel HF Radio

Figure 3-2-8 Military Airworthiness Design Standards Related to HF Systems and Equipment

Civil Airworthiness Standards Related to HF Systems and Equipment	
1.	**TSO-C59b,** Airborne Selective Calling (SELCAL) Equipment
2.	**TSO-C170,** High Frequency (HF) Radio Communications Transceiver Equipment Operating within the Radio Frequency Range 1.5 To 30 Megahertz
3.	**TSO-C158,** HF Data Link

Figure 3-2-9 Civil Airworthiness Design Standards Related to HF Systems and Equipment

3.2.9 Satellite Communication

1. The acceptable civil airworthiness design standards for airborne Satellite Voice (SATVOICE) systems supporting Air Traffic Services are identified in Figure 3-2-10.

2. The ICAO designation for two-way communications via satellite pertaining to the safety and regularity of flight along national and international civil air routes is Aeronautical Mobile-Satellite (R) Service (AMS[R]S).

3. TSO-C132b identifies the MOPS associated with Aeronautical Mobile Satellite Services (AMSS) avionics utilizing services provided by near-Geosynchronous Orbit (GEO). TSO-C159e identifies the MOPS associated with AMSS avionics utilizing services provided by satellite constellations characterized by their orbital parameters, as follows: Low-Earth Orbit (LEO); Medium-Earth Orbit (MEO), High-Earth Orbit (HEO) and near-Geosynchronous Orbit (GEO). The INMARSAT satellite constellation consists of GEO satellites. The Iridium satellite constellation consist of LEO satellites.

4. The different satellite constellations (e.g., INMARSAT versus Iridium) provide differing levels of service and cost. For example, Iridium provides complete coverage of the earth, while INMARSAT does not provide coverage at far northern/southern latitudes. The decision on which service to procure is an operational decision that needs to be made by the PMO/WSM, in consultation with DAR, the OAA and respective fleet. For example, for operations

in the Northern Domestic Airspace and Polar Region, specific guidance is provided for the certification of aircraft systems in TAA Advisory 2017-02.

5. For other applications, such as the communication requirements associated with the support of NATO operations and/or interoperability with allies, the WSM/PMO should consider the applicability of the NATO STANAG 4232, *Digital Interoperability Between SHF Tactical Satellite Communications Terminals Requirements*.

	Civil Airworthiness Design Standards Related to Satellite Communication Systems and Equipment
1.	**AC 20-150B,** Airworthiness Approval of Satellite Voice (SATVOICE) Equipment Supporting Air Traffic Service (ATS) Communication
2.	**TSO-C132b,** Minimum Operational Performance Standards for Geosynchronous Orbit Aeronautical Mobile Satellite Services (AMSS) Avionics
3.	**TSO-C159e,** Next Generation Satellite Systems (NGSS) Equipment

Figure 3-2-10 Civil Airworthiness Design Standards Related to Satellite Communication Systems and Equipment

3.2.10 Aircraft Datalink Systems

1. The acceptable civil airworthiness design standards for design approval of aircraft communications systems used for air traffic services data communications are identified in Figure 3-2-11.

2. Datalink content can be routed through different sub-networks, such as VHF, HF radio and/or the SATCOM system. Guidance specific to each sub-network type has been provided in the relevant sections of this chapter (e.g., 3.2.6 for VHF datalink systems).

3. For requirements associated with the recording of Data Link transmissions, consult Part 3, Chapter 6 – *Crash Data Recorders and Emergency Locator Transmitters*.

4. Although operational in nature, FAA AC 90-117 – *Data Link Communications* provides excellent background information, which helps to improve understanding of Datalink systems and equipment.

	Civil Airworthiness Design Standards Related to Datalink Systems and Equipment
1.	**AC 20-140C,** Guidelines for Design Approval of Aircraft Data Link Communication Systems Supporting Air Traffic Services (ATS)
2.	**AC 20-160A,** Onboard Recording of Controller Pilot Data Link Communication in Crash Survivable Memory
3.	**EASA CS-ACNS, Issue 4, Subpart B, Section 2,**Data Link Services (DLS)
4.	**EASA AMC 20-9,** Acceptable Means of Compliance for the Approval of Departure Clearance via Data Communications over ACARS
5.	**EASA AMC 20-10,** Acceptable Means of Compliance for the Approval of Digital ATIS via Datalink over ACARS
6.	**ARINC 619,** ACARS Protocols for Avionics End Systems
7.	**ARINC 622,** ATS Data Link Applications Over ACARS Air-Ground Network
8.	**ARINC 724,** Mark 2 Aircraft Communication Addressing and Reporting Systems (ACARS)

Figure 3-2-11 Civil Airworthiness Design Standards Related to Satellite Communication Systems and Equipment

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 3 — AIRCRAFT NAVIGATION SYSTEMS

3.3.1 Introduction

1. This chapter sets out the certification requirements, standards, as well as means and methods of compliance considered acceptable by the Technical Airworthiness Authority (TAA) for the certification of navigation systems and navigation capabilities used on crewed Department of National Defence (DND)/Canadian Armed Forces (CAF) aircraft.

2. For the purposes of this chapter, Aircraft Navigation Systems include the following equipment and/or systems:

a. Automatic Direction Finder (ADF);

b. VHF Omnidirectional Range/Distance Measuring Equipment (VOR/DME);

c. Instrument Landing System (ILS);

d. Tactical Air Navigation System (TACAN);

e. Doppler Navigation System (DNS);

f. Radar Altimeter (RadAlt);

g. Attitude Heading and Reference System (AHRS);

h. Inertial Navigation System (INS);

i. Global Navigation Satellite System (GNSS); and

j. Flight Management Systems (FMS).

3. In addition, this chapter identifies the airworthiness design standards that the TAA has adopted for the certification of the following navigation-associated functions and capabilities:

a. Navigation Databases (NavDB);

b. Required Navigation Performance Capability (RNPC);

c. Performance Based Navigation (PBN); and

d. Reduced Vertical Separation Minimal (RVSM).

4. Program Management Offices (PMO)/Weapon System Managers (WSM), in conjunction with the Directorate Air Requirements (DAR) and the Operational Airworthiness Authority (OAA)/fleet, are responsible for determining the type of aircraft navigation systems, functionality and/or capabilities that are operationally required for their respective fleets.

3.3.2 General

1. The minimum performance standards, advisory and guidance materials identified in this chapter are deemed acceptable by the TAA for the installation and certification of aircraft navigation systems. While Federal Aviation Administration (FAA) Technical Standard Orders (TSOs) are identified, equivalent Transport Canada Civil Aviation (TCCA) CAN-TSOs and the European TSOs (ETSOs) of the European Union Aviation Safety Agency (EASA) are also acceptable. In a few instances, the listed FAA TSOs are followed by an ETSO identified as ETSO-2C (e.g., FAA

TSO-C41d/ETSO-2C41d). The rationale behind this pairing is that the FAA Minimum Operational Performance Standards (MOPS) and the EASA ETSO MOPS are not identical, or there is no equivalent FAA TSO.

2. The ADSM has been developed under the expectation that the standards and advisory material provided in each chapter will be used to certify new designs, i.e., either a new aircraft type design or a major design change to an existing DND/CAF fleet. The use of more recent versions of the standards or advisory material that may have become available after this version of the ADSM has been published is recommended and may, at times, even be required if the more recent material addresses a newer functionality that was not addressed by the previous material. Earlier versions of those standards or guidance material may be used, provided they are acceptable to the TAA.

3. This chapter supplements the applicable processes of Part 2 of this manual with guidance specific to aircraft navigation systems. Design changes that introduce or modify these systems must meet the requirements of their certification basis, as detailed in Part 3, Chapter 2 of the Technical Airworthiness Manual (TAM).

4. The FAA/EASA/TCCA TSO will typically reference an industry standard (e.g., Society of Automotive Engineering SAE document) or aviation Minimum Operational Performance Specification (e.g., RTCA MOPS or EUROCAE ED specification). When this is the case, and a TSO is listed as an acceptable standard, the individual industry standard or aviation MOPS will not be identified separately.

5. The guidance in this chapter is not meant to be all-encompassing, and it focuses on the electronic aspects associated with the installation of Navigation Systems; its various sections and figures predominately represent those aspects. Naturally, other certification aspects for the equipment and its installation need to be considered (e.g., structural, electrical, lightning, High-Intensity Radiated Fields [HIRF], mechanical mounting, etc.). The certification basis must be assessed to determine what other airworthiness standards and requirements, if any, need to be addressed. This should include the development of a certification plan that clearly identifies the certification basis applicable to the entire installation. Consult the TAM (Part 2, Chapter 1 – *Initial Airworthiness*, or Part 3, Chapter 2 – *Design Changes*) for further details on defining the certification basis associated with either a new design, or a design change, respectively.

6. Although not specifically a technical airworthiness requirement, radiation hazards (RADHAZ) to personnel, ordinance, and combustibles, when Radio Frequency emitters are operated on the ground, also need to be considered. This type of hazard may need to be considered when installing transmitting navigation equipment (e.g., Radio Altimeters, Doppler Radar, etc.). For additional information, consult Part 2, Chapter 3 of this manual, which references the requirements and guidance on RF survey and survey procedures provided in C-55-040-001/TS-002 – *Radio Frequency Safety Standards and Requirements*.

3.3.3 Aircraft Installation Standards and Guidance

1. The aircraft installation airworthiness standards and guidance listed in Figure 3-3-1, Figure 3-3-2 and Figure 3-3-3 are acceptable for application to DND/CAF aircraft navigation systems.

NOTE

With respect to Figure 3-3-2, it is beneficial to understand the recent historical changes that 14 CFR Part 23 has undergone. In 2011, the FAA established an Aviation Rulemaking committee (ARC) to examine Part 23 airworthiness requirements. The ARC recommended that Part 23 be completely restructured, and a transition be undertaken from traditional prescriptive regulations to performance-based regulations, underpinned by consensus standards. Therefore, with the publication of 14 CFR Part 23 amendment 23-64, dated August 30, 2017, the FAA moved from prescriptive-based regulations to performance-based regulations for Part 23 aircraft. EASA and TCCA did the same with the publication of performance-based regulations in EASA CS-23 amendment 5 dated 29 March 2017, and Airworthiness Manual (AWM) Section 523-18 dated September 21, 2021, respectively. As a result, since the norm in the ADSM is to reference the most recent design standards, 14 CFR Part 23/EASA CS-23/TCCA AWM 523, paragraphs 1301 and 1309, are not included in this figure.

Military Airworthiness Design Standards Related to Aircraft Installation	
1.	**MIL-HDBK-516C, Airworthiness Certification Criteria 516C, Paragraph 11.1.1.5,** Navigation subsystem
2.	**European Military Airworthiness Certification Criteria (EMACC) Handbook, Paragraph 11.1,** Avionics Architecture

Figure 3-3-1 Military Airworthiness Design Standards Related to Aircraft Installation

Civil Airworthiness Design Standards Related to Aircraft Installation	
1.	**14 CFR Part 25/27/29/CS-25/27/29 /TCCA Airworthiness Manual Section 525/527/529,** 1301 Function and Installation
2.	**14 CFR Part 25/CS-25/TCCA Airworthiness Manual Section 525,** 1307(e) Miscellaneous Equipment
3.	**14 CFR Part 25/27/29/CS-25/27/29/TCCA Airworthiness Manual Section 525/527/529,** 1309 Equipment, Systems and Installation
4.	**14 CFR Part 25/29/CS-25/29/TCCA Airworthiness Manual Section 525/529,** 1431 Electronic Equipment
5.	**14 CFR Part 23/CS-23/TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level System Requirements
6.	**14 CFR Part 23/CS-23/TCCA Airworthiness Manual Section 523,** 2505 Function and Installation
7.	**14 CFR Part 23/CS-23/TCCA Airworthiness Manual Section 523,** 2510 Equipment systems and installation

Figure 3-3-2 Civil Airworthiness Design Standards related to Aircraft Installation

Civil Advisory Circulars Related to Aircraft Installation	
1.	**FAA AC 23-8C,** Flight Test Guide for Certification of Part 23 Airplanes
2.	**FAA AC 23-17C,** Systems and Equipment Guide for Certification of Part 23 Airplanes
3.	**FAA AC 23.1309-1E,** Equipment, Systems and Installations in Part 23 Aircraft
4.	**FAA AC 25-7D,** Flight Test Guide for Certification of Transport Category Airplanes
5.	**FAA AC 25.1309-1A,** System Design and Analysis
6.	**FAA AC 27-1B,** Certification of Normal Category Rotorcraft
7.	**FAA AC 29-2C,** Certification of Transport Category Rotorcraft
8.	**EASA CS-ACNS Issue 4,** Certification Specification and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance

Figure 3-3-3 Civil Advisory Circulars Related to Aircraft Installation

3.3.4 Radio Licensing and Frequency Spectrum Management

1. Radio licensing and frequency spectrum management policies need to be considered during the planning and acquisition phases of a navigation system project. The primary concerns are proper licencing and the safe operation of the air vehicle.

2. RCAF radio equipment must be licensed by DND's Frequency Spectrum Management (DFSM) through delegated authority from the Assistant Deputy Minister (ADM) Information Management (IM)/Director General Information Management Operations (DGIMO), in compliance with the *Canadian Radio Communications Act*.

3. Frequency spectrum management enquiries should be directed to ADM(IM) DFSM. Details and contact information about DFSM can be found internally, within DND, at: http://admim-smagi.mil.ca/en/it-services/radio-spectrum-space/spectrum.page.

4. DFSM's policy, standards for spectrum management, and instructions for obtaining spectrum supportability, licencing and frequency assignments for DND/CAF radio-frequency emitters are published in CFTO B-GT-D-35-001/AG-000, *DNDP 35 Management of the Radio Frequency Spectrum*. This publication is also referred to as DNDP 35, and is available internally, within DND, at: http://admim-smagi.mil.ca/en/it-services/radio-spectrum-space/spectrum-management/dndp-35.page.

3.3.5 Military Aircraft as 'State Aircraft'

1. Aircraft on a military register, or identified as such within a civil register and used in the military service, are considered State Aircraft, with the requirement to operate with 'due regard'.

2. The Convention on International Civil Aviation, Part 1, Article III of ICAO Doc 7300, details the military exemption from ICAO regulations. Even though exempted, military aircraft are required to operate with 'due regard' to maintain the safety of navigation of civilian aircraft while exempt aircraft are engaged in military operations.

3. The navigation system design standards and certification requirements identified as acceptable to the TAA have been selected to meet the 'due regard' criteria.

4. GPH 204A is DND's Flight Planning and Procedures publication for Canada and North Atlantic. GPH 204A provides the operational requirements related to meeting the 'due regard' criteria.

3.3.6 Link to Operational Requirements

1. Many of the requirements to equip with specific aircraft navigation equipment can be linked to operational requirements, which are published on the Division Instrument Check Pilot (DICP) Website (available only internally, within DND, on the Defence Wide Area Network [DWAN]). These documents include the RCAF Flight Ops Manual and B-GA-100-001/AA-000 – *National Defence Flying Orders*. The website also includes links to other useful operational documents, such as the Manual of Instrument Flying A-GA-148-001/AG-000 which includes flight crew-based information on the theory of operation associated with individual items of avionic equipment.

3.3.7 Automatic Direction Finder (ADF)

1. The ADF and Non-Directional Beacon (NDB) navigation system works based on a ground-based radio transmitter (the NDB) emitting an omnidirectional signal that is received by an aircraft directional antenna. The result is a cockpit instrument (the ADF) that displays the aircraft bearing relative to a NDB station, allowing a pilot to "home" to a station or track a course from a station.

2. The TAA-accepted design standards for ADF systems are shown in Figure 3-3-4.

	Civil Airworthiness Design Standards Related to Automatic Direction Finder (ADF) Equipment
1.	**FAA TSO C41d/ETSO-2C41d,** Airborne Automatic Direction Finding (ADF) Equipment

Figure 3-3-4 Civil Airworthiness Design Standards Related to Automatic Direction Finder Equipment

3.3.8 VHF Omnidirectional Range/Distance Measuring Equipment (VOR/DME)

1. VOR/DME refers to a combined radio navigation station for aircraft, which consists of two units placed together: a VHF Omnidirectional Range (VOR) receiver and Distance Measuring Equipment (DME) transceiver. The VOR identifies which radial the aircraft is located on, while the DME indicates the slant distance to the ground-based station. Together, they provide the two measurements needed to produce a navigational "fix". It should be noted that aircraft can be equipped with one or more VORs, only DME equipment or a combination of both.

2. The aircraft VOR installation will normally consist of:

   a. receiving antennae and electronic equipment;

   b. VOR control head; and

c. VOR navigation display.

3. The aircraft DME installation will normally consist of:

a. a combined receive/transmit antenna;

b. DME control head; and

c. DME distance, groundspeed and time display.

4. Modern avionics may integrate the control and display of VOR and DME information within an FMS and associated Primary Flight Displays (PFD), respectively.

5. The TAA-accepted design standards for VOR/DME systems are shown in Figure 3-3-5.

Civil Airworthiness Design Standards Related to VOR/DME Equipment	
1.	**FAA TSO C40c/ETSO-2C41d,** VOR Receiving Equipment Operating Within the Radio Frequency Range of 108 to 117.95 MHz
2.	**RTCA DO 176,** FM Broadcast Interference Related to Airborne ILS, VOR and VHF Communications
3.	**FAA TSO C66c/ETSO-2C66b,** Distance Measuring Equipment Operating Within the Radio Frequency Range of 960 to 1215 MHz

Figure 3-3-5 Civil Airworthiness Design Standards Related to VOR/DME Equipment

3.3.9 Instrument Landing System (ILS)

1. An ILS operates as a ground-based instrument approach system that provides precision lateral and vertical guidance to an aircraft approaching and landing on a runway. An aircraft ILS installation will normally consist of:

a. receivers and antennae for localizer, glide path and marker beacon signals;

b. cockpit displays for localizer and glide path steering signals; and

c. marker beacon lights.

2. The TAA-accepted design standards for ILS systems are shown in Figure 3-3-6.

Civil Airworthiness Design Standards Related to ILS Equipment	
1.	**FAA TSO C34e/ETSO-2C34f,** ILS Glide Slope Receiving Equipment Operating Within the Radio Frequency Range of 328.6 to 335.4 MHz
2.	**FAA TSO C35d/ETSO-2C25d,** Airborne Marker Beacon Receiving Equipment
3.	**FAA TSO-C36e/ETSO-2C36f,** Airborne ILS Localizer Receiving equipment Operating Within the Radio frequency range 108 to 112 MHz

Figure 3-3-6 Civil Airworthiness Design Standards Related to ILS Equipment

3.3.10 Tactical Air Navigation (TACAN)

1. The TACAN system is a UHF omnidirectional navigation aid that provides continuous azimuth information in degrees from the station, slant range distance information up to 200 NM from the station. An aircraft installation will normally consist of a TACAN antenna, transceiver/control and display.

2. The TAA-accepted design standards for TACAN systems are shown in Figure 3-3-7.

Military Airworthiness Design Standards Related to TACAN Equipment
1. **MIL-STD-291C,** Standard Tactical Air Navigation Signal

Figure 3-3-7 Military Airworthiness Design Standards Related to TACAN Equipment

3.3.11 Doppler Navigation System (DNS)

1. A DNS is a self-contained dead reckoning system that requires no external inputs or references from ground stations. The DNS can provide an accurate measurement of the aircraft's drift and ground speed. An aircraft DNS installation will normally consist of:

a. receiver/transmitter;

b. control head;

c. display; and

d. antennae.

2. The TAA-accepted design standards for DNSs are shown in Figure 3-3-8.

Civil Airworthiness Design Standards Related to DNS
1. **FAA TSO-C65a,** Airborne Doppler Radar Ground Speed and/or Drift Angle Measuring Equipment (for Air Carrier Aircraft)

Figure 3-3-8 Civil Airworthiness Design Standards Related to DNS

3.3.12 Radar Altimeter (RadAlt)

1. A RadAlt provides the distance between the antenna and the ground directly below it, in contrast to a barometric altimeter, which provides the distance above a defined datum, usually mean sea level. Radar altimeters are an essential part of CAT II ILS and ground proximity warning systems (GPWS), warning the pilot if the aircraft is flying too low or descending too quickly. An aircraft radar altimeter installation will normally consist of:

a. receiver/transmitter/antennae;

b. control head; and

c. display.

2. The TAA-accepted design standards for radar altimeter systems are shown in Figure 3-3-9.

NOTE

Portions of the C-Band telecommunications spectrum have recently been auctioned off for cellular use. Cellular usage in these newly allocated portions of the spectrum has caused radio frequency interference with aircraft Radar Altimeters. The FAA and RTCA are currently in the process of developing a new Radar Altimeter RTCA Minimum Operational Performance Specification to address this interference. In the interim, DTAES 6-2 should be approached to discuss interference concerns, and DTAES 6-4 for equipage selection issues.

Civil Airworthiness Design Standards Related to RadAlt Systems
1. **FAA TSO-C87a,** Airborne Low-Range Radio Altimeter

Figure 3-3-9 Civil Airworthiness Design Standards Related to RadAlt Systems

3.3.13 Attitude and Heading Reference System (AHRS)

1. An AHRS provides attitude and heading information to flight crew. Although not specifically a navigation system in and of itself, the information provided by the AHRS is required to support many navigation functions found on most modern aircraft. A typical aircraft AHRS installation would consist of:

   a. inertial sensing unit which includes angular rate sensors, accelerometers and/or inclinometers;

   b. electronics that process the sensor data into a useable format; and

   c. a magnetic sensing unit.

2. Operational regulations require a means of establishing direction that is not dependent on a magnetic source when operating within the Northern Domestic Airspace (NDA). Consult TAA Advisory 2017-02 – Requirements for Navigation in Northern Domestic Airspace and Polar Regions – which addresses the technical airworthiness approval requirements for navigation equipment used in the NDA during night and Instrument Flight Rules (IFR) operations.

3. The TAA accepted design standards for attitude and heading reference systems are shown in Figure 3-3-10.

Civil Airworthiness Design Standards Related to AHRSs	
1.	**FAA AC 20-181 with Change 2,** Airworthiness Approval of Attitude Heading Reference System Equipment
2.	**FAA TSO-C201,** Attitude and Heading Reference Systems (AHRS)
3.	**ARINC 705,** Attitude Reference and Heading System

Figure 3-3-10 Civil Airworthiness Design Standards Related to AHRSs

3.3.14 Inertial Navigation Systems (INS)

1. An INS is a navigation aid that uses a computer, motion sensors, rotation sensors and, occasionally, magnetic sensors to continuously calculate the acceleration, velocity, position and the orientation of a moving object without the need for external references. An aircraft INS installation will normally consist of:

   a. inertial sensor platform and processor; and

   b. Control Display Unit (CDU).

2. The TAA-accepted design standards for civil and military INSs are shown in Figure 3-3-11 and Figure 3-3-12, respectively.

Civil Airworthiness Design Standards Related to INSs	
1.	**FAA AC 20-138D with Change 2,** Airworthiness Approval of Positioning and Navigation Systems
2.	**ARINC 704A,** Inertial Reference System
3.	**ARINC 738A with Supplement 1,** Air Data and Inertial Reference Systems

Figure 3-3-11 Civil Airworthiness Design Standards Related to INSs

Military Airworthiness Design Standards Related to INSs	
1.	**SNU 84-1 Specification for USAF,** Standard Medium Accuracy Inertial Navigation Unit
2.	**MIL-N-85516A (AS),** Navigation Set, Inertial AN/ASN-130A, Aircraft

Figure 3-3-12 Military Airworthiness Design Standards Related to INSs

3.3.15 Global Navigation Satellite System (GNSS)

1. GNSS is ICAO's terminology for a space-based satellite navigation system used to pinpoint the geographic location of a user's receiver anywhere in the world. There are a number of countries that operate GNSSs in accordance with the ICAO Annex 10 requirement in support of civil aviation operations. For example, the United States operate the NAVSTAR Global Positioning System (GPS) while the European Space Agency operates Galileo GNSS and the Russian Federation operates the GLONASS GNSS. There are other countries that have, or are in the process of implementing, ICAO-compliant GNSS systems.

2. Generally, a GNSS has three parts:

   a. Space Segment/GNSS Satellites;

   b. Control Segment/Ground Based Control Stations; and

   c. User Segment/GNSS Receiver Units.

3. Three main types of receivers exist for aviation use:

   a. portable GPS Units;

   b. stand-alone Panel-Mounted GPS; and

   c. GNSS receivers that provide navigational data for use by other systems (e.g., Flight Management Systems [FMS]).

4. The TAA-accepted design standards for civil and military GNSS receivers are shown in Figure 3-3-13 and Figure 3-3-14, respectively.

	Civil Airworthiness Design Standards Related to GNSS (including embedded GPS Receivers)
1.	**FAA AC 20-138D with Change 2,** Airworthiness Approval of Positioning and Navigation Systems
2.	**EASA CS-ACNS Issue 4,** Certification Specification - Airborne Communications, Navigation and Surveillance
3.	**FAA TSO-C129a,** Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
4.	**FAA TSO-C145e,** Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite Based Augmentation System
5.	**FAA TSO-C146e,** Stand-alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite Based Augmentation System
6.	**FAA TSO-C144a,** Airborne Global Positioning System Antenna
7.	**FAA TSO-C161b,** Ground Based Augmentation System Positioning and Navigation Equipment
8.	**FAA TSO-C190,** Active Airborne Global Navigation Satellite System (GNSS) Antenna
9.	**FAA TSO-C196b,** Airborne Supplemental Navigation Sensors for GPS Equipment Using Aircraft-Based Augmentation

Figure 3-3-13 Civil Airworthiness Design Standards Related to GNSS

	Military Airworthiness Design Standards Related to GNSS (including embedded GPS Receivers)
1.	**MSO-C129a,** Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)/Precise Positioning Service (PPS)

Figure 3-3-14 (Sheet 1 of 2) Military Airworthiness Design Standards Related to GNSS

	Military Airworthiness Design Standards Related to GNSS (including embedded GPS Receivers)
2.	**MSO-C145b,** Airborne Navigation Sensors Using the Global Positioning System (GPS)/Precise Positioning Service (PPS) for Area Navigation (RNAV) in Required Navigation Performance (RNP) Airspace: RNP-20 RNAV through RNP-0.3 RNA
3.	**U.S.DoD CI MAGR 500,** Performance Specification for the NAVSTAR Global Positioning Miniaturized Airborne GPS Receiver 2000-S

Figure 3-3-14 (Sheet 2 of 2) Military Airworthiness Design Standards Related to GNSS

3.3.16 Flight Management Systems (FMS)

1. A FMS is a key component of a modern suite of aircraft avionics. A FMS is an integrated suite of sensors, receivers and computers, coupled with one or more databases. The heart of the FMS is a specialized computer system that automates a wide variety of in-flight tasks, reducing the workload on the flight crew. The FMS generally provides performance and navigation guidance to displays and automatic flight control systems. Inputs can be accepted from multiple sources, such as GNSS, INS, DME and VOR. These inputs may be applied either one at a time, or in combination, to provide a navigation solution. From the cockpit, the FMS is normally controlled through a Control Display Unit (CDU), which incorporates a screen and keyboard or touchscreen. The FMS typically transmits the navigation information for display on an Electronic Flight Instrument System (EFIS), Navigation Display (ND), or Multifunction Display (MFD). An aircraft FMS installation will normally consist of:

a. FMS Control Display Unit (CDU);

b. multiple navigation sensors; and

c. electronic flight displays.

2. The TAA-accepted design standards for FMSs are shown in Figure 3-3-15.

	Civil Airworthiness Design Standards Related to FMSs
1.	**FAA AC 20-138D with Change 2,** Airworthiness Approval of Positioning and Navigation Systems
2.	**FAA AC 25.1329-1C with Change 1,** Approval of Flight Guidance Systems
3.	**FAA AC 25-15,** Approval of Flight Management Systems in Transport Category Airplanes **NOTE** *Position and navigation functions are covered in AC 20-138D Change 2, while autopilot, autothrottle/autothrust and flight director are covered in AC 25.1329-1C. AC 25-15 is acceptable for flight planning and performance management when used with AC 25-31, Take-off Performance Data for Operations on Contaminated Runways.*
4.	**ARINC 702A-5**, Advanced Flight Management Computer Systems (FMCS)
5.	**EASA CS-ACNS** Issue 4, Certification Specification – Airborne Communications, Navigation and Surveillance

Figure 3-3-15 Civil Airworthiness Design Standards Related to FMS

3.3.17 Navigation Databases (NavDB)

1. Modern avionics, such as FMSs and GPS receivers, are typically equipped with an aeronautical database. These are also referred to as navigation databases (NavDB). An aeronautical database is any data that is stored electronically in a system that supports airborne aeronautical applications. An aeronautical database is normally updated at regular intervals. Aeronautical databases are produced and updated by a number of companies, such as Jeppesen, Lufthansa Systems and NAVBLUE SAS, for example. DND may also produce specialized databases for use in DND/CAF aircraft. The navigation database contains the elements from which the flight plan is constructed. These are typically defined via ARINC 424, *Navigation System Data Base Standard*. The NavDB is normally updated

every 28 days to ensure its currency. Each FMS contains only a subset of the ARINC data, relevant to the capabilities of the FMS. For example, a NavDB may contain all the information required for building a flight plan, consisting of:

a. waypoints/intersection;

b. airways;

c. radio navigation aids including distance measuring equipment (DME), VOR, NDB ILS;

d. airports;

e. runways;

f. Standard Instrument Departure (SID);

g. Standard Terminal Arrival (STAR);

h. holding patterns; and

i. Instrument Approach Procedure (IAP).

2. The Digital Aeronautical Flight Information File (DAFIF) is a comprehensive aeronautical database of airports, airways, navigation data, military operating areas, military training routes and other information relevant to flying in the entire world. The database is managed by the U.S. National Geospatial-Intelligence Agency (NGA). Access to DAFIF is restricted to the U.S. military, DoD customers and foreign government bilateral exchange agreement partners. DAFIF has a unique format that is suitable for military mission planning but has limited flight management system (FMS) applications. In some aircraft systems, to make DAFIF useful for an aircraft FMS, it must be converted to the international ARINC 424 format. DND typically uses blended data from both the DAFIF and commercial ARINC 424 databases, such as Jeppesen, to create the in-flight navigation database files used in DND/CAF aircraft.

3. The TAA-accepted design standards for navigation databases are shown in Figure 3-3-16.

Civil Airworthiness Design Standards Related to NavDBs	
1.	**FAA AC 20-153B,** Acceptance of Aeronautical Data Processes and Associated Databases
2.	**RTCA DO-200B,** Standards for Processing Aeronautical Data
3.	**RTCA DO-201B,** User Requirements for Navigation Data
4.	**ARINC 424,** Navigation System Data Base Standard
5.	**EASA CM-AS-009 Issue 01 dated 23 July 2019,** Certification Memorandum – Certification of aircraft systems with databases

Figure 3-3-16 Civil Airworthiness Design Standards Related to NavDBs

3.3.18 Required Navigation Performance Capability (RNPC)

1. RNPC airspace is defined as follows in the NAV CANADA Aeronautical Information Publication (AIP) Enroute, Section ENR 2.2.1:

> *"Required navigation performance capability (RNPC) airspace is defined as a* ***controlled airspace*** *within the Canadian Domestic Airspace (CDA) in the Designated Airspace Handbook (TP 1820E; see Figure 2.2.2, RNPC, CMNPS and CMNPS Transition Airspace"). RNPC airspace accommodates area navigation (RNAV) operations and is contained within the Southern Domestic Airspace (SDA) and Northern Control Area (NCA)."*

2. It is important to note that RNPC Airspace is the controlled airspace within CDA identified in the Designated Airspace Handbook (DAH) Figure 2.2.2. In other words, uncontrolled airspace does not include any RNPC airspace

within it, since the purpose of RNPC airspace is to allow reduced ATC separation between suitably equipped aircraft. Furthermore, ATC only has jurisdiction within controlled airspace.

3. The AIP Enroute Section ENR 2.2.1 identifies the following certification requirements for RNAV operations within RNPC Airspace:

a. The aircraft must be certified by the State of Registry or the State of the Operator as meeting the RNPC permitted to conduct RNAV operations.

b. Long-range RNAV systems must be certified and capable of navigation performance that permits position determination within ±4 NM. Such navigation performance capability must be verified by the State of Registry or the State of the Operator, as appropriate.

c. One long-range RNAV system, plus a short-range navigation system VOR/DME, or ADF, must be certified to meet the minimum navigation equipment requirement for RNPC operation.

4. The TAA will consider it acceptable to amend the AFM to indicate that the aircraft is appropriately equipped and certified to conduct area navigation operations within RNPC airspace when the requirements of 3.3.18.3.b and 3.3.18.3.c are met.

5. Since RNPC is exclusively a Canadian airspace construct (i.e., there is no equivalent airspace defined by other ICAO States), there is no specific ICAO flight plan code to identify the aircraft as RNPC-compliant.

6. NAV CANADA will consider an aircraft to be RNPC-compliant when any of the following have been indicated on the ICAO flight plan form equipment codes:

a. X (MNPS approved);

b. G (GNSS) or I (Inertial Navigation); or

c. by the equipment suffix R accompanied by one of the PBN indicators: A1, L1, B1, B2, B2B3, B2B4, B3B4, B3B5, B4B5, B5, C1, C2, C2C3 and C4.

3.3.19 Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM)

1. The term CNS/ATM refers to a group of technologies that support reduced aircraft separation and improve ATC efficiencies. CNS/ATM is a system based on digital technologies, satellite systems and enhanced automation to achieve a seamless global air traffic control and separation. The most critical technology elements of the new CNS/ATM environment are:

a. Navigation – satellite-based navigation;

b. Communications – increased use of data links for pilot/controller communication in oceanic/remote airspace, enroute and terminal environments; and

c. Surveillance – improved surveillance that enhances both ground and cockpit situational awareness.

2. Specifically with respect to the navigation category of CNS/ATM, the following sections provide more details on PBN and RVSM. The Communications and Surveillance elements of CNS/ATM are addressed in Part 3, Chapter 2 of this manual and TAA Advisory 2021-01 – Technical Airworthiness Clearance of Surveillance Systems, respectively.

3. DND's policy regarding CNS/ATM is promulgated in the *DND/CAF Airworthiness Program* CFTO A-GA-005-000/AG-000.

3.3.20 Performance Based Navigation (PBN)

1. PBN is a core element of the navigation component of the wider CNS/ATM (air traffic management initiative). PBN specifies system navigation performance requirements for aircraft operating in the enroute, terminal and approach environment. Performance requirements are defined in ICAO Navigation Specifications (detailed in 3.3.20.4 through 3.3.20.9). These specifications identify the accuracy, integrity, continuity, availability and

functionality needed for the proposed operation. PBN Navigation Specifications are divided into two areas: Area Navigation (RNAV) and Required Navigation Performance (RNP).

2. Paragraph 6 of Chapter 8 of Book 1 of the CFTO B-GA-100-001/AA-000, *The RCAF Flying Order* requires that an appropriate airworthiness clearance or approval is required to perform any operation in accordance with an RNAV or RNP navigation specification. This section specifically addresses the TAA requirements associated with a PBN airworthiness clearance. The OAA should be contacted to assist in identifying the Operational Airworthiness criteria applicable to a PBN airworthiness clearance.

3. The PBN concept represents a shift from sensor-based navigation (VOR, NDB) to multi-sensor- and multi-system-based navigation. PBN is part of ICAO's initiative to modernize and harmonize many National Airspace Systems globally.

4. The ICAO navigation specifications are a set of aircraft and aircrew requirements that define PBN operations. The PBN navigation specifications are published in the ICAO PBN Manual – *Performance Based Navigation (PBN)*, Fifth Edition – 2023, Doc 9613-AN/937 (available internally, within DND, at AEPM RDIMS Library #2276077). The PBN Manual comprises two volumes:

a. Volume I, which describes the PBN Concept, the Airspace Concept and how the PBN Concept is used in practice; and

b. Volume II, which is made up of three parts. Part A describes on-board performance monitoring and alerting, and Safety Assessments, whilst Parts B and C contain ICAO's RNAV and RNP specifications, respectively, which can be used by States as a basis for creating their individual national certification and operational approval requirements and regulations.

5. Figure 3-3-17 further illustrates the two types of ICAO PBN navigation specifications:

a. **RNAV Specifications.** A navigation specification for area navigation that does not include the requirement for on-board performance monitoring and alerting. These are designated by the prefix RNAV (e.g., RNAV 5, RNAV 1); and

b. **RNP Specifications.** A navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting. These are designated by the prefix RNP (e.g., RNP 1, RNP 4, and RNP APCH).

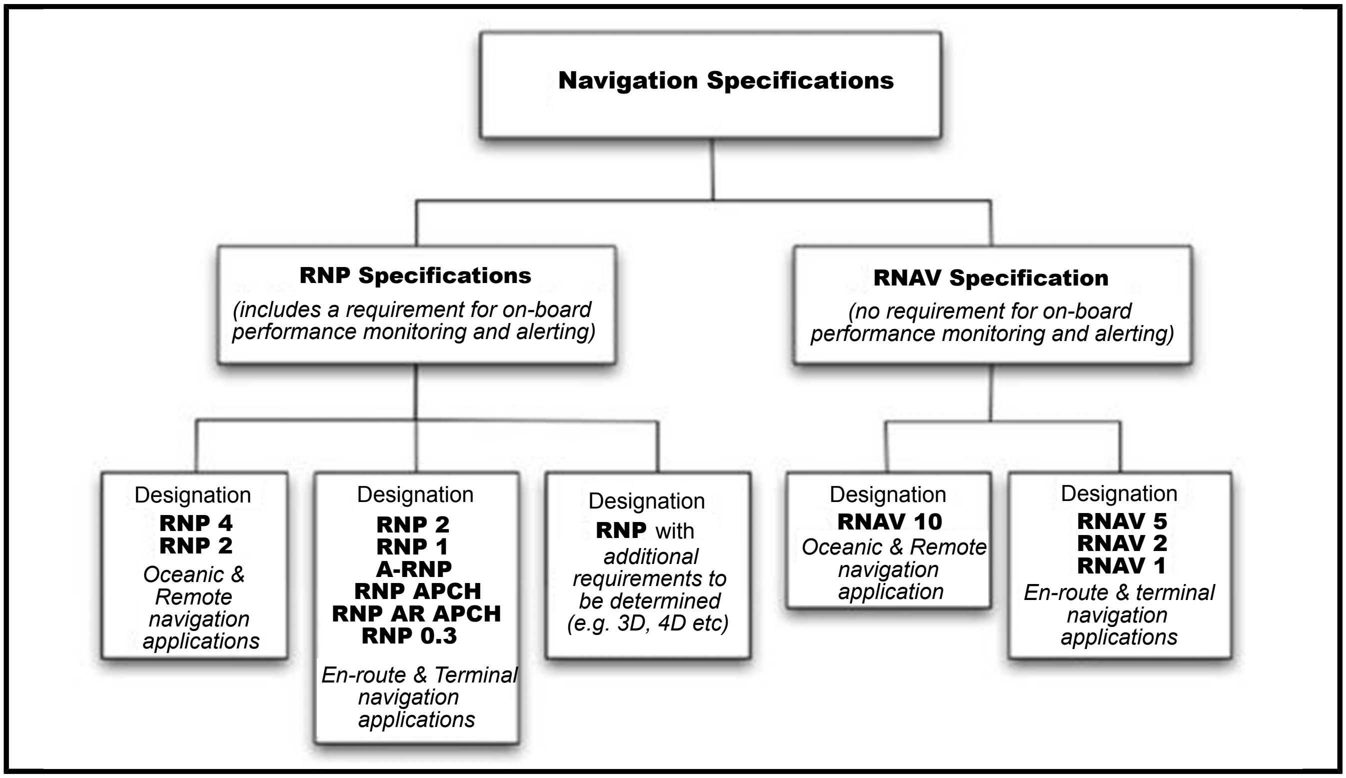

Figure 3-3-17 ICAO Navigation Specification Tree (Source: ICAO PBN Manual)

6. The ICAO navigation specifications describe in detail the aircraft eligibility requirements placed on the area navigation system for operation along a particular route, procedure or within an airspace where approval against the navigation specification is prescribed. These requirements include:

a. the area navigation system performance required in terms of accuracy, integrity and continuity;

b. the area navigation system functions required to achieve the mandated performance;

c. the navigation sensors, that may be used to achieve the mandated performance;

d. flight crew and other procedures needed to achieve the stipulated performance; and

e. any appropriate maintenance requirements, including the provision of navigation databases.

7. ICAO's intent in publishing the navigation specifications is to ensure interoperability and international standardization. Each of the ICAO member states, which include Canada, are expected to use the ICAO navigation specifications as a basis for the development of their own material to regulate the airworthiness and operational approval of PBN capabilities.

8. The TAA and OAA have adopted the ICAO navigation specifications as the primary DND requirements applicable to the certification and approval of PBN capabilities for DND/CAF aircraft. The navigation specification provides both technical and operational requirements related to the approval of PBN capabilities. The OAA should be contacted for guidance on PBN operational requirements.

9. The ICAO PBN Manual outlines the eligibility requirements for an aircraft to receive an operational approval to conduct PBN operations. The addition of a PBN capability to a DND-registered aircraft, including any changes to the associated aircraft systems or equipment, requires an airworthiness approval of the design. Certification will be documented by an entry in the TAA/OAA Approved Flight Manual (AFM) for each aircraft type. An aircraft is

normally eligible for a PBN approval, provided there is a clear statement that the aircraft has been 'Approved for PBN Operations' in the following documentation:

a. The Type Certificate. Normally for recently manufactured aircraft, where the PBN capability is approved under the type certificate, there may be a statement in the AFM limitations section that identifies the operations for which the aircraft is approved. There is also usually a statement that the specified approval does not in itself constitute an approval for an operator to conduct those operations;

b. The Design Change Approval. Alternate methods of achieving the airworthiness approval of the aircraft for PBN operations is for the design to have a TAA design approval, or if the design change has an existing Supplemental Type Certificate (STC) that was issued by a TAA-recognized airworthiness authority (AA);

c. A statement of approved capability in the AFM, or equivalent document; or

d. A compliance statement from the manufacturer certifying that the capability has been approved by a TAA-recognized AA.

10. The TAA has elected to adopt the U.S. Federal Aviation Administration's (FAA) Advisory Circular (AC) 20-138D Change 2, *Airworthiness Approval of Positioning and Navigation Systems* (detailed in 3.3.20.11 and 3.3.20.12) as the TAA's preferred means of obtaining an airworthiness approval for aircraft positioning and navigation equipment that will be used for PBN. As described in the ADSM Part 1, Chapter 2 – Airworthiness Codes, instead of developing its own advisory material for the approval of PBN capabilities on DND aircraft, the TAA may choose to adopt the advisory material published by other Civil and Military Airworthiness Authorities. AC 20-138D Change 2 was selected by the TAA based on its world-wide use in certifying PBN designs. This AC has also been adopted by TCCA, as well as many of the other civil and military airworthiness authorities.

11. AC 20-138D Change 2 provides PBN criteria and guidance material for the airworthiness approval of installed positioning and navigation equipment. Throughout the AC 20-138D Change 2, the phrase 'the criteria in this AC' refers to the principle or standard used to evaluate or judge compliance with the Advisory Circular, as well as the PBN navigation specifications. The AC also provides an acceptable means of demonstrating compliance with the requirements of the ICAO navigation specifications for RNAV and RNP. The AC addresses the following avionics:

a. GPS equipment, including that using GPS augmentations;

b. RNAV equipment integrating data from multiple navigation sensors;

c. RNAV equipment intended for RNP operations; and

d. Baro-Vertical Navigation (VNAV) equipment.

12. The TAA provides the following guidance for the use of 20-138D Change 2 on DND aircraft in certification projects:

a. only the airworthiness content of the AC is accepted;

b. any reference to "FAA Administrator" and "Administration" should be read as the "TAA";

c. any reference to FAR sections (Part 23 to 29) will only apply to those FAR elements that have been included in the TAA-approved certification basis for the design; and

d. no advisory circular can modify or change a TAA-specified requirement or standard.

13. **PBN–Area Navigation (RNAV)**

a. RNAV, formerly known as "random navigation" (hence the acronym RNAV), enables aircraft to fly on any desired flight path within the coverage of ground or space-based navigation aids and/or the capability limits of the self-contained aircraft navigation systems (e.g., Inertial Reference System). This can minimize distance flown, reduce congestion and allow flights into airports that are not equipped with ground-based aids.

b. The TAA-accepted design standards for PBN-RNAV are shown in Figure 3-3-18.

Civil Airworthiness Design Standards Related to PBN-RNAV	
1.	**FAA AC 20-138D, with Change 2,** Airworthiness Approval of Positioning and Navigation Systems
2.	**EASA CS-ACNS Issue 4,** Certification Specification – Airborne Communications, Navigation and Surveillance

Figure 3-3-18 Civil Airworthiness Design Standards Related to PBN-RNAV

14. **PBN–Required Navigation Performance (RNP)**

a. RNP is a type of performance-based navigation that allows an aircraft to fly a specific path between two 3D-defined points in space. RNAV and RNP systems are fundamentally similar. The key difference is that RNP adds the requirement for the aircraft navigation system to monitor its achieved navigation performance and alert the flight crew when the required performance is not met. If the accuracy, integrity and on-board performance monitoring/alerting requirements are met, then there would be no “messages or alerts”. This capability is called on-board performance monitoring and alerting.

b. A navigation specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as a RNP specification. Figure 3-3-17 (provided in 3.3.20.5) illustrates the different RNP designations, RNP-1, RNP-4, RNP 0.3, etc. The RNP designation refers to the RNP specification that includes a requirement for a designated lateral accuracy in nautical miles. For example, RNP 1 may be specified for operations while conducting a Standard Instrument Arrival (STAR). This will require that the aircraft remain within 1.0 NM of the published track centerline 95% of the flight time.

c. The TAA-accepted design standards for RNP are shown in Figure 3-3-19.

Civil Airworthiness Design Standards Related to PBN-RNP	
1.	**FAA AC 20-138D with Change 2,** Airworthiness Approval of Positioning and Navigation Systems
2.	**EASA CS-ACNS Issue 4,** Certification Specification - Airborne Communications, Navigation and Surveillance
3.	**FAA TSO-C115d,** Required Navigation Performance (RNP) Equipment Using Multi-Sensor Inputs
4.	**FAA Memorandum 18-6B0-DM413,** dated 30 Oct 2018, ‘General memorandum on FAA requirements for demonstrating compliance to TSO-C115d Appendix 1, the Fixed Radius Transition (FRT) function’

Figure 3-3-19 Civil Airworthiness Design Standards Related to PBN-RNP

3.3.21 Reduced Vertical Separation Minimum (RVSM)

1. A Reduced Vertical Separation Minimum (RVSM) represents a vertical separation minimum (VSM) of 1,000 feet (300 metres) that applies to an airspace with horizontal and vertical limits that are:

a. specified in the Designated Airspace Handbook, in Canadian airspace, and

b. designated or otherwise recognized by the competent aviation authority of the foreign country, in foreign airspace.

2. RVSM was implemented in the North Atlantic Region in 1997 and, in certain portions of the Pacific Region, in 2000. In the European Region and Northern Canadian Airspace, RVSM was implemented in 2002, and in the entire United States (U.S.) Domestic airspace, in 2005. Due to the volume and complexity of air traffic along the

Canada/U.S. border, the expansion of RVSM in Canadian airspace occurred concurrently with the implementation of RVSM in the U.S. Domestic airspace.

3. In 2014, Transport Canada Civil Aviation (TCCA) introduced RVSM requirements into regulation in Canadian Aviation Regulation (CAR) section 604.56, which identified requirements for:

a. flight crew member;

b. aircraft eligibility;

c. aircraft continued airworthiness maintenance; and

d. aircraft navigation systems.

4. When a Statement of Operating Intent, or the applicant, identifies a need to fly in RVSM airspace between FL 290 and FL 410 inclusive, the TAA determines if the aircraft type is technically capable of supporting RVSM operations as configured.

5. Figure 3-3-20 identifies the RVSM standards and advisory material that have been accepted by the TAA for application to DND/CAF aircraft. While EASA CS-ACNS is listed, the TAA preferred means of compliance is FAA AC 91-85B. For projects intending to demonstrate compliance via CS-ACNS, it is recommended that the TAA staff be contacted early in the process.

Civil Airworthiness Design Standards and Guidance Material Related to RVSM	
1.	**CAR section 604.56,** RVSM Requirements (SOR/2014-131, s. 18)
2.	**FAA Advisory Circular AC 91-85B (or later),** Authorization of Aircraft and Operators for Flight in Reduced Vertical Separation Minimum Airspace
3.	**EASA CS-ACNS Issue 4,** Certification Specification and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance, Subpart E, Section 2

Figure 3-3-20 Civil Airworthiness Design Standards related to RVSM

6. **Aircraft Equipage Requirements.** The minimum equipment fit should conform to Appendix A, paragraph A.4 of FAA AC 91-85B, as tailored below. Additional guidance on legacy aircraft configurations for which RVSM approval is requested can be found in Appendix A, paragraph A.6 of the same advisory circular.

a. **Two independent altitude measurement systems.** Each system should be comprised and configured with the following elements:

(1) **Static Sources.** Cross-coupled static source/system, provided with ice protection if located in areas subject to ice accretion.

(2) **Altitude Display.** Equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew.

(3) **Altitude Reporting.** Equipment for providing a digitally coded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes.

(4) **Altimetry System Components.** The altimetry system components should comprise all those elements involved in the process of sampling free stream static pressure and converting it to a pressure altitude output. The elements of the altimetry system fall into two main groups:

(a) Airframe plus static sources (pitot-static probe/static port), including the area around the static sources in the system design that must be maintained; and

(b) Avionics and/or instruments.

(5) **Altimetry System Accuracy.** The total altimetry system accuracy should satisfy the requirements of FAA AC 91-85B Appendix A, paragraphs A.5.2.1 and A.5.2.2, or paragraph A.5.3.2, as appropriate.

(6) **Static Source Error Correction (SSEC)**. If the design and characteristics of the aircraft and altimetry system are such that the altimetry system accuracy standards are not satisfied by the location and geometry of the static sources alone, then suitable SSEC should be applied automatically within the avionic part of the altimetry system. The design aim for SSEC, whether aerodynamic/geometric or avionic, should be to produce a minimum residual SSE, but in all cases, it should lead to satisfaction of the altimetry system accuracy standards, as appropriate.

(7) **Output to the Automatic Altitude Control and Altitude Alert Systems.** The altimetry system equipment fit should provide reference signals for automatic altitude control and alerting at selected altitude. These signals should be derived from an altitude measurement system meeting the full requirements of this appendix. The output may be used either directly or combined with other sensor signals. If SSEC is necessary to satisfy the altimetry system accuracy requirements, then an equivalent SSEC must be applied to the altitude control output. The output may be an altitude deviation signal, relative to the selected altitude, or a suitable absolute altitude output. Whatever the system architecture and SSEC system, the difference between the output to the altitude control system and the altitude displayed must be minimal.

(8) **System Safety Analysis.** During the RVSM approval process, it must be verified analytically that the predicted rate of occurrence of undetected altimetry system failures does not exceed 1 x 10-5 per flight-hour. All failures and failure combinations whose occurrence would not be evident from cross-flight deck checks, and which would lead to altitude measurement/display errors outside the specified limits, need to be assessed against this budget. No other failures or failure combinations need to be considered.

(9) **Air Data Systems (ADSs) and Configurations with Multiple Static Source Inputs.** Many aircraft are produced with ADSs making use of three or more static source inputs, and/or three or more air-data computers (ADC). Such systems (often referred to as “triplex” systems or “voting” schemes) are designed with integrated algorithms that monitor and compare the pressures sensed at the static sources. Sources providing “good” pressure values are used in the calculation of corrected altitude. Such configurations are acceptable provided at least two ADSs meet the requirements of FAA AC 91-85B Appendix A, paragraphs A.4.1.1.1 through A.4.1.1.8. Upon failure of one ADS, a second system must remain fully functional in compliance with the requirements of paragraphs A.4.1.1.1 through A.4.1.1.8.

b. **One Secondary Surveillance Radar (SSR) Altitude Reporting Transponder.** Any transponder meeting or exceeding the requirements of TAA Advisory 2021-01 – Technical Airworthiness Clearance of Surveillance Systems dated 6 May 2021 or later. An aircraft may be equipped with one or more transponders. If only one is fitted, it should have the capability for switching to obtain input from either altitude measurement system.

c. **An Altitude Alert System.** The altitude alert system should be capable of operation from either of the two required independent altitude measurement systems. The altitude alert system may be comprised of one or more LRUs. The altitude alert system may be comprised of one or more LRUs, or it may be an integral part of a flight management system (FMS) or flight management computer (FMC). The altitude deviation warning system should signal an alert when the altitude displayed to the flight crew deviates from selected altitude by more than a nominal value. The nominal value of the altitude alert system shall not be greater than ±300 ft, however, ±200 ft is recommended for new fleet. The overall equipment tolerance in implementing these nominal threshold values should not exceed ±50 ft.

d. **An Automatic Altitude Control System.** The automatic altitude control system is generally comprised of an autopilot with altitude hold mode. The automatic altitude control system should be capable of operation from either of the two required independent altitude measurement systems.

(1) As a minimum, a single automatic altitude control system should be installed which is capable of controlling aircraft height within a tolerance band of ±65 ft (±20 m) about the acquired altitude when the aircraft is operated in straight and level flight under nonturbulent, non gust conditions.

NOTES

1. *Aircraft types for which application for type certificate has been on or before April 9, 1997 and are equipped with an automatic altitude control system with FMS/performance management system inputs allowing variations up to ±130 ft (±40 m) under nonturbulent, nongust conditions do not require retrofit or design alteration.*

2. *If specific tuning is needed for a "legacy" autopilot to meet performance standards in RVSM airspace, this gain scheduling or tuning must not negatively impact the way the autopilot performs in other phases of flight and at non-RVSM altitudes. For example, it is common for older systems to be tuned to meet RVSM tolerance, only to realize they no longer have acceptable vertical performance on a coupled approach. Additional guidance for legacy aircraft configurations (i.e., CF188, CP140, etc.) for which RVSM approval is requested can be found in Appendix A, paragraph A.6 of FAA AC 91-85B.*

(2) Where an altitude select/acquire function is provided, the altitude select/acquire control panel must be configured such that an error of no more than ±25 ft (±8 m) exists between the display selected by the flight crew and the corresponding output to the control system.

7. **Additional Equipment for the Airspace.** To conduct RVSM operations in Canadian airspace, an aircraft is required to have:

a. lateral navigation equipment that meets the requirements set in in paragraphs 1.3.3 through 1.3.6 of the ICAO*North Atlantic Operations and Airspace Manual*, NAT Doc 007, V.2023-1;

b. an Airborne Collision Avoidance System (ACAS)/Traffic Alert and Collision Avoidance System (TCAS) meeting the requirements of Part 3, Chapter 4 of this manual; and

c. an ADS–B Out system that meets the equipment performance requirements corresponding to the operational airspace requirements set out in a fleet's Statement of Operating Intent, unless authorized otherwise.

8. **Aircraft Performance.** Altitude-keeping performance of airplanes is a key element in ensuring safe operations in RVSM airspace. Aircraft should meet the altimetry system performance stipulated in Appendix A, paragraph A.5 of FAA AC 91-85B.

9. **Supplementary Maintenance Requirements.** Appropriate instructions and procedures in respect of continued airworthiness (maintenance and repair) practices and programs have been implemented in the approved maintenance program. The RVSM maintenance requirements identified are normally satisfied through the incorporation of manufacturer's approved maintenance instructions for the RVSM component into the aircraft's ICAs/approved maintenance program. The approved maintenance program must include the RVSM-specific supplementary maintenance requirements, which are identified in the TAM, Part 5, Chapter 3, Section 2, Annex A.

10. **Approved Flight Manual/Aircraft Operating Instructions (AFM/AOI).** The RVSM approval shall be documented by an entry in the AFM or AOI for each aircraft type. Where the aircraft is delivered from the manufacturer already configured/equipped for RVSM operations, the RVSM approval should already be identified in the AFM delivered with the aircraft. Where the RVSM capability is a design change to an in-service aircraft, the RVSM capability statements need to be approved as part of the design change approval. The WSM Senior Design

Engineer (SDE) is responsible for inserting the statements into the AFM/AOI as part of the AFM/AOI updates. The capability statements should be consistent with the format and structure of the existing AFM/AOI.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 4 — HAZARD AVOIDANCE AVIONICS SYSTEMS

3.4.1 Introduction

1. This chapter sets out the Technical Airworthiness Authority (TAA)-acceptable certification requirements, standards, and means and methods of compliance to certify the functionality of hazard avoidance systems for use on crewed DND/CAF aircraft. This chapter also includes advisory material applicable to the design, integration and qualification of hazard avoidance systems.

2. Hazard avoidance systems have been designed to increase crew situational awareness of terrain, obstacles, traffic and weather hazards, and supplement their ability to avoid or mitigate them. These systems include:

a. Airborne Collision Avoidance System (ACAS), also known as Traffic Alert and Collision Avoidance System (TCAS);

b. Terrain Awareness Warning System (TAWS) also known as Enhanced Ground Proximity Warning System (EGPWS); and

c. Weather Radar Systems.

3. Unless required for a specific operational approval, hazard avoidance systems are normally not required by the aircraft certification basis. However, once a fleet decides to equip, the systems are considered required for safe flight and landing by the TAA, and their installation is considered a major design change. Furthermore, failure to equip may result in Preventative Measures (PMs) from the Airworthiness Investigative Authority (AIA) following a related flight safety occurrence investigation. As such, the TAA recommends equipage when practicable.

3.4.2 Hazard Avoidance Airworthiness Design Standards and Installation Guidance

1. The minimum performance standards, advisory and guidance materials identified in this section are acceptable for installation and certification of hazard avoidance systems. While Federal Aviation Administration (FAA) Technical Standard Orders (TSOs) are identified, equivalent Transport Canada Civil Aviation (TCCA) CAN-TSOs and the European TSOs (ETSOs) of the European Union Aviation Safety Agency (EASA) are also acceptable. The use of more recent versions of the standards and advisory material is recommended. Earlier versions of the Standard or Guidance Material may be used, provided they are acceptable to the TAA.

2. This chapter supplements the applicable processes of Part 2 by providing guidance specific to hazard avoidance systems. Design changes that introduce or modify these systems must meet their certification basis as detailed in the TAM Part 3, Chapter 2. The design standards and means of compliance identified in the respective figures may include information that relates to certification basis elements that are not identified in the tables. In those cases, that guidance is not all-encompassing and must be used in conjunction with Part 2 – Certification Processes.

3. **ACAS and TCAS**

a. An ACAS is an installed system whose function is to interrogate nearby aircraft transponders, listen to their broadcast messages, and use internal complex algorithms to identify and display potential collision threats. The intended function is normally provided by a combination of multiple equipment, including:

(1) a TCAS/ACAS Line-Replaceable Unit (LRU);

(2) flight display(s), which may be dedicated or shared;

(3) a Mode S transponder (see TAA Advisory 2021-01 – Technical Airworthiness Clearance of Surveillance Systems for more information on acceptable design standards);

(4) antennas, which may be shared between the TCAS LRU and the Mode S transponder; and

(5) aural annunciation capability.

b. To function correctly, the ACAS system also normally requires input from a radar altimeter, barometric altimeter and various aircraft discrete inputs, like weight-on-wheel status. More background information on ACAS systems can be found in the FAA Introduction to TCAS II booklet.

c. Figure 3-4-1 identifies acceptable design standards and means of compliance for ACAS/TCAS systems.

	ACAS/TCAS Airworthiness Design Standards and Means of Compliance
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x,** 1301 Function and installation
2.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level Systems Requirements
3.	**MIL-HDBK-516 11.1.1.6,** Surveillance Subsystem
4.	**FAA TSO-C118a,** Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I
5.	**FAA TSO-C119c,** Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II with Optional Hybrid Surveillance
6.	**FAA TSO C-147a,** Traffic Advisory System (TAS) Airborne Equipment
7.	**FAA TSO-C219,** Airborne Collision Avoidance System Xa/Xo
8.	**FAA AC 20-151c,** Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 and 7.1, and Associated Mode S Transponders

Figure 3-4-1 ACAS/TCAS Airworthiness Design Standards and Means of Compliance

d. When installing an ACAS or a TCAS, it should meet the performance requirements of TSO-C119c with software version 7.1 or later. TCAS II v7.1 provides improved TCAS Resolution Advisory (RA) sense reversal logic in vertical chase situations. In addition, all “Adjust Vertical Speed, Adjust” RAs are converted to “Level-Off, Level-Off” RAs to make it clearer that a reduction in vertical rate is required. However, it is understood that some aircraft do not have the flight performance required to safely fly RAs associated with climbs. While many TCAS II equipment have the ability to inhibit problematic RAs based on the aircraft configuration, this solution may not be desired and, therefore, a fleet may elect to equip with a TAS or TCAS I instead.

e. Operational use of the ACAS is documented in operational documentation, for example GPH204A, *Flight Planning and Procedures Canada and North Atlantic*. The TAA does not certify ACAS systems to be used as a primary or sole means of avoiding collision with other aircraft. The TAA certifies ACAS systems for use as a supplement to the pilot and the air traffic management system, who retain primary responsibility for avoiding mid-air collisions. Because of its role as a supplemental system, ACAS is normally associated with hazardous failure conditions, and not catastrophic.

4. **Terrain Awareness Warning System (TAWS)**

a. A TAWS is an installed system whose function is to provide flight crew increased awareness of obstacle and terrain via visual and aural alerts. The intent of a TAWS is to reduce the likelihood of collision with terrains or obstacles. The TAWS equipment normally requires as input a horizontal position source, a vertical position source, various databases and, in some cases, a radar altimeter input. Crews normally interface with the TAWS via a control panel, which includes the ability to switch between various modes and to inhibit certain alerting in specific situations. The output of the TAWS is normally a set of aural and visual alerts and, in some cases, a terrain/obstacle display, which may be dedicated or shared.

b. Figure 3-4-2 identifies acceptable design standards and means of compliance for TAWS systems.

TAWS Airworthiness Design Standards and Means of Compliance	
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x,** 1301 Function and installation
2.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level Systems Requirements
3.	**MIL-HDBK-516 11.1.1.6,** Surveillance Subsystem
4.	**FAA TSO C151b,** Terrain Awareness and Warning Systems
5.	**FAA TSO-C194,** Helicopter Terrain Awareness and Warning System
6.	**FAA AC 23-18,** Installation of Terrain Awareness and Warning System (TAWS) Approved for Part 23 Airplanes
7.	**FAA AC 25-23,** Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System (TAWS) for Part 25 Airplanes
8.	**FAA AC 27-1B MG 18,** Helicopter Terrain Awareness and Warning System (HTAWS)
9.	**FAA AC 29-2C MG 18,** Helicopter Terrain Awareness and Warning System (HTAWS)
10.	**EASA Certification Memorandum (CM) CM-FT-004 Issue 01,** Helicopter Terrain Awareness and Warning System and Ground Proximity Warning System alerting functions for Offshore Operations
11.	**RTCA DO-376/EUROCAE ED-285,** Minimum Operational Performance Standard (MOPS) for Offshore Helicopter Terrain Awareness & Warning System (HTAWS), Helicopter Terrain Awareness Warning System
12.	**ETSO-2C522,** Helicopter Terrain Awareness and Warning System (HTAWS) Advanced Features

Figure 3-4-2 TAWS Airworthiness Design Standards and Means of Compliance

c. For civil aeroplanes, TCCA mandates that the TAWS installation meet its altitude accuracy requirement, by requiring the TAWS to give priority to sources of altitude that are independent of any pilot action or input, independent of altimeter setting on the altimeter(s), and independent of temperature and pressure deviations from the International Standard Atmosphere (ISA). See Section 551.102(b)(3) of the TCCA Airworthiness Manual for more information. In practice, this usually results in the TAWS equipment including a GPS-based altitude input. The TAA recommends that the provisions of this enhanced altitude accuracy (EAA) requirement be met for both airplanes and helicopters.

NOTE

Certain flight operations (e.g., Required Navigation Performance Authorization Required [RNP AR] Approaches) may require a TAWS with EAA implemented, depending on the selected means of compliance for the operation.

d. To perform its intended function, the TAWS requires obstacle and terrain databases. While the TAA recognizes the safety benefits of updating the databases regularly, the decision to update is at the discretion of the Type Certificate Holder (TCH) organization and the operational community, who are to ensure that the TAWS equipment terrain and the airport database are compatible with the area of operations.

NOTE

Certain flight operations (e.g., RNP AR Approaches) may require a TAWS with the most recent databases, depending on the selected means of compliance for the operation.

e. Before updating the databases, the TCH organization must ensure that they are acceptable for installation. An acceptable way to satisfy this requirement is to receive updates from a Type 2 Letter of Approval (LOA) holder, in accordance with FAA (RNP AR) AC 20-153B. Before updating the databases, the TCH organization must ensure that the end-user responsibilities of AC 20-153B are met. However, Original Equipment Manufacturer (OEM) of older TAWS (e.g., TSO-C151b) may not be a Type 2 LOA holder, because the TAWS TSO pre-dates AC 20-153B. In that situation, the TAWS databases are considered approved with the TAWS directly, and changes to the databases are often approved as a

TSO minor design change. A letter from the OEM documenting the approval of the minor design change is sufficient to demonstrate the acceptability of the database for installation.

f. FAA AC 29-2C MG 18 recognizes that rotorcraft can benefit from a reduced protection mode that limits the number of false alarms when operating off-airfields (helipads or other destination not coded in the database), at unimproved landing zones, or for continuous operations in the vicinity of an airfield. This functionality is usually approved at the equipment level as a non-TSO functionality, with the functionality to be approved as part of the installation approval; MG 18 provides guidance on evaluating the installed performance. The TAA recognizes that DND/CAF fixed-wing aircraft operating tactically may also benefit from a reduced protection mode, sometimes labelled as a tactical mode. An applicant can leverage the guidance of AC 29-2C MG 18 to be used as a means of compliance for the tactical mode.

g. The TAA does not certify TAWS systems for use as a primary or sole means of avoiding collision with terrain or obstacles. The TAA certifies TAWS systems to be used as a supplement to the pilot and the air traffic management system, who retain primary responsibility for avoiding controlled flight into terrain. Because of its role as a supplemental system, TAWS is normally associated with major failure conditions, and not catastrophic. If an applicant wants to certify a system to be used as a primary means of navigation with respect to terrain and obstacles, the TAA staff should be contacted for further guidance.

5. **Weather Radar**

a. A weather radar system actively senses potentially problematic weather conditions with the intent of helping crews make appropriate decisions. The intended function is normally provided by a combination of multiple equipment, including:

(1) a weather radar LRU;

(2) means for the crew to control various radar parameters, like tilt, mode, range, etc., usually in the form of a dedicated control panel, or occasionally controlled via flight display selections;

(3) flight display(s), which may be dedicated or shared;

(4) antennas, usually protected by a radome; and

(5) aural annunciation capability.

b. Figure 3-4-3 identifies acceptable design standards and means of compliance for weather radars.

	Weather Radar Airworthiness Design Standards and Means of Compliance
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x,** 1301 Function and installation
2.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level Systems Requirements
3.	**MIL-HDBK-516 11.1.1.6,** Surveillance Subsystem
4.	**FAA TSO C63c,** Airborne Weather and Ground Mapping Pulsed Radars
5.	**FAA TSO-C105,** Optional Display Equipment for Weather and Ground Mapping Radar Indicators
6.	**RTCA DO-213,** Minimum Operational Performance Standards for Nose-Mounted Radomes
7.	**FAA AC 20-182A,** Airworthiness Approval for Aircraft Weather Radar Systems

Figure 3-4-3 Weather Radar Airworthiness Design Standards and Means of Compliance

c. Depending on the revision of TSO-C63, the weather radar may include different functionalities, defined as equipment classes. Equipment classes starting at revision FAA TSO-C63e include forward-looking windshear detection (class A), forward-looking turbulence detection (class B), airborne weather and ground mapping (class C), and atmospheric threat awareness (class D). The selection of the equipment class is the fleet's decision. The ground mapping function of class C is not intended for terrain following or terrain avoidance during normal operations. Rather, its intended function is to provide the capability to maintain situational awareness of geographical features (shoreline, mountains, etc.) as a supplement to traditional navigation.

d. The weather radar Installation Manual will normally define the expected radome electrical performances in the form of an RTCA DO-213 revision number and radome equipment class.

e. While paragraph 5.6 of FAA AC 20-182A includes guidance on identifying areas of radiation hazards to personnel and wildlife, the DND Radio Frequency Safety Program (refer to Defence Administrative Orders and Directives [DAODs] 3026-0 and 3026-1) must be followed. Consult Part 2, Chapter 3 of this manual for radiation hazard (RADHAZ) requirements specific to personnel, ordinance and fuel.

f. Operational use and credits associated with weather radars are provided in operational documents, for example GPH204A, *Flight Planning and Procedures Canada and North Atlantic*. A weather radar is one of multiple means available to crews to detect and avoid adverse weather conditions, including proper flight planning, ATC reports of severe weather, etc. Crew procedures when encountering unexpected hazardous weather also exist in various operational documents. For these reasons, weather radars are normally associated with failure conditions with a major severity. This severity assumes that challenging weather conditions will be avoided by crews, rather than crews relying on the radar displays to navigate through hazardous conditions. For a different intended function, the TAA staff should be consulted for guidance.

g. Many DND/CAF aircraft are equipped with a tactical radar that includes a weather mode. For many fleets, this tactical radar was originally certified as mission equipment, and therefore its functionality was not validated and verified by the TAA during the initial airworthiness compliance program. To be used for weather avoidance purposes, the tactical radar weather mode must be certified by the TAA to ensure it provides the intended function, and its use does not create unsafe conditions. Part of the compliance activity should include a gap analysis against the applicable requirements of Figure 3-4-3 as a starting point. The TAA staff should be contacted for further guidance.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 5 — FLIGHT CONTROL AND AUTOPILOT SYSTEMS (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 6 — CRASH DATA RECORDERS AND LOCATOR SYSTEMS

3.6.1 Introduction

1. For the DND/CAF Airworthiness Investigative Authority (AIA) to perform its investigation tasks efficiently, several tools are necessary. Crash data recorders are such tools and, as a result, they have been mandated for all DND/CAF aircraft. This chapter defines the requirements and standards for these systems. They can be located on-board, or, in the case of smaller Uncrewed Aircraft Systems (UAS), on the ground. This chapter applies to all new DND/CAF aircraft, including UAS, as well as in-service fleets undergoing a design change involving a recording system.

2. This chapter also defines the requirements and standards for the various locator systems installed or carried on DND/CAF aircraft, including UAS.

3. For the purposes of this chapter:

a. Crash data recorders, also known as flight recorders, refer to a device that is installed in the aircraft for the purpose of supporting accident/incident investigation or flight analysis. This chapter is specific to flight recorders that are installed to comply with the DND/CAF Cockpit Voice Recorder (CVR)/Flight Data Recorder (FDR) Policy, and may include CVRs, FDRs, Data Link Recorders (DLR), and Cockpit Image Recorders (CIR). Note that CIRs are also identified as Airborne Image Recorders (AIR) by ICAO, and both designations are used interchangeably; and

b. Locator systems refer to devices that are installed in the aircraft for the purpose of locating an aircraft or its crash data recorders in support of an accident/incident investigation. These systems may include Emergency Locator Transmitters (ELTs) and Underwater Locator Devices (ULDs).

3.6.2 DND/CAF CVR/FDR Policy

1. The DND/CAF policy that mandates the fitment of CVR/FDR systems in DND/CAF aircraft is addressed in the following DND publications:

a. CVR/FDR Policy (Rev 1), promulgated by the Chief of the Air Force Staff (C Air Force Staff) under letter 1016-18 (DFS) dated 7 May 2007 (available internally, within DND, at AEPM RDIMS library # 757830), with updated implementation guidance approved by C Air Force Staff under letter 1150-21 (DFS) dated 21 June 2010 (AEPM RDIMS library #994252);

b. B-GA-100-001/AA-000 – National Defence Flying Orders; and

c. A-GA-135-003/AG-001 – Airworthiness Investigation Manual (AIM).

2. The core elements of the DND/CAF CVR/FDR policy, as expressed in the C Air Force Staff letter of 21 June 2010, are summarized as follows:

a. All new DND/CAF fleets acquried or contracted after 31 December 2010, including military-registered aircraft, and civilian-registered aircraft provided by contractors for a specific role, are to meet the applicable CVR/FDR standards or submit a waiver request; and

b. The CVR/FDR requirements shall also apply to any in-service fleet that goes through a significant avionics upgrade, such as a cockpit upgrade, mid-life extension project, etc. Case-by-case guidance is provided by the AIA.

3. The CVR/FDR airworthiness requirements and design standards defined in this chapter are those deemed acceptable by the Technical Airworthiness Authority (TAA) to obtain a DND Type Certificate for a new aircraft, or

obtain a design change airworthiness approval for changes related to flight recorders or locator devices implemented with the intent of meeting the CVR/FDR policy requirements.

4. Crash data recorders and locator systems are considered required systems that must be shown to comply with the certification basis of the aircraft in which they are installed. This chapter supplements the applicable processes of Part 2 by providing guidance specific to crash data recorders and locator systems. Design changes that introduce or modify these systems must meet their certification basis as detailed in the TAM Part 3, Chapter 2. The design standards and means of compliance identified in the respective figures may include information that relates to certification basis elements that are not identified in the figures. In those cases, that particular guidance is not all-encompassing and must be used in conjunction with Part 2 – Certification Processes.

NOTES

1. *Every effort has been made in this chapter to reference the most current standards (as of the date of publication of this ADSM Change). The use of more recent versions of the standards or advisory material that may have become available after that date is recommended and may, at times, be required, if the more recent material addresses a functionality that was not addressed by the previous material. Earlier versions of the Standard or Guidance Material may be used, provided they are acceptable to the TAA.*

2. *While Federal Aviation Administration (FAA) Technical Standard Orders (TSOs) are identified, equivalent Transport Canada Civil Aviation (TCCA) CAN-TSOs and the European TSOs (ETSOs) of the European Union Aviation Safety Agency (EASA) are also acceptable.*

3.6.3 Crash Data Recorders Airworthiness Design Standards and Applicable Guidance

1. The airworthiness design standards specified in 3.6.4 through 3.6.6 are mandated for the certification and installation of crash data recorders.

3.6.4 CVR Airworthiness Design Standards and Guidance

1. Figure 3-6-1 identifies the TAA-acceptable design standards and means of compliance related to CVR systems.

	CVR Civil Airworthiness Design Standards
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x. 1457,** Cockpit Voice Recorders
2.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x. 1301,** Function and Installation
3.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523. 2500,** Aeroplane Level Systems Requirements
4.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523. 2505,** Function and Installation
5.	**FAA TSO C123c,** Cockpit Voice Recorder Equipment
6.	**FAA TSO-C177a,** Data Link Recorder Equipment
7.	**FAA TSO-C155b,** Recorder Independent Power Supply
8.	**EUROCAE ED-112A,** Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems

Figure 3-6-1 Civil Airworthiness Design Standards Related to CVRs

2. The TAA requires that the applicable certification basis elements identified in the latest amendments of references 1 through 4 of Figure 3-6-1, as applicable, be added to the aircraft certification basis for new fleets, or when equipping an existing fleet with a CVR. For fleets with a military certification basis, the most appropriate requirements from the TCCA AWM based on the type and size of aircraft (e.g., 529.1301 and 529.1457 for large military helicopters, etc.) shall be selected. It should be noted by applicants that using the latest amendment will result in the requirement to equip with a Recorder Independent Power Supply (RIPS) as per 2x.1457(d)(5).

3. For fleets requiring a Data Link Recorder as per 2x.1457(a)(6), ED-112A Annex IV-A contains a list of datalink information that must be recorded.

4. For a CVR type and design to be considered appropriate for its intended function, it must have a recording duration of two hours or greater (class 1, 4, 5, or 6 of ED-112A). Guidance to demonstrate that the CVR functions properly when installed is available in ED-112A chapters 2-5, I-6 and IV-6 (if applicable). Within DND, CVR recordings are privileged in accordance with the *Aeronautics Act*, hence will normally not be available to Finding Authorities. However, a letter from the Recognized Flight Recorder Playback Center (FRPC) documenting the acceptability of the CVR recording is normally sufficient. Please see 3.6.6.6 for more information.

5. Many commercial CVRs include a bulk erase function. That bulk erase function usually erases the information required to access the recorded data using normal replay methods (e.g., deleting a memory pointer). This bulk erase function is different from the tactical applications described in 3.6.6.4 in that non-normal replay methods may still access the information. Applicants may choose to implement or not this commercial erase function, usually by wiring an erase switch or button from the CVR control head to the CVR. If the bulk erase function is implemented, then the corresponding switch/button must be protected against inadvertent operations, normally using either of the following methods:

a. a guarded-type switch that is secured with witness wire;

b. requiring by design at least two sets of logic to be satisfied prior to a crew-initiated bulk erase. ED-112A I-2.1.7 includes guidance and recommends the parking brake be one set of logic. However, other sets of logics acceptable to the TAA can be used so that bulk erase may be initiated in flight. The set of logic used should be documented in the Certification Plan (CP); or

c. any other method acceptable to the TAA.

NOTE

Notwithstanding the method used, applicants should seek endorsement of the method from the AIA to ensure an Investigative Authority Clearance (IAC) will be achievable for their design.

3.6.5 FDR Airworthiness Design Standards and Guidance

1. Figure 3-6-2 identifies the TAA-acceptable design standards and means of compliance for FDR systems.

	FDR Civil Airworthiness Design Standards
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x. 1459,** Flight Data Recorders
2.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x. 1301,** Function and installation
3.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523. 2500,** Aeroplane Level Systems Requirements
4.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 52. 2505,** Function and Installation
5.	**FAA TSO C124c,** Flight Data Recorder Equipment
6.	**FAA TSO C-176a,** Cockpit Image Recorder Equipment
7.	**EUROCAE ED-112A,** Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems ED-112A chapters 2-5, II-6 and III-6 (if applicable) detail installation requirements

Figure 3-6-2 Civil Airworthiness Design Standards Related to FDRs

2. It is a TAA requirement that the applicable certification basis elements identified in Figure 3-6-2 rows 1 through 4, as applicable at their latest amendment, be added to the aircraft certification basis for new fleets, or when equipping an existing one with a FDR. For fleets with a military certification basis, the most appropriate requirements from the TCCA AWM based on the type and size of aircraft (e.g., 529.1301 and 529.1459 for large military helicopters, etc.) shall be selected.

3. For a FDR type and design to be considered appropriate for its intended function, it must have a recording duration of at least 25 hours for fixed-wing aircraft (Class A), and 10 hours for rotary-wing aircraft (Class B).

4. Each FDR system shall obtain data within the parameters specified in ED-112A and any additional parameters defined in Annex A of this chapter for the applicable DND/CAF aircraft type and family.

NOTES

1. *The applicant must determine, in consultation with the AIA, those parameters from ED-112A and Annex A of this chapter that are to be recorded. The agreed list of parameters to be recorded must be documented and captured in the certification plan. The FDR system will only be determined to function properly when installed if it records those parameters acceptably. If the parameter is required by 1459(a)(1), the finding of compliance will be made against that requirement, otherwise, it will be against the applicable 1301 certification requirement.*

2. *Some amendments of AWM Chapter 523 did not include 1301(d). In those cases, 1309(a) must be used. 1309(a) was not included in Figure 3-6-2 because only the latest amendments of the airworthiness standards are included.*

5. The use of a CIR is recommended, but not mandated, for RCAF aircraft: recorded ‘images’ of the cockpit environment can be used to augment existing data and audio recordings to better investigate accidents. In such cases, the TAA treats the installation of image recorders as Mission Equipment, in accordance with TAA Advisory 2006-04, Installation of Miscellaneous Non-Required Equipment. However, a CIR may also be used as an alternative means of recording data that is required by the AIA when it is impractical or prohibitively expensive to record on a FDR (ED-112A CIR Class C). This situation must be identified in the CP, and the AIA concurrence to the use of an image recorder for required parameters should be referenced. When used in lieu of a FDR, the recorder shall meet the applicable criteria of Figure 3-6-2. If parameters mandated by 2x.1459(a) are recorded by a CIR, a request for a deviation or exemption will be required against that certification basis element. ED-112A III-2.4.1 identifies that, for Class C CIR, the recording duration shall be that of the FDR. At the time of publication of this ADSM Chapter, there were no known commercially available CIRs with 10 or 25 hours of recording duration. As such, the TAA considers that a two-hour image recorder is sufficient to ensure the CIR is of a design appropriate to its intended function. However, applicants should seek concurrence from the AIA that this is acceptable.

6. Guidance on how to demonstrate that the data recorders function properly when installed is available in ED-112A chapters 2-5, II-6 and III-6 (if applicable). Within DND, most FDRs are considered non-designated data recorders and, as such, their recordings are not privileged in accordance with the *Aeronautics Act*, unless a flight safety occurrence is suspected or determined to have occurred. As such Finding Authorities may have access to the recording, if deemed necessary to make findings of compliance. However, unless the design involves complex or novel features, or at any point during the execution of the compliance program specific factors raised significant concerns for the Finding Authorities, a letter from the Recognized Flight Recorder Playback Center (FRPC) documenting the acceptability of the FDR recording is normally sufficient to confirm the parameters are recorded acceptably. Please see 3.6.6.6 for more information.

3.6.6 Additional Guidance Applicable to all Flight Recorders

1. **Use of Combined Recorders.** For small aircraft (usually defined as having a maximum take-off weight of 5,700 kg or less), it may be challenging or impossible to include separate CVR and FDR equipment. In such cases, the installation of a combined recorder may be warranted, and the appropriate compliance matrix sub-sections (e.g., AWM Chapter 523.1457 [d][6] and 523.1459 [a][7]) may be marked Not Applicable (N/A). The AIA must be consulted to determine if a combined recorder is acceptable on case-by-case basis.

2. **Installation of Flight Recorders on Rotorcrafts.** For rotorcrafts, the installation location requirements for non-ejectable flight recorders are set out in paragraphs 52x.1457(e) and 52x.1459(b) of Chapters 527 and 529 of the Airworthiness Manual. For aeroplanes, an installation location at the aft would normally satisfy the requirements. For rotorcraft, however, it may be preferable to install the flight recorders in a forward location, as the forward locations are generally less susceptible to fire. In addition, a forward location may avoid a significant weight penalty, in

comparison to an aft location. Based on these considerations, it is acceptable to install non-ejectable flight recorders in forward locations of rotorcraft, provided that the recorders are certified to the standards specified in Figure 3-6-1 and Figure 3-6-2.

3. **Installation of Deployable Flight Recorders.** For Search and Rescue (SAR), shipborne and maritime patrol aircraft, consideration should be given to install a deployable recorder system compliant with ED-112A. Where a deployable recorder is used, the deployable module shall incorporate an Emergency Locator Transmitter (ELT) in lieu of an Underwater Locator Device (ULD).

4. **Tactical Applications.** The following TAA-acceptable requirements should be respected:

   a. If required for operational reasons, it is acceptable to install a manual means of stopping the CVR/FDR recording function, enabling data encryption, or initiating a bulk erase/reset to zero function to protect sensitive mission data. If such a security function is implemented, the operator interface design must incorporate the following, as a minimum:

      (1) a guarded-type switch that must be secured with witness wire, to minimize the probability of inadvertent operation; and

      (2) a visual indication in the cockpit, to show that the security function is enabled.

   b. The installation design shall ensure that the CVR/FDR reverts to normal operation, when the security function is deselected, and must be automatically de-selected during aircraft start-up; and

   c. If the security feature incorporates a bulk erase function, the installation shall be designed to minimize the probability of inadvertent operation and actuation during crash impact.

NOTE

The inclusion of a security function is an operational decision. The Directorate of Air Requirements should be consulted, in conjunction with the AIA, before a decision is made to equip.

5. **Flight Recorders for Uncrewed Aircraft Systems (UAS).** The AIM identifies which flight recorders are required for UAS operations. Flight recorder identified as required in the AIM must meet the UAS certification basis and are not considered mission equipment.

6. **Requirements for Flight Recorder Testing of Initial Installation.** For each initial installation of a flight recorder on a DND/CAF aircraft, an initial test recording shall be made in accordance with ED-112A. The applicant for a type certificate or design change airworthiness approval is responsible to:

   a. arrange with the DND/CAF-recognized FRPC for an analysis of recorded material; and

NOTES

1. *The FRPC may request documentation related to the means utilized to convert data sensed at the source into signals suitable for input to the flight recorders. The FRPC will request documentation related to data conversion and logic for translation of the recorded data stream into either of the parameters expressed in engineering units for FDRs or recorded information for the CVR/DLR. The applicant is responsible for providing requested information to the FRPC and if requested, to the TAA and AIA.*

2. *The applicant is responsible for funding this testing, as well as any repeat testing, should the initial testing not be successful.*

   b. submit, upon receipt of the FRPC report, evidence to demonstrate to the AIA and the TAA that the quality and intelligibility of the recorded information are satisfactory.

NOTE

In the event of any significant aircraft or system design change that could adversely affect the flight recorder operation, the process for the initial installation will need be repeated and documented.

7. **Flight Recorder Playback Centre.** Aircraft occurrence recordings, initial installation test recording and scheduled maintenance test recordings shall be submitted to the following facility, which is approved for type certification, playback and occurrence investigation. This playback facility may also provide maintenance analysis, aircraft design change advice/recommendations, follow-on flight recorder installation evaluation and aircraft acceptance work:

National Research Council (NRC)
Flight Research Laboratory
Flight Recorder Playback Centre (FRPC)
1200 Montreal Road, Bldg. U-61, Ottawa, ON K1A 0R6 (Postal)
1920 Research Road, Building U-61, Ottawa, ON, K1V 9B4 (Courier)

8. **In-Service Support Requirements.** In-service support maintenance requirements of flight recorders shall be carried out in accordance with TCCA Standard 625, Appendix C. In some cases, the yearly FDR correlation check may be replaced by a reasonableness check (for example, when recorded parameters can be demonstrated to be identical to those utilized for operation of the aircraft). Applicants should consult with the AIA to ensure the instructions for continuing airworthiness will be sufficient for an IAC. As part of the IAC, the applicant must ensure that the DND/CAF-recognized FRPC has Crash Damage Recovery Equipment (CDRE). The AIA should be consulted for further guidance.

3.6.7 Locator Systems Airworthiness Design Standards and Applicable Guidance

1. The airworthiness design standards specified in 3.6.8 through 3.6.10 are mandated for the certification and installation of locator systems.

3.6.8 Emergency Locator Transmitters Airworthiness Design Standards and Guidance

1. Figure 3-6-3 identifies the TAA-acceptable design standards and means of compliance for ELT systems.

	ELT Airworthiness Design Standards
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x,** 1301 Function and installation
2.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level Systems Requirements
3.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2505 Function and Installation
4.	**TCCA AWM 551.104,** Aircraft Equipment and Installation - Emergency Locator Transmitter
5.	**FAA TSO-C126c,** 406 MHz Emergency Locator Transmitter (ELT)

Figure 3-6-3 Civil Airworthiness Design Standards Related to ELTs

2. The ELT must operate at both 406 MHz and 121.5 MHz, be self-activating and coded as per Annex B of this chapter. Additional operation at 243 MHz and transmission of GNSS position is desirable.

3. Earlier revisions of TSO-C126c may be found acceptable. However, previous projects have highlighted the need to consider lithium battery thermal runaways when performing a zonal analysis for an ELT certified to TSO-C126b or earlier.

4. TSO-C126c defines two possible operating temperature ranges, Class 1 (-40°C to +55°C) and Class 2 (-20°C to +55°C). When procuring an ELT, that ELT should meet the operating temperature range of Class 1.

NOTE

For an applicant to register a 406 MHz ELT it must hold a Type Approval Certificate from COSPAS-SARSAT showing that it meets the requirements of COSPAS-SARSAT C/S T.001. This is a prerequisite to demonstrating compliance with FAA TSO-C126c and then registering with Innovation, Science and Economic Development Canada in coordination with the DND Frequency Spectrum Manager in ADM (Information Management) specifically Director Joint Command and Control Information Systems Force Development (DJC2ISFD).

3.6.9 Underwater Locator Devices (ULD) Airworthiness Design Standards and Guidance

1. Figure 3-6-4 identifies the TAA-acceptable design standards and means of compliance for ULD systems.

	ULD Airworthiness Design Standards
1.	**14 CFR Part 2x./CS-2x./TCCA Airworthiness Manual Section 52x,** 1301 Function and installation
2.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2500 Aeroplane Level Systems Requirements
3.	**14 CFR Part 23./CS-23./TCCA Airworthiness Manual Section 523,** 2505 Function and Installation
4.	**FAA TSO-C121b,** Underwater Locating Devices (Acoustic) (Self-Powered)
5.	**FAA TSO-C200a,** Airframe Low Frequency Underwater Locating Device (Acoustic) (Self-Powered). Only mandated for Search and Rescue (SAR), shipborne and maritime patrol aircraft

Figure 3-6-4 Civil Airworthiness Design Standards Related to ULDs

3.6.10 Locator Systems In-Service Support Requirements

1. In-service support maintenance requirements of locator systems shall be carried out in accordance with TCCA Standard 625, Appendix C.

ANNEX A

CVR/FDR ADDITIONAL REQUIREMENTS BY FLEET FAMILY

3.6A

1. EUROCAE's ED-112A, *Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*, does not address military role specific parameters to be recorded. As a result, an additional set of parameters has been developed for each family of aircraft. The various aircraft roles and types of recording equipment were taken into account in determining the requirement for airborne recorder systems on board DND/CAF aircraft. Accordingly, the aircraft required to support the CAF operations were divided into several families, some with slightly different recording requirements. Discriminators used in the assignment of aircraft to various families are:

a. Aircraft type (fixed wing, rotary wing, or UAS);

b. Aircraft role (trainer, transport, combat, SAR);

c. Number of engines (single or multi-engine);

d. Aircraft maximum take-off weight (more or less than 12,500 lbs/5682 Kg);

e. Maximum aircraft speed (greater or less than 450 knots Indicated Air Speed [IAS]);

f. Number of crew members; and

g. Special considerations, such as whether the aircraft is ejection seat capable or weapons capable.

2. Based on these discriminators, five generic fixed-wing families and four rotary wing families were identified as follows:

a. Fixed Wing Aircraft:

(1) Trainer: No additional parameters required.

(2) Light Transport: No additional parameters required.

(3) Heavy Transport: Refer to Appendix 1.

(4) Heavy Combat: Refer to Appendix 2.

(5) Fast Combat: Refer to Appendix 3.

b. Rotary Wing Aircraft

(1) Single Engine Trainer: Refer to Appendix 4.

(2) Multi Engine Trainer: Refer to Appendix 5.

(3) Transport/SAR: Refer to Appendix 6.

(4) Combat: Refer to Appendix 7.

APPENDIX 1, ANNEX A

FIXED WING HEAVY TRANSPORT AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration and Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Altitude Warning Selections	Discrete, as installed	1			Radio altimeter warning bug altitude
Emergency Shut-off Valves Activation	Discrete, as installed	1			Activation (manual or auto) of all emergency shut-off valves (engine fuel, hydraulics, pneumatics, etc.) + status of valve positions (open, closed, failed)
Fire Bottle Activation	Discrete, as installed	1			Activation (manual or auto) of all fire-fighting agents + status of activated devices (fail, depleted, etc.)
TACAN Navigation	As installed	1	As installed	As installed	Frequency selected, status of equipment, bearing + distance readout
Cabin Pressure Altitude	As installed	1	As installed	As installed	Pressurization readout
Emergency Brakes Selection	Discrete, as installed	1			Selection of emergency brakes

APPENDIX 2, ANNEX A

FIXED WING HEAVY COMBAT AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration and Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Stores Status	As installed	1			Stores status data (type, location), taken from the mission computer
Weapons Status	Discrete, as installed	1			A discrete signal must be recorded every time a weapon departs the aircraft
Fire Fighting Equipment	Discrete, as installed	1			Activation (manual or auto) of all fire-fighting agents + status of activated devices (fail, depleted, etc.)
Master Arm Mode	Discrete, as installed	1			A discrete signal must be recorded every time the master arm function changes status
Altitude Warning Selections	Discrete, as installed	1			Radio altimeter warning bug altitude

APPENDIX 3, ANNEX A

FIXED WING FAST COMBAT AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration Audio Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
STORES MANAGEMENT SYSTEMS					
External Stores Status	Discrete, as installed	1			A discrete signal must be recorded every time an external store departs the aircraft
Pressing Of Triggers/launch Buttons	Discrete, as installed	1			A discrete signal must be recorded every time a weapon trigger or launch button/switch is activated
Master Arm Mode	Discrete, as installed	1			A discrete signal must be recorded every time a master arm or weapons select override function changes status
AIRCRAFT GENERAL					
Maintenance + System Status Codes	Discrete, as installed	1			Each systems status or maintenance code triggered shall be recorded, e.g., Maintenance Monitor Panel (MMP) codes
Display Cautions, Warnings And Advisory Messages	Discrete, as installed	1			Each message sent to the cockpit displays, as well as illumination of associated lights
FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval In Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Altitude Warning Selections	Discrete, as installed	1			Selected value, as well as silent/ mute/override selection
Arresting gear selection + status	Discrete, as installed	1			Selection of arresting gear deployment/retraction/ activation, as well as status

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval In Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
Ejection Seat Dual Cockpit Mode	Discrete, as installed	10			Mode selection for dual cockpit ejection system (e.g., norm, solo, aft initiate)
Flight Control Computers Messages	Discrete, as installed	1			Status changes, errors, failures and degradations in normal modes of operation
Data Link Systems	Discrete, as installed	5			Status of equipment
Auto Throttle (ATC)	Discrete, as installed	1			Engage/disengage + status (fail, degd, etc.)
Engine Exhaust Nozzle Position	As installed	0.5	As installed	As installed	Nozzle aperture + thrust vectoring position, if applicable
Fuel Quantities	As installed	10	As installed	As installed	Recording of all fuel tank quantities, as well as indicated total fuel as displayed in cockpit
Emergency Shut-off Valves Activation	Discrete, as installed	1			Activation (manual or auto) of all emergency shut-off valves (engine fuel, hydraulics, pneumatics, etc.) + status of valve positions (Open, Closed, Failed)
Fire Bottle Activation	Discrete, as installed	1			Activation (manual or auto) of all fire-fighting agents + status of activated devices (fail, depleted, etc.)

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval In Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
TACAN Navigation	As installed	1	As installed	As installed	Frequency selected, status of equipment, bearing + distance readout
Crew Oxygen System	As installed	10	As installed	As installed	Pressure/quantity in system, system status
Cockpit Pressure Altitude	As installed	1	As installed	As installed	Pressurization readout
Emergency Brakes Selection	Discrete, as installed	1			Selection of emergency brakes
G Suit Pressure, Status	As installed	0.5	As installed	As installed	Recording of pressure supplied to G suit and status of equipment

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval In Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
Radar Warning Receiver Status	Discrete, as installed	1			Changes in mode of operation and status of RWR
Radar Mode Of Operation	As installed	1			Recording of master mode used, and changes of status (Air Mode, Ground Mode, Nav Mode, etc.)
Radar Status Messages	Discrete, as installed	1			Serviceability status + messages (Fail, Degd, Receive Only, etc.). Also which mode of operation is used

APPENDIX 4, ANNEX A

ROTARY WING SINGLE ENGINE TRAINER CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration Audio Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval In Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Ground Speed	0 to 300	1	As installed	± 1 knot	As installed (equipment capable of producing a groundspeed readout)

APPENDIX 5, ANNEX A

ROTARY WING MULTI ENGINE TRAINER AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration Audio Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Ground Speed	0 to 300	1	As installed	± 1 knot	As installed (equipment capable of producing a groundspeed readout)

APPENDIX 6, ANNEX A

ROTARY WING TRANSPORT OR SAR AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration Audio Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
AIRCRAFT GENERAL					
Ground Speed	0 to 300	1	As installed	± 1 knot	As installed (equipment capable of producing a groundspeed readout)

APPENDIX 7, ANNEX A

ROTARY WING COMBAT AIRCRAFT CVR/FDR SPECIFICATIONS

CVR REQUIREMENTS		
Duration Audio Recording	**Application**	**Remarks**
2 hours minimum	All crew positions + area mike	All radios unless in secure mode

FDR PARAMETERS					
Parameter	**Minimum Recording Range**	**Maximum Recording Interval in Seconds**	**Recording Accuracy**	**Recording Resolution**	**Remarks**
STORES MANAGEMENT SYSTEMS					
All Loaded External Racks/Pylons/ Launchers/Rails	Discrete, as installed	1			A discrete signal must be recorded every time a rack/ pylon/launcher or rail departs the aircraft or changes in status (e.g., Failed, Degraded)
Master Arm Mode	Discrete, as installed	1			A discrete signal must be recorded every time a master arm or weapons select override function changes status
AIRCRAFT GENERAL					
Aircraft Ground Speed	As installed	1	± 3 %	1 kt	
Maintenance + System Status Codes	Discrete, as installed	1			Each systems status or maintenance code triggered shall be recorded (e.g.,Maintenance Monitor Panel (MMP) codes)
Emergency Shut-off Valves Activation	Discrete, as installed	1			Activation (manual or auto) of all emergency shut-off valves (engine fuel, hydraulics, pneumatics, etc.) + status of valve positions (open, closed, failed)
TACAN Navigation	As installed	1	As installed	As installed	Frequency selected, status of equipment, bearing + dist readout
ELECTRONIC WARFARE					
Radar Warning Receiver Status	Discrete, as installed	1			Changes in mode of operation and status of RWR
Radar Mode Of Operation	As installed	1			REcording of master mode used, and changes of status (Air Mode, Ground Mode, Nav Mode, etc.)
Radar Status Messages	Discrete, as installed	1			Serviceability status + messages (Fail, Degraded, Receive Only, etc.). Also which mode of operation is used

ANNEX B

406 MHZ ELT CODING PROTOCOLS

3.6B 406 MHZ ELT CODING PROTOCOLS

1. The 406 MHz Emergency Locator Transmitters (ELTs) used on DND/CAF aircraft shall conform to the following coding protocols:

a. An ELT that can determine its own location shall be coded as follows:

(1) in the case of a Type AF, AP or AD ELT, using the Standard Location Protocol and the 24-bit binary ICAO aircraft address assigned when registering the aircraft by DND (military aircraft registry) or Transport Canada (civil aircraft registry), to uniquely identify the ELT;

(2) in the case of a Type S ELT, using the Standard Location Protocol and the unique serial number assigned to the ELT by the ELT manufacturer and the COSPAS-SARSAT (International Satellite System for Search and Rescue Services) beacon type approval certificate number to uniquely identify the ELT;

NOTES

1. *The aircraft 24-bit ICAO address is currently being used in other airborne systems such as TCAS and provides the advantage of uniquely identifying the airframe in addition to the ELT.*

2. *If the ELT does not interface with a Global Positioning System (GPS) or any other navigation source equipment, the ELT should be reprogrammed as though it is an ELT that is not able to determine its own location, in accordance with (b) below. Otherwise, the search and rescue (SAR) response to the ELT distress signal could be delayed.*

b. An ELT that is not capable of determining its own location shall be coded as follows:

(1) in the case of a Type AF, AP or AD ELT, using the Serial User Protocol oded with the 24-bit binary ICAO aircraft identification assigned when registering the aircraft by DND (military aircraft registry) or Transport Canada (civil aircraft registry), to uniquely identify the ELT;

(2) in the case of a Type S ELT, using the Serial User Protocol with a unique Beacon Serial Number to allow the unique identification of each Type S ELT when more than one ELT of this type are to be carried on an aircraft.

c. The country code shall reflect the state (i.e., Canada) in which the aircraft is registered.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 7 — PROPELLERS, ROTORS AND ROTOR DRIVE SYSTEMS (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 8 — ELECTRICAL POWER GENERATION, CONVERSION, DISTRIBUTION AND PROTECTION

3.8.1 Introduction

1. This chapter sets out the acceptable standards for airworthiness and guidance for the design and installation of aircraft electrical systems for DND/CAF aerospace products. It has been written to take into account that the DND/CAF operates a mix of military and civil pattern aircraft.

2. **Electrical Power System.** The electrical power system shall be sized and configured to provide onboard generation, conversion, storage, distribution, protection and control of the electric power required for all phases of air vehicle operation, including ground maintenance.

3. **Requirement Rationale.** The electrical power system is the primary energy source for operation of electrical and electronic equipment onboard the air vehicle. Proper specification of the functional and performance characteristics is essential for the safe and reliable operation of utilization systems and equipment. Typical aircraft electrical systems are broken down into the following main categories:

a. **Generation.** This includes that portion from the generators up to and including the bus contactors. It also includes the batteries and all control and protection for these parts of the electrical system.

b. **Conversion.** This includes the transformers, rectifiers, converters, inverters, etc., which might reasonably be classified in the other three groups but will be considered as a separate category.

c. **Distribution.** This part of the electrical system performs the function of transmitting the generated power to the utilization equipment or systems. It includes the main bus or buses, the contactors, the distribution feeders, general wiring and their protective devices as well as the sub-buses from which the power is distributed to the loads.

d. **Utilization.** This includes all of the many electrically operated devices or systems that receive power from the aircraft electrical power system. Refer to Part 2, Chapter 4 – Airborne Software and Airborne Electronic Hardware for utilization equipment requirements.

4. Civil regulations, such as the U.S. Title 14 CFR (14 CFR) and the TCCA Airworthiness Manual (AWM), define a baseline upon which to build. The civil regulations adequately address all electrical equipment, power generation and distribution requirements for aircraft that are used in conformance to the civil role for which it was certified. However, it may be necessary to use military standards in lieu of or in addition to the civil standards for civil pattern aircraft that will be operated in more demanding military roles and/or environment. Refer to 1.4.3, Military Design Standards (Airworthiness). It should be noted that the civil regulations, unlike those of the military, typically do not identify any design standards for equipment, only general requirements for the "system".

5. **Terminology.** The term 14 CFR xx or AWM x applies or corresponds to 14 CFR Parts 23, 25, 27 and 29, or AWM Parts 23, 25, 27 or 29, respectively.

3.8.2 Acceptable Standards for Aircraft Electrical Systems

1. The following standards are applicable to DND/CAF aircraft electrical power generation, conversion, distribution and protection systems.

General Standards
General Airworthiness Design Standards
1. All electrical systems and equipment shall meet the requirements of the relevant chapter(s) in this part and chapter of the ADSM.
2. A safety assessment of the electrical system shall be carried out in accordance with ADSM Part 2, Chapter 1 – System Safety Assessment. Refer to Annex A of this chapter for additional guidance.
3. Electrical system EMI/EMC and Lightning protection shall comply with the requirements of ADSM Part 2, Chapter 3 – Electromagnetic Environmental Effects Protection (E3).
4. An Electrical Load Analysis (ELA) shall be provided in accordance with MIL-E-7016 during aircraft acquisition and modifications that affect the electrical system loading. When the theoretical analysis approaches the limits of the generating system, as defined in this document, a physical or actual load analysis shall be performed to determine conclusively that the loading is within the safe operating limits of the generating system. Source: U.S. DoD JSSG-2009, Appendix H, AWM 5xx.1351 and AWM 551.200.
Military Airworthiness Design Standards
1. Aircraft grounding receptacles shall comply with the requirements of MIL-STD-7080 and MIL-STD-464.
2. Aircraft electrical bonding and grounding shall meet the requirements of MIL-STD-464.
3. Equipment used in the electrical power generating and distribution systems shall be selected and installed in accordance with MIL-STD-7080 or equivalent standard.
Civil Airworthiness Design Standards
1. All components within the electrical system shall be designed for full, unrestricted operation throughout the entire spectrum of the aircraft operational environment as defined in the aircraft Statement of Operating Intent (SOI). Source: AWM 5xx.1309.
DND/CAF-Ratified International Standards
1. Provision for connection of external electrical power supplies to the aircraft electrical system shall be incorporated using receptacles in accordance with STANAG 7073.

Figure 3-8-1 General Standards Related to Electrical Power Generation, Conversion, Distribution and Protection

Electrical Generation, Conversion and Storage
General Airworthiness Design Standards
1. When a battery is required to provide emergency electrical power, in the event of a total generated power supply failure, the battery shall have sufficient capacity to meet the emergency load demand and a re-start of an inoperative engine, for the period of time specified in the certification basis or the vehicle specification. Where no time is specified in the certification basis of the aircraft, the battery endurance shall not be less than 30 minutes flying time. Refer to 3.8.6.3 for guidance. Source: U.S. DoD JSSG-2009, Appendix H and AWM 551.201.
2. An independent emergency power source shall be provided to supply power to all essential loads in the event of failure of the normal power source. Source: JSSG-2009, NAVAIR SD-24L, SAE ARP 4404 and AWM 529.1351.
Military Airworthiness Design Standards
1. Primary power systems shall operate in such a manner that safe and continuous operation of electrical loads is assured through all phases of flight and ground operation. Source: U.S. DoD JSSG-2009, Appendix H.

Figure 3-8-2 (Sheet 1 of 2) Electrical Power Generation, Conversion and Storage Standards

Electrical Generation, Conversion and Storage
2. The electrical power system capacity shall be at least twice the maximum continuous load of the initial production air vehicle to allow for safe operation of the air vehicle in the event of prime power failures, based on a theoretical loads analysis, unless it is demonstrated to the satisfaction of the TAA that other overriding considerations prevent this, or other specifications are agreed. Refer to Annex A of this chapter for guidance on electrical system capacity requirements. Source: U.S. DoD JSSG-2009, Appendix H.
3. The aircraft electrical power provided at the input terminals of utilization equipment shall meet the minimum electrical power characteristics as specified in MIL-STD-704 or equivalent standard. Source: U.S. DoD JSSG-2009, Appendix H.
4. The aircraft battery shall be capable of isolation from the aircraft electrical system except those services required in an emergency and specified in the aircraft specification. Source: DEF STAN 00-970.
Civil Airworthiness Design Standards
1. For all battery performance calculations, 80 per cent of battery rated capacity shall be used. Source: FAA AC 29-2C.
2. All batteries installed in aircraft and airborne equipment shall be approved for airborne applications. Source: AWM 5xx.1301.

Figure 3-8-2 (Sheet 2 of 2) Electrical Power Generation, Conversion and Storage Standards

Distribution
General Airworthiness Design Standards
1. **MANDATORY**. Wire splices shall be AS81824 environment resistant sealed splices. Large wires, size 6 to 10 AWG, shall use D-436 series environment resistant splices. Source: C-17-010-002/ME-001.
2. **MANDATORY**. Splices shall not be used on firing or control circuits associated with electrically initiated devices, ordnance or explosive sub-systems, including fire extinguisher squibs. Source: SAE AS 50881 and C-17-010-002/ME-001.
Military Airworthiness Design Standards
1. **MANDATORY**. The E3 classification of a system shall be indicated by a letter identification code incorporated into the wire identification code identifying a specific E3 category for each wire or cable. Classification and marking schemes provided by an OEM may be acceptable for use, provided they are deemed adequate by the procuring authority. Additionally, in some instances, a published identification scheme for E3 wire coding may be acceptable in lieu of physically marking the wire with the E3 code. TAA and procuring authority approval is required prior to acceptance of this format. Source: C-17-010-002/ME-001.
2. **MANDATORY.** MIL-DTL-81381, Polyimide (Kapton), or comparable polyimide insulated wire and cable, shall not be introduced into aircraft wiring systems or in aerospace products. For existing aircraft fleets designed with Kapton wire, a suitable and approved replacement wire shall be used for all repairs, replacements or modifications. Source: C-17-010-002/ME-001.
3. **MANDATORY.** For new acquisitions, modifications and when replacing wires, Polyvinyl Chloride (PVC) insulated wire and cable shall not be introduced into aircraft wiring systems or in aerospace products. Source: C-17-010-002/ME-001.
4. **MANDATORY.** For new acquisitions, modifications and when replacing wires, aluminium wire shall not be introduced into aircraft wiring systems or in aerospace products. Repairs to existing aluminium wiring shall be carried out in accordance with the OEM’s standard wiring practices. Source: C-17-010-002/ME-001 and C-17-010-002/CS-006.

Figure 3-8-3 (Sheet 1 of 2) Electrical Power Distribution Standards

Distribution
5. **MANDATORY.** Only wire constructions approved by the TAA, as listed in C-17-010-002/ME-001, shall be used in DND/CAF aerospace products. This approval is application specific and does not permit universal use of a wire product without examination of the wire specification, test and qualification data to ensure suitability. TAA approval of a wire type may be obtained by submitting information identifying the design specification, documented proof of successful tests to accepted standards or by submission of wire samples to a DND facility for quality verification. Refer to Annex C for guidance on seeking TAA approval for introducing a new wire type on DND/CAF aerospace products. Source: C-17-010-002/ME-001.
6. **MANDATORY.** Splices shall not be used in any flight critical system or any system with a failure criticality of catastrophic or where failure of the system could result in serious injury or loss of life or aircraft. Source: C-17-010-002/ME-001.
Civil Airworthiness Design Standards
1. The aircraft wiring installation shall comply with the requirements of SAE AS 50881. Refer to Annex B for guidance on DND/CAF wire requirements.
2. **MANDATORY.** Wiring of sensitive circuits that may be affected by electromagnetic interference, including RF and antenna cables, shall be routed away from other wiring. Signal and control wiring shall not be routed in the same bundle as power wiring. Refer to Annex A for guidance. Source: C-17-010-002/ME-001 and SAE AS 50881.
3. **MANDATORY.** The Electrical Wiring Interconnection System (EWIS) shall be designed and rated to safely conduct the maximum load developed under worst case situations and take into account ambient and electrically generated thermal heating. Source: SAE AS 50881.
4. **MANDATORY.** Identification and marking of electrical wire and cable shall be in accordance with SAE AS 50881 and C-17-010-002/ME-001. The identification code for wires and cables shall be assigned in accordance with SAE AS 50881, Appendix B, Significant Wire Identification. Hot stamp marking shall not be used for new acquisitions, modifications or when wires need to be replaced for maintenance purposes.

Figure 3-8-3 (Sheet 2 of 2) Electrical Power Distribution Standards

Protection
1. Circuit breakers shall not be used as ON/OFF switches unless specifically designed for this purpose. Source: MIL-HDBK-5400 and FAA AC 43.13-1B.
2. External power monitors shall be provided, in accordance with MIL-PRF-24021 for each external power receptacle to protect the electrical power system and utilization equipment against unsuitable external power being applied to the aircraft. Source: JSSG-2009, AWM 5xx.1351 and SAE ARP 4404.

Figure 3-8-4 Electrical Power Protection Standards

3.8.3 Guidance Information – Electrical Power Generation

1. **U.S. Military.** MIL-STD-704 – *Aircraft Electric Power Characteristics*, defines the requirements for, and characteristics of, aircraft electrical power to be provided at the input terminals of consumer equipment. This standard provides detailed requirements for normal, abnormal and emergency power, load balance and transients for 115VAC, 28VDC and 270VDC, however, it has no coverage of electrical system functional testing and gives no requirements for distribution system design and installation. If the original design requirements of a power supply cannot be established, MIL-STD-704 characteristics must be used to set the operating requirements for utilization equipment.

2. **UK Military.** DEF STAN 00-970, Volume 1, Chapter 707 (Fixed Wing) and Volume 2, Chapter 706 – *(Rotary Wing) Electrical Systems* – provides appropriate electrical power generation guidance. Leaflet 706/1 and 707/1 make general recommendations concerning the design of electrical installations and Leaflet 706/2 and 707/2 provides further information on the standard power supplies and their application to the installations. Leaflet 706/3 and 707/3 lists British Standards (BS) and Defence Standards that contain advice on accessories and components. British Standard BS 3G 100, which is referenced in Chapter 706 and 707, specifies characteristics for electrical generating,

distributing and consumer units. DEF STAN 00-970 Part 1/2, Section 6 provides requirements regarding ground and flight tests of the aircraft electrical system.

3. **AWM/14 CFR/CSs.** TCCA AWM, FAA 14 CFR, and EASA CSs provide commercial aircraft requirements for power supplies and associated control, regulation, and protective devices. Commercial class aircraft require analyses to be undertaken to establish compliance. An alternative standard, RTCA DO-160 – *Environmental Conditions and Test Procedures for Airborne Equipment*, provides test methods for qualifying commercial aircraft equipment. RTCA DO-160 covers a range of environmental conditions and includes power and electromagnetic characteristics. It provides similar guidance to British Standard BS 3G 100 for electrical systems. Additionally, an Electrical Load Analysis (ELA) is mandatory for transport, large rotorcraft and commuter aircraft. 14 CFR regulations use broad requirements that concentrate on safety related issues.

4. **In-Service Considerations and Guidance.** Even if the original design requirements of a power supply cannot be established, MIL-STD-704 characteristics must be used to set the operating requirements for load equipment. MIL-STD-704 is suitable for specifying aircraft acquisition requirements but is less useful for setting test requirements of individual avionics components and equipment. An alternative standard, RTCA DO-160 – *Environmental Conditions and Test Procedures for Airborne Equipment*, provides test methods for qualifying commercial aircraft equipment. RTCA DO-160 covers a range of environmental conditions and includes power and electromagnetic characteristics.

3.8.4 Guidance Information – Electrical Power Distribution

1. **U.S. Military.** SAE AS 50881 (supersedes MIL-W-5088L), *Wiring Aerospace Vehicle*, provides detailed design and selection guidance for wiring and wiring devices for use in aircraft, and is acceptable for DND/CAF aircraft provided it is supplemented by the additional DND/CAF requirements specified in Annex B of this chapter. The intent of SAE AS 50881 is to provide background on wide ranging installation requirements pivotal to aircraft safety, performance and reliability, ease of maintenance, and aircraft service life. Since all aircraft classes are covered, requirements must be tailored for a particular aircraft or installation. A cross-reference of hardware, materials and procedural specifications is provided at the front of the Standard. It is important to recognize that the requirements for equipment, parts or components are based on military standard products, and in many cases these may not provide the most cost effective solution (i.e., invoking military standard products when suitable less expensive Commercial-Off-The-Shelf (COTS) equivalents are satisfactory). SAE AS 50881 is the primary electrical system design document as it describes an installation rather than a function. It also has sound information for in-service management of aircraft electrical systems and is the standard upon which the DND/CAF's aircraft wiring manual C-17-010-002/ME-001 is based. MIL-STD-7080, *Selection and Installation of Aircraft Electric Equipment*, covers the general and detailed requirements for the selection and installation of electric equipment in military aircraft. Electric equipment includes electric power generation, conversion, storage and distribution equipment, electric power control and protective devices and motors.

2. **UK Military.** DEF STAN 00-970 provides adequate design and selection guidance for wiring and wiring devices for use in aircraft and is acceptable for DND/CAF aircraft, provided it is supplemented by the additional DND/CAF requirements specified in Annex B of this chapter. However, SAE AS 50881 provides substantially more comprehensive guidance and is therefore preferred by the DND/CAF.

3. **AWM/14 CFR/CSs.** Parts xx.1307, xx.1309, xx.1351, xx.1353, xx.1355, xx.1357, xx.1359 and xx.1363 cover aircraft electrical equipment and installations for various types of aircraft, however, specific requirements are limited and generally do not provide sufficient detail for aircraft acquisition or modification. AWM/14 CFR/CS regulations should be supplemented with commercial specifications, such as SAE ARP 4404, *Aircraft Electrical Installation*, which provide guidance on electrical installations for transport aircraft. These documents are acceptable for DND/CAF aircraft, provided they are supplemented by the additional DND/CAF requirements specified in Annex B of this chapter. SAE ARP 4404 guidance is equivalent to that provided by SAE AS 50881, favouring the installation perspective rather than functional requirements. Topics covered include wire selection and routing, connectors and terminations, circuits for essential equipment, circuit protection, bonding and grounding, provisions for future electrical equipment, corrosion protection, load distribution, system tests, and emergency controls and procedures. In addition, SAE ARP 4404 details functional testing, which is not covered in SAE AS 50881.

3.8.5 Guidance Information – Aircraft Electrical Load Analysis (ELA)

1. **Aircraft Acquisition Projects.** Prior to aircraft delivery and aircraft acceptance, an actual loads analysis will need to be performed, and the results provided, by the contractor. This ELA will facilitate the determination of compliance required prior to the release to service of the aircraft and establish a baseline for entering service life. The results data will need to be provided in an appropriate electronic format to facilitate data transfer into a database or other software tool used to manage electrical load changes.

2. **Aircraft Modifications.** All aircraft modification programs affecting the electrical system, or involving electrical power components, will need to include a review and update of the ELA as a product deliverable. This will provide continued assurance that the electrical loads are still within the capacity of the power source, associated busses, wiring and circuit protection devices and do not exceed the requirements of the power system design standard, as identified in the certification basis. After acceptance/incorporation of the modification, the ELA will need to be amended to reflect the post modification aircraft configuration.

3. **Electrical Power Management (EPM)**. Consideration should be given to enrolling the aircraft into an EPM program. The EPM subsection at the Aerospace and Telecommunications Engineering Support Squadron (ATESS) may be tasked to provide aircraft electrical load verification, calculation and measurement services to the DND/CAF. ATESS will create a database of the electrical loads for each aircraft bus and will maintain and update the database on behalf of the customer throughout the life of the aircraft to take into account changes to the electrical loads as a result of modifications and upgrades. Normally, the database will be structured to track electrical loads on an aircraft “type” basis. However, for those fleets that have a mixed configuration to allow for specialized operations, separate databases can be created and maintained for each variant.

3.8.6 Guidance Information – Electrical Power Storage

1. **General.** Batteries are used widely in DND/CAF aircraft applications. They supply electrical power prior to engine start, during emergencies and for equipment that operates independently from normal aircraft power supplies. Batteries used in aircraft are of various chemical compositions and range from large “main” aircraft batteries to ‘button’ batteries used for computer data retention.

2. **Main Batteries.** Several types of secondary (rechargeable) ‘main’ batteries are currently fitted to DND/CAF aircraft. While these batteries are used for various applications, including engine and APU starting, powering aircraft systems when ground power is unavailable, etc., their primary purpose is to provide emergency electrical power to flight critical systems when all other aircraft power supplies are unavailable.

3. **Main Battery Capacity.** During an electrical system emergency involving loss of generated power, the main aircraft battery will be needed to power essential flight instruments, such as standby instrumentation, lighting, communication, fire detection and extinguishing, and to start the APU or to re-start the engines in flight. An analysis will be required to show that, following a minimum of three engine or APU start attempts, the battery will still have sufficient capacity remaining to power the essential flight services long enough to land the aircraft safely. The capacity requirements for the battery will vary depending on the aircraft type and role; however, an endurance of 30 minutes or more should be the design goal. This endurance requirement may be extended, depending upon the intended operation of the aircraft. Verification of the battery capacity, and its ability to meet these requirements, will need to be included in the ELA, formatted as per MIL-E-7016.

4. **Battery Charge Acceptance and Recovery Time.** For those aircraft where a battery is required for the ground start of engines or an APU and to provide emergency electrical power, the ELA will need to show the time, following an engine or APU start, for the battery state of charge to recover to 80 per cent rated capacity (considered to be the minimum airworthy state of charge). This will ensure an adequate duration of the emergency power source should a failure of generated power occur shortly after takeoff. This recharge time requirement prior to take-off will need to be included in the Aircraft Operating Instructions (AOI) and/or Approved Flight Manual (AFM) – refer to Figure 3-8A-1 in Annex A of this chapter. Any limitations concerning battery capacity, such as the impact of cold weather on charge acceptance and capacity, will also need to be included.

5. **Battery Types.** The main types of batteries currently approved for use in DND/CAF aircraft are:

a. **Vented Lead Acid Batteries.** The advantages of these batteries are low cost, simple maintenance, ruggedness and reliability. These battery types are a “flooded” design and contain an electrolyte solution of sulphuric acid.

b. **Sealed Lead Acid Batteries (SLABs).** SLAB batteries are virtually maintenance free; however, they will be irreversibly damaged if severely discharged and, therefore, may not always be suitable where engine starting from the battery is required. Nevertheless, SLABs have been retrofitted to several DND/CAF aircraft where excessive maintenance problems have been encountered with their original battery systems. There is no free electrolyte in this type of battery.

c. **Vented Nickel Cadmium Batteries.** This type of battery is constructed with a number of replaceable vented cells. While some of the performance characteristics of these batteries exceed those of lead acid batteries, they have higher initial costs and increased maintenance requirements. It is necessary to recondition nickel cadmium batteries at periodic intervals due to prolonged constant potential cycling in the aircraft installation.

6. **Equipment Batteries.** Various other battery chemistries, both non-rechargeable (primary) and rechargeable (secondary), are currently in use in DND/CAF aircraft equipment such as computers, clocks, emergency beacons and radios, flashlights and emergency exit lighting. Prior to adoption and use of any battery or cell that has not been previously approved for use in DND/CAF aerospace products, a thorough examination of the battery’s characteristics and suitability must be undertaken. Some of the battery chemistries presently in use are:

a. **Carbon Zinc, (Primary).** Carbon Zinc batteries provide an economical power source for devices requiring light to moderate drain. The average capacity remains above 90 per cent after storage for one year at 21ºC. These are primary cells and cannot be recharged.

b. **Alkaline, (Primary).** Alkaline batteries provide an economical power source for devices requiring heavy or continuous use. The average capacity remains above 95 per cent after storage for one year at 21ºC. These are primary cells and cannot be recharged.

c. **Alkaline, (Secondary).** A variety of sealed, rechargeable alkaline batteries chemistries and formats is available and they provide good power and temperature characteristics. Caution needs to be exercised to differentiate between batteries designed for domestic use and those specifically designed to withstand the aerospace environment.

d. **Sealed Nickel Cadmium, (Secondary).** Sealed nickel cadmium batteries are the most widely used sealed rechargeable batteries. They maintain a relatively constant potential during discharge and can be stored in any state of charge. The charge retention of nickel cadmium cells is poor and will drop to approximately 50 per cent after storage for five weeks at 21ºC. They can be recharged many times; however, sealed nickel cadmium cells suffer from memory effect if subjected to repeated shallow discharge/charge cycles. While sealed nickel cadmium cells can be discharged over a wide temperature range, (-20ºC to 45ºC), charging needs to be carried in a much narrower range. Maximum charge retention will be achieved if the cell temperature can be maintained at 20 to 35ºC.

e. **Nickel Metal Hydride, (Secondary).** Nickel Metal Hydride (NiMH) cells are essentially an extension of the proven sealed nickel cadmium technology with the substitution of a hydrogen absorbing negative electrode for the cadmium based electrode. This substitution increases the cell electrical capacity for a given weight and volume (up to 40 per cent) and eliminates the cadmium toxicity concerns. The nickel metal hydride cell has similar cell voltage to the nickel cadmium cell, however it has a much lower self-discharge rate and little or no memory effect.

f. **Lithium, (Primary And Secondary).** The electrical characteristics and outstanding performance of lithium cells make them an ideal choice for applications where cost is not the overriding consideration. The safety concerns surrounding the use of lithium batteries when they were first developed and introduced have been reduced with the introduction of safer chemistries and cell constructions. Batteries based on lithium chemistries have the highest specific energy (energy per unit weight) and energy density (energy per unit volume) of all chemistry types. Certain types of lithium batteries also have extended operating temperature range, enabled by the absence of water and the nature of the materials used. Specifically, lithium/thionyl chloride (Li-SOCl2) can operate at temperatures as low as -55ºC and as high as 85ºC. Lithium batteries have an excellent shelf life (low self-discharge rate) of up to 15 years, however due to toxic materials, they also have specific handling, storage and disposal requirements.

7. Appropriate cells and batteries need to be selected to provide a reliable and effective power source under all envisaged operating conditions. Several of the listed batteries have specific protective and handling requirements and these must be addressed in the aircraft/component design. Acceptable specifications and standards for aircraft and equipment batteries are listed in Figure 3-8-5, in the Associated Publications and Standards section of this document.

3.8.7 Associated Publications and Standards

1. The following source references in Figure 3-8-5 are associated with the design, installation, maintenance and in-service usage of the Electrical Power System.

Regulator or Organization	Number	Title
Air Force Interoperability Council (AFIC)	AIR STD-70/24	Aircraft Electrical Systems Characteristics
DND/CAF	C-05-002-000/SG-001	Minimum standards for non-rechargeable lithium batteries in airborne applications
	C-17-010-002/ME-001	Installation Practices, Aircraft Electrical and Electronic Wiring
FAA	AC 20-16	Advisory – Electrical Fault and Fire Prevention and Protection
	AC 20-136	Advisory – Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning
	AC 23/25/27/29.1301	Advisory – Equipment General – Function and Installation (There may be ACs associated with each aircraft type.)
	AC 23/25/27/29.1309	Advisory – Equipment, Systems and Installations (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1351	Advisory – Electrical Systems and Equipment – General (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1353	Advisory – Electrical Equipment and Installations (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1355	Advisory – Distribution System (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1357	Advisory – Circuit Protective Devices (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1359	Advisory – Electrical System Fire and Smoke Protection (There may be ACs associated with each aircraft type)
	AC 23/25/27/29.1363	Advisory – Electrical System Tests (There may be ACs associated with each aircraft type)
	AC 23/25/27/29, Appendix B	Advisory – Airworthiness Guidance for Instrument Flight (There may be ACs associated with each aircraft type)
	AC 23/25/27/29 MG 2	Advisory – Miscellaneous Guidance 2 (There may be ACs associated with each aircraft type)

Figure 3-8-5 (Sheet 1 of 4) Associated Publications and Standards Related to the Electrical Power System

Regulator or Organization	Number	Title
FAA (Cont)	AC 25-10	Advisory – Guidance for Installation of Miscellaneous, Non-Required Electrical Equipment
	AC 25-11	Advisory – Transport Category Airplane Electronic Display Systems
	ANM-01-04	FAA Policy Statement – System Wiring Policy for Certification of Part 25 Airplanes
	14 CFR 23	Standards – Normal, Utility, Acrobatic, and Commuter Category Airplanes
	14 CFR 25	Standards –Transport Category Airplanes
	14 CFR 27	Standards – Normal Category Rotorcraft
	14 CFR 29	Standards – Transport Category Rotorcraft
	Memo 00-111-159 27 April 2001	Policy Statement with respect to All Electrical Attitude, Altitude, Direction and Airspeed Systems using Battery Standby Power
	SFAR 88	Transport Airplane Fuel Tank System Design Review
IEC	IEC 60952	Aircraft Batteries
EASA	CS 23, 25, 27 & 29	Requirements for Aircraft Electrical Wiring
PrEN	PrEN 4240	Aerospace series, Primary active lithium battery aircraft use Technical Specification
RTCA	DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
	DO-227	Minimum Operational Performance Standards for Lithium Batteries
SAE	ARP 1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
	ARP 4404	Aircraft Electrical Installations
	ARP 4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
	AS 4373	Test Methods for Insulated Electric Wire
	AS 50881	Wiring Aerospace Vehicle (replaces MIL-W-5088)
NATO	STANAG 3456	Aircraft Electrical Power System Characteristics
	STANAG 7073	Connectors for Aircraft Electrical Servicing Power
TCCA	AWM 523.1307, 1309, 1351, 1355, 1357 & 1363	Normal, Utility, Acrobatic, and Commuter Category Aeroplanes
	AWM 525.1307, 1309, 1351, 1355, 1357 & 1363	Transport Category Aeroplanes
	AWM 527.1307, 1309, 1351, 1355, 1357 & 1363	Normal Category Helicopters
	AWM 529.1307, 1309, 1351, 1355, 1357 & 1363	Transport Category Helicopters
	AWM 551.200	Electrical Power System
	AWM 551.201	Battery

Figure 3-8-5 (Sheet 2 of 4) Associated Publications and Standards Related to the Electrical Power System

Regulator or Organization	Number	Title
TSO	C-142	Lithium Batteries
UK MoD	DEF STAN 00-56	Safety Management Requirements for Defence Systems
	DEF STAN 00-970 Vol. 1	Design and Airworthiness Requirements for Service Aircraft – Aeroplanes
	DEF STAN 00-970 Vol. 2	Design and Airworthiness Requirements for Service Aircraft – Rotorcraft
	DEF STAN 00-970 Part 1, Section 6	Design and Airworthiness Requirements for Service Aircraft – Equipment
	DEF STAN 61-3	General Specification for Batteries, Non-Rechargeable, Primary
	DEF STAN 61-6	Aircraft Electrical Circuit Identification
	DEF STAN 61-7	Identification of Electrical and Electronic Systems, Wiring and Components
	DEF STAN 61-9	General Specification for Batteries, Rechargeable, Secondary
	DEF STAN 61-12	Wires, Cords and Cables, Electrical, General Specification
	DEF STAN 61-17	The Requirements for the Selection of Batteries for Service Equipment
U.S. DoD	JSSG-2009	Air Vehicle Systems
	MIL-B-18	Batteries, Non Rechargeable, Dry
	MIL-B-5087	Bonding, Electrical and Lightning Protection, for Aerospace Systems
	MIL-B-8565	Battery Storage, Aircraft General Specifications
	MIL-B-49430	Batteries, Non Rechargeable, Lithium Sulphur Dioxide
	MIL-B-49436	Batteries, Rechargeable, Nickel-Cadmium, Sealed
	MIL-B-49458	Batteries, Non Rechargeable, Lithium Manganese Dioxide
	MIL-B-55130	Batteries, Rechargeable, Nickel-Cadmium, Sealed
	MIL-B-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft, General Specifications
	MIL-B-295958(AS)	Batteries and Cells, Lithium, Aircraft, General Specifications
	MIL-DTL-22759	Wire, Electrical, Polytetrafluoroethene/Polyimide Insulated
	MIL-E-7016	Electric Load and Power Source Capacity
	MIL-HDBK-217	Reliability Prediction of Electronic Equipment, Reliability Analysis Center
	MIL-HDBK-454	General Guidelines for Electronic Equipment
	MIL-HDBK-5400	Electronic Equipment, Airborne, General Guidelines
	MIL-HDBK-XXX	Airworthiness Certification Criteria (DRAFT dated 12 April 2002)
	MIL-STD-464	Electromagnetic Environmental Effects – Requirements For Systems
	MIL-STD-704	Aircraft Electric Power Characteristics
	MIL-STD-810	Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
	MIL-STD-882	Standard Practice for System Safety
	MIL-STD-2223	Test Methods for Insulated Electric Wire
	MIL-STD-7080	Selection and Installation of Aircraft Electric Equipment

Figure 3-8-5 (Sheet 3 of 4) Associated Publications and Standards Related to the Electrical Power System

Regulator or Organization	Number	Title
U.S. DoD (Cont)	MIL-W-22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

Figure 3-8-5 (Sheet 4 of 4) Associated Publications and Standards Related to the Electrical Power System

NOTE

For guidance as to whether to use the original standards or newer standards, refer to Part 1, Chapter 3 of the ADSM.

ANNEX A

GUIDANCE INFORMATION FOR AIRCRAFT ELECTRICAL POWER GENERATION, STORAGE, DISTRIBUTION AND PROTECTION SYSTEMS

3.8A.1 Classification of Electrical Loads

1. The electrical loads on an aircraft must be classified as being emergency (critical), essential, and non-essential, and busses with appropriate levels of redundancy must be established for each type of load. This classification must be the result of a Functional Hazard Analysis and the resultant assignment of criticality based upon the impact of failure of that system. Emergency loads are typified as engine fire detection and extinguishing, oxygen, flight control system and cockpit displays, etc. Essential loads typically include ice detection, ATC transponder, anti- and de-icing, Environmental Control System (ECS), etc. For military aircraft, the mission avionics, such as missile and radar warning systems, electronic warfare, anti-submarine warfare, etc., should be treated as essential loads. Typical non-essential or utility loads on commercial transports are galley equipment, reading lights, electric shaver outlets, passenger entertainment system, etc.

3.8A.2 SAE ARP 4404 Definitions for Electrical Circuits

1. Emergency: Emergency circuits (critical) are those essential circuits, the failure of which may result in the inability of the aircraft to maintain controlled flight and effect a safe landing.

2. Essential: Essential circuits are those necessary to accomplish the mission of the aircraft under the most adverse environmental conditions for which the aircraft was designed.

3.8A.3 Power Distribution

1. An effective distribution system is needed to transmit electric power to the using equipment in a safe and reliable manner. JSSG-2009, Appendix H, provides guidance on bus structure and distribution circuits.

2. The electrical system bus and load shedding architecture must be designed to ensure that emergency and essential loads are powered under various electrical system failure conditions. Consideration needs to be given to the criticality of the system or item to maintain control of the air vehicle. For instance, aircraft designed with “fly-by-wire” flight controls and other flight critical loads that require continuous power to maintain control of the air vehicle, consideration should be given to the use of un-interruptible power sources.

3. UK DEF STAN 00-970, Volume 1, Chapter 707 and Volume 2, Chapter 706 provide guidance on what systems need to be powered under various electrical system failure conditions. Also, the AWM/14 CFR/CSs provide direction as to the minimum systems that need to be retained in the event of electrical system failures. The DEF STANs should be used to supplement the civil regulations when specifying electrical system requirements for military aircraft and civil aircraft that are operated in a military role and environment to ensure military flight essential systems are powered under various electrical system failure conditions.

3.8A.4 Mission Completion Power

1. When considering electrical system architecture, it needs to be determined whether the aircraft is required to be able to complete the mission in the event of power source failures (generators and conversion units). This will likely lead to the creation of a list of flight essential and mission essential equipment and systems that will need to be powered under various combinations of electrical system failures. Operational staff will need to be involved with making these determinations. This will have an effect on which bus the systems are powered from and could have an effect on the capacity of the power source(s). The following sources should be referred to for guidance:

a. NAVAIR SD-24, Volume I – Fixed Wing Aircraft.

b. NAVAIR SD-24, Volume II – Rotary Wing Aircraft.

c. DEF STAN 00-970, Volume 1, Chapter 707 – Fixed Wing Aircraft.

d. DEF STAN 00-970, Volume 2, Chapter 706 – Rotary Wing.

3.8A.5 Electrical System Capacity

1. It is essential to define the required capacity of the electrical power system since it is a critical design parameter affecting the air vehicle design. Care needs to be taken to avoid over specifying the amount of reserve and growth capacity because weight and space impacts can be significant. Conversely, sufficient reserve capacity must be allocated for future growth.

2. Specifications and standards that should be consulted when preparing contractual documentation and/or specifications when specifying the installed capacity of the generation and conversion systems are described in Figure 3-8A-1. The information is presented as it appears in the source documents.

Guidance on Electrical System Capacity	
Source Document	
DEF STAN 00-970, Chapter 706, Paragraph 3.2.2	**Generating Capacity.** The generating capacity shall be at least 50 per cent greater than the maximum continuous demand (Refer also to Leaflet 706/2, Paragraph 3.). This estimate shall be based on the fully equipped aircraft as at the date of the Final Conference or earlier as agreed with the Aircraft Project Director.
DEF STAN 00-970, Leaflet 706/2, Paragraph 3	**Design of Main System** 3.1 During the initial design stages of an aircraft the maximum continuous electrical load is not definitely known. For instance, there may be new equipment developed before the final acceptance date and this may be added as a requirement.
	3.2 In addition, Chapter 706, Paragraph 3.2.2, requires a reserve of power at the time of the Final Conference in order to allow for further requirement of the aircraft during its service life.
	3.3 In order to cover these two points it has been found by experience that 100 per cent spare power should be allowed at the initial design stage based on the maximum continuous demand under the worst conditions of flight. The maximum continuous demand should not include high current peaks of short duration such as starting current for heavy motors. In calculating spare power, certain large loads, e.g., de-icing, need not be factored. When application of the requirement to the overall electrical power supply could lead to serious penalty the designer should consult the Aircraft Project Director.
FAA Memorandum 00-111-159 dated 27 April 2001	**Aircraft Battery Endurance.** The purpose of this memorandum is to clarify Federal Aviation Administration (FAA) certification policy with respect to All Electrical Attitude, Altitude, Direction and Airspeed Systems using Battery Standby Power. With the advent of highly reliable, low power, Liquid Crystal Display (LCD) electrical indicators, applicants are replacing previous pneumatic indicators with electric ones, resulting in an all electric attitude, altitude, direction or airspeed configuration. Many of these installations rely on time-limited batteries to power the instruments in the event of loss of generator power on the airplane. As such, all electric configurations must be designed to ensure continued safe flight and landing after any failure or combination of failures not shown to be extremely improbable, including the loss of generated electrical power. **NOTE** *The above is a short description of the original FAA document. It is recommended that users consult the original document for the complete text.*

Figure 3-8A-1 (Sheet 1 of 2) Electrical System Capacity

Guidance on Electrical System Capacity	
SAE ARP 4404, Paragraph 6.2.2	**Capacity of Generators.** The installed capacity of the generation system should be at least 100 per cent in excess of the amount required for operation of all essential loads under any flight condition. As used herein, installed generation system capacity means the actual available capacity of all generators under the particular altitude and cooling conditions prevailing during the various flight conditions. In paralleled generator systems, due to paralleling tolerances, the electric load, as indicated by the load analysis, should not exceed 85 per cent of the continuous or short time capacity of the generation system under the specified conditions of ground or flight operation (Refer to MIL-E-7016 or MIL-E-7017 for a method of conducting a load analysis). The electric power available in excess of essential requirements may be used for convenience or passenger comfort items such as reading lights, electric shavers, water heaters, etc. In the event that one or more generators are lost, passenger comfort items may be disconnected as required by the reduced generator capacity. Consideration should generally be given to means for disconnection of convenience loads by manual or automatic monitoring, in order not to exceed the short time capacities of the generators (Refer also to Paragraph 14.2 for growth capacity).
SAE ARP 4404, Paragraph 14.2.1	**Selection of Generators.** In order to stay within the load requirements indicated in Paragraph 6.2, design experience has shown that generators should be selected so that the total load, including passenger comfort items, as shown by the preliminary design load analysis, will not exceed 60 per cent of the installed generating capacity (all generators operating).
U.S. DoD JSSG-2009, Appendix H, Paragraph H 3.4.8.2	**Capacity.** Electrical power system capacity should normally be at least twice the maximum continuous load of the initial production air vehicle to provide for growth, unless other overriding considerations prevent this growth capacity. Providing for this level of growth is commonly implemented for cargo and bomber air vehicles. Smaller growth margins (on the order of 30 per cent) are often used for fighter air vehicles because the increased weight associated with larger capacity components is usually considered to be unacceptable. Factors listed below should be considered: • Steady state and short duration load requirements. • Component power ratings. • Capacity de-rating factors such as temperature and altitude (including oil supply, input speed, and horse-power). • Growth requirements. • Redundancy for flight critical systems.
U.S. Navy NAVAIR SD-24L, Volume II, Paragraph 3.16.2	**Electric Power System.** An electric power system shall be provided, capable of supplying the following power as shown on an acceptable preliminary load analysis. The electric load on any power supply or generator shall not exceed 65 per cent of its capacity. Electric power load shall not exceed 65 per cent of the generating capacity. The simplest bus arrangement for reliable power distribution shall be used. Characteristics of all sources of electric power shall be as required for the primary power. The electric system shall operate automatically. A switch, accessible to flight personnel, shall be provided for manual over-ride of each electric power source in the event of an emergency.

Figure 3-8A-1 (Sheet 2 of 2) Electrical System Capacity

3.8A.6 Routing and Segregation of Wiring and Cabling for Electromagnetic Compatibility (EMC)

1. In the past, modification instruction leaflets have often been introduced containing vague statements such as “route new wiring via existing wire bundles”. This practice can lead to a degradation in EMC because of non-compliance with the OEM’s design practices and standard procedures. Modification instructions or design change

specifications to an approved design incorporating new or additional wiring need to ensure that fitment is in accordance with the approved OEM's standard practices or in accordance with C-17-010-002/ME-001.

2. Moreover, for new acquisitions and major design changes to existing aircraft, contractual documents need to include a requirement for the contractor to provide information regarding how wires and cables are classified and segregated, including minimum separation distances for bundles and termination techniques used. It is recommended that this information be included both on the electrical harness installation drawings and in the wiring practices maintenance manual. As a minimum, the contractor's routing and segregation practices will need to meet the requirements for routing and segregation of wires and cables as specified in C-17-010-002/ME-001. Consideration should also be given to including a requirement for the contractor to mark wires and cables in such a manner that maintenance personnel can visually identify the EMC category for each wire or cable. Acceptable marking schemes for categorizing EMC can be found in C-17-010-002/ME-001. An alternative scheme used by some fleets is a wire information electronic database to record important data covering wire, cable, connections, routing, harness identification, symbology, Electromagnetic Interference (EMI) separation, wiring categories, etc., to provide Life Cycle Maintenance Managers (LCMMs) and maintenance personnel with sufficient data to manage the configuration and maintain the integrity of the electrical wiring interface system.

3. Further to the above, CFTO C-17-010-002/ME-001 provides instructions for terminating shields on shielded and coaxial cables.

3.8A.7 Phase Imbalance

1. It is important for a three-phase system to have a balanced or nearly balanced load. The neutral current in a balanced system is zero. When a phase imbalance occurs, a current flows in the neutral conductor, which is proportional to the degree of imbalance. This can result in increased problems with Electrical Environmental Effects (E3). The first step in working towards an acceptable E3 baseline is to minimize electrical problems of this nature.

2. If one phase of a three-phase system is significantly more heavily loaded, several problems and complications can arise. It is possible that the source capacity of the heavily loaded phase could be exceeded, resulting in a dangerous overload condition. The overloaded phase could become overheated, leading to premature failure of the generator. The voltage output of that phase would probably be pulled lower than the other two phases as well, resulting in an unbalanced voltage feed to all three phase loads connected to that generator. The output voltage of that phase would probably no longer be a sine wave, meaning that there would be harmonic distortion content. These generated harmonics could, in turn, add to E3 problems.

3. The voltage regulation of the overloaded phase would also be compromised and transient power demands could cause voltage transients. Voltage transients can cause numerous problems, especially if they transmit through to DC buses.

3.8A.8 Spare Circuits

1. For new aircraft, allowance should be made for a minimum of ten percent increase in the number of main cable runs, connectors, circuit breakers and fuse holders to facilitate through life development of aircraft systems. Sufficient space should be left in junction boxes and control panels for such increases.

2. For upgrades to existing aircraft, a five percent growth margin is acceptable.

3. DEF STAN 00-970 and SAE ARP 4404 provide additional guidance regarding expansion provisions for additional circuits.

ANNEX B

ADDITIONAL DND/CAF WIRE REQUIREMENTS

3.8B

1. The major civilian and military wiring standards, as detailed in 3.8.4, Guidance Information – Electrical Power Distribution, are largely acceptable to the DND/CAF, with the exception of some wire insulating and conductor materials. These exceptions are detailed in the following paragraphs.

2. **Prohibition of MIL-DTL-81381 (Kapton) Wiring.** Polyimide-based wiring insulation (commonly known by the Du Pont trade name Kapton) has been found to be vulnerable to pyrolization, arc tracking and flashover when momentary short-circuit arcs have occurred on aircraft power systems. Short-circuit arcs between wire pairs that pyrolize the polyimide insulation result in a conductive char between conductors that may sustain the arc (arc tracking). Furthermore, the arc tracking may spread (flashover) to other wire pairs within a wire bundle. For this phenomenon to occur, damaged insulation, a conductive path to another wire of different potential or ground and sufficient voltage and source current capability to sustain arcing are required. While typical arc propagation testing uses 115VAC, testing has shown that MIL-W-81381 wire will sustain a destructive arc at 28 VDC and a current of one ampere or less. As a further contribution to this phenomenon, this type of polyimide insulation is prone to hydrolytic degradation which alters the polymer characteristics and promotes radial cracking.

3. The DND/CAF policy regarding MIL-W-81381 insulated wires and cables is:

   a. For aircraft originally accepted into service with MIL-DTL-81381 (formerly MIL-W-81381) Kapton wire, no further use of this wire is permitted. Rewiring of the aircraft will not necessarily be required due to prohibitive costs and operational impact. However, consideration must be given to replacing Kapton installations during major upgrade programs.

   b. MIL-W-81381 Kapton is prohibited for in-service repairs and modifications which must be completed using the acceptable replacement wire types specified in C-17-010-002/ME-001.

   c. The prohibition against the introduction of this wire type onto DND/CAF aircraft also applies to hook-up wire and aerospace components and products.

4. **Polyimide Insulated Wiring Chemically Equivalent to MIL-W-81381 Kapton.** Numerous commercial specification wire types exist that are chemically equivalent to MIL-W-81381 Kapton wire. The introduction of these wire types into DND/CAF aerospace product is prohibited. All wire types proposed for introduction into CAF fleets must conform to the requirements of Annex C of this chapter.

5. **Prohibition of Polyvinyl Chloride (PVC) Insulated Wiring.** Burning PVC releases hydrogen chloride (HCl) gas, which is very acidic in the presence of moisture. The HCl poses a health threat and, along with smoke, can be transported throughout the ventilated areas of an aircraft. The acidic HCl will also corrode electronic equipment. Coaxial cables historically have relied on PVC jackets in their manufacture. Some instances may arise where a PVC jacketed cable has no replacement. Cables falling into this category already installed on existing fleets may be retained providing a risk assessment is made to identify any safety hazards and to make a determination as to whether the wire must be replaced or if changes to the maintenance program will be necessary to ensure that the wire is given extra attention. However, consideration must also be given to replacing PVC wiring, where possible, in the flight deck, cabin. For new acquisitions or modifications to existing aircraft, the contract document must specify that PVC insulated wire shall not be used. The prohibition against the introduction of this wire type onto DND/CAF aircraft also applies to hook-up wire and aerospace components and products.

6. **Hybrid Polyimide Insulated Wiring.** In an attempt to overcome the deficiencies of polyimide insulation, a hybrid construction has been introduced and widely accepted by the civil aviation industry and for use in some military aircraft. The hybrid wire types in question are those specified as MIL-W-22759/80 to MIL-W-22759/92; the insulation consists of an aromatic polyimide insulation sandwiched between two layers of fluoropolymer. The aromatic polyimide film used in this type of wire differs in its chemical properties from that originally used in MIL-W-81381 in that its susceptibility to hydrolysis has been dramatically reduced. This is a relatively new innovation

and appears to have eliminated many of the problems experienced with Kapton. However, all insulation chemistries have some weakness and, while this hybrid has performed well, it may not have been in service long enough yet for any faults to emerge, remembering that Kapton faults took six to eight years to surface initially. For this reason the use of hybrid polyimide insulated wire in DND/CAF aircraft is regulated and approval must be sought from the TAA. When proposed, details of quantities and areas of use must be well documented in the submission to the TAA.

7. DEF STAN 00-970 places restrictions on the use of wire and cable containing polyimide insulation in their construction; Leaflets 706/1 and 707/1 provide guidance regarding permissible applications for wire and cable containing polyimide insulation and limitations/restrictions regarding its use. For DND/CAF policy regarding the prohibition and exemption process for polyimide insulated wire, refer to Annex C of this chapter.

8. **Ribbonized Arranged Cable Systems.** This cabling system uses military specification wire woven into a flexible harness. As an extremely flexible wiring arrangement, ribbonised cable offers advantages in weight reduction and heat dissipation and allows a consistent baseline to be set for electromagnetic compatibility (EMC) design. Use of composite circular connectors is another weight saving measure which complements ribbonised cable, but they do not have the same level of immunity to the effects of lightning as metal connectors. Overall, ribbonised cable systems are not considered suitable for use in DND/CAF aircraft, as they have proved problematic. Accordingly, ribbonised wire installations are not approved for use in DND/CAF aircraft. Any proposals to use ribbonized cable systems in DND/CAF aircraft must be submitted, in accordance with Annex C of this chapter.

9. **In-Line Splices.** In-line splices are to be avoided. However, if this is not possible, the restrictions on the use of splices shall be in accordance with C-17-010-002/ME-001. The location of splices used to assemble sub-assemblies shall be clearly defined in the aircraft drawings. In general, splices are considered to be a temporary repair to wiring and the damaged wire will be replaced during maintenance. Due to possible degradation over time and unquantifiable reliability data, splices must not be permanently installed in flight critical systems or those containing electro-explosive devices. Flight critical systems are defined as those whose failure could result in the loss of the aircraft or crew.

10. **Minimum Wire Size.** The minimum wire size for aircraft hook-up wire is AWG 22. This restriction is due to the problematic nature of installations using wires of a smaller AWG. In addition, smaller AWG sizes introduce difficulties with handling, identification and marking. Proposals to use wire smaller than AWG 22 must be supported by full substantiation and be referred to the TAA for approval.

ANNEX C

GUIDANCE INFORMATION FOR SEEKING TAA APPROVAL TO INTRODUCE A NEW WIRE TYPE INTO DND/CAF AIRCRAFT

3.8C

1. Under the direction of the Director of Technical Airworthiness and Engineering Support, who holds responsibility as the Technical Airworthiness Authority (TAA) for Canadian Armed Forces Aircraft fleets, persons seeking approval for the introduction of a new wire type in DND/CAF aircraft not listed in C-17-010-002/ME-001 must formally submit to the TAA the following information:

   a. a copy of the specification to which the wire has been tested in English or bilingual English/French.

   b. verification that the wire/cable in question has been tested and qualified by an agency recognized by the TAA and in accordance with recognized test practices and standards.

   c. a copy of the Qualification Testing results/report produced by the facility responsible for testing of the product.

NOTES

1. *Qualification standards presently deemed acceptable by the TAA for the testing of wire are:*

   a. *MIL-STD-2223, "Test Methods for Insulated Electrical Wire".*

   b. *DEF STAN 61-12 Part 0, "Wires Cords and Cables Electric".*

2. *Levels of review. TAA review may vary from examination of the submitted qualification standard for equivalency and acceptability to the conduct of actual physical testing on wire samples.*

3. *The TAA will provide a written response through the WSM/PMO indicating approval or denial of the requested approval.*

4. *New wire types, approved by the TAA, will be listed in C-17-010-002/ME-001.*

5. *Quality standards for wire testing currently deemed acceptable to the TAA are MIL-STD-2223 and DEF STAN 61-12.*

2. Wire proposed for use in DND/CAF aircraft must not contain any known detrimental properties or design deficiencies that would knowingly introduce a hazardous condition into the aircraft. Such properties include: wet and dry arc propagation, hydrolysis, generation of hazardous quantities of smoke, poor self-extinguishing properties or lack of robustness which could accelerate deterioration from the environmental or physical conditions typically found in the aerospace environment.

3. Wire that has not successfully undergone qualification testing to an acceptable quality standard recognized and approved by the TAA must not be used in DND/CAF aircraft.

4. All submissions are to be forwarded to:

DGAEPM
National Defence Headquarters
101 Colonel By Drive
OTTAWA, Ontario, K1A 0K2
Canada
Attention: DTAES 6

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 9 — AIRCRAFT LIGHTING AND NIGHT VISION IMAGING (TO BE PROMULGATED)

3.9.1 Introduction (To Be Promulgated)

3.9.2 Lighting System – Airworthiness Requirements (To Be Promulgated)

3.9.3 Night Vision Imaging Systems – Design Requirements (To Be Promulgated)

ANNEX A

NIGHT VISION IMAGING SYSTEMS – ANVIS HUD AND HMD (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 10 — PROPULSION SYSTEMS

3.10.1 Introduction

1. This chapter identifies the airworthiness design standards and associated guidance information accepted by the Technical Airworthiness Authority (TAA) for military and civil pattern engines. This chapter will not delve into the process leading to the certification of an engine. The process is similar enough to the generic aircraft certification. The design standards are, however, unique to aircraft engines.

2. As per the TAM, Part 2, Chapter 1, Section 1, *"The intention of the Technical Airworthiness Program is not to proceed with the type certification of an engine or propeller type design that is separate from the aircraft type on which it is installed. ...In most cases, the airworthiness approval for an engine or propeller type design will be included as part of the airworthiness approval granted to an aircraft type design during the type certification process."* Therefore, a Type Certificate will normally not be issued against an engine type. Once an engine has been deemed acceptable by the TAA, it will simply fall under the umbrella of the aircraft Type Certificate.

3.10.2 Scope

1. At this time, this chapter is limited to engine requirements; it does not address its installation into an airframe. From a hardware perspective, this limitation can best be described as relating to the highest-level assembly produced by an engine manufacturer. As examples, the term "engine" for the CC130 means the T56 turbo-prop, including the reduction gearbox but excluding the propeller; for the CH146, "engine" means the PT6T-3D turbo-shaft, including the combining and accessory gearboxes. A future revision of this chapter will address propeller requirements and the incorporation of an engine into an airframe, i.e., a powerplant.

NOTE

> ***Engine – Installed and Uninstalled.*** *During the conduct of certification activities, individuals involved must be cognizant of whether or not their task is related to an engine installed into an airframe, herein referred to as installed and uninstalled. Engine performance and the certification requirements are significantly different between the two scenarios. For example, the performance of an uninstalled engine is higher which, for specific fuel consumption and specific thrust, can be by as much as 10 per cent (J D Mattingly, W H Heiser, D T Pratt, Aircraft Engine Design, 3rd Ed, AIAA, Reston VA, 2002.), compared to the same installed engine.*

2. This chapter is limited to air breathing engines, of the following types:

   a. Gas turbines, namely the turbo-shaft, turbo-prop, turbo-jet and turbo-fan.

   b. Reciprocating engines.

3. **Terminology**. The following definitions apply for this chapter of the ADSM:

   a. Engine: (Oxford, 10th Ed, 2001) *"a machine with moving parts that converts power into motion"*. In the context of the ADSM, it is a device for converting the calorific energy of fuel into thrust or shaft power.

   b. Engine Structural Integrity Program (ENSIP): (MIL-HDBK-1783B, 15 Feb 02) *"An organized and disciplined approach to the structural design, analysis, qualification, production, and life management of gas turbine engines"*. The goal of ENSIP is to ensure engine structural safety, durability, reduced life cycle costs, and increased service readiness.

c. Gas Turbine: (Termium) *"A type of engine which consists of an air compressor, a combustion section, and a turbine. Thrust is produced by increasing the velocity of the air flowing through the engine".* Thrust can be transformed into mechanical power.

d. Power Plant: (Termium) *"Any source of power, together with its housing, installation and accessory equipment"*. In the context of the ADSM, it means an installed engine and its ancillary systems (i.e., governor, lubrication, cooling ...).

e. Propulsion System: (Termium) *"A system consisting of a power-unit and all other equipment utilized to provide those functions necessary to sustain, monitor and control the power/thrust output of any one power-unit following installation on the airframe"*. In the context of the ADSM, it can be used interchangeably with "power plant".

f. Reciprocating Engine: (Termium) *"An engine in which the to-and-fro motion of a piston is changed into circular motion by a crankshaft"*.

3.10.3 Standards

1. Figure 3-10-1, Paragraphs 1 to 4 and Figure 3-10-2 list acceptable airworthiness design standards that may be selected to form the certification basis for new acquisitions and/or proposed design changes to an approved engine design. Figure 3-10-1, Paragraphs 5 to 7 will need to be used by a Project Authority, as part of an engine or aircraft acquisition program, as they may apply to the intended role.

Military Airworthiness Design Standards
1. **DEF STAN 00-971** (dated 29 May 1987) – applicable to gas turbines.
2. **JSSG-2007** (dated 30 Oct 1998) – applicable to gas turbines.
3. **MIL-E-005007E(AS)** (dated 1 Sep 1983) – applicable to turbo-jet and turbo-fan engines.
4. **MIL-E-008593E(AS)** (dated 1 Mar 1984) – applicable to turbo-shaft and turbo-prop engines.
5. **Maritime Aircraft Operating Consistently at Low Altitudes.** The applicant shall ensure that the engine has a demonstrated capability to operate in a salt-laden environment, in accordance with, one of the following sources:
a. **DEF STAN 00-971,** Sections 9.4 and 19.1.2.1 Procedure A.
b. **JSSG-2007,** Section 3.3.1.3.
c. **MIL-E-008593E(AS),** Sections 3.2.5.5 and 4.6.4.3.
d. **MIL-E-005007E(AS),** Sections 3.2.5.6.4. and 4.6.4.7.
6. **Rotorcraft Earmarked to Deploy in a Sandy Environment.** The applicant shall ensure that the engine has a demonstrated capability to operate in a sand-laden environment, in accordange with, one of the following sources:
a. **DEF STAN 00-971,** Sections 9.8 and 19.1.6.
b. **JSSG-2007,** Section 3.3.2.4.
c. **MIL-E-008593E(AS),** Sections 3.2.5.6.4 and 4.6.4.7.
d. **MIL-E-005007E(AS),** Sections 3.2.5.6.4 and 4.6.4.7.
7. **For Airplanes Earmarked to Operate Occasionally from Dirt Strips, and All Rotorcraft.** The applicant shall ensure that the engine rotating components have demonstrated a minimum capability to operate with damage from Foreign Object Damage (FOD), in accordance with, one of the following sources:
a. **DEF STAN 00-971,** Sections 9.9 and 19.1.14.
b. **JSSG-2007,** Section 3.3.2.2.
c. **MIL-E-008593E(AS),** Sections 3.2.5.6.2 and 4.6.4.5.
d. **MIL-E-005007E(AS),** Sections 3.2.5.6.2 and 4.6.4.5.

Figure 3-10-1 Military Airworthiness Design Standards Related to Engine Design

Civil Airworthiness Design Standards
1. **FAR Part 33** – applicable to gas turbines and reciprocating engines.
2. **JAR-E** – applicable to gas turbines and reciprocating engines.
3. **TCCA Airworthiness Manual, Part V, Chapter 533** – applicable to gas turbines and reciprocating engines.

Figure 3-10-2 Civil Airworthiness Design Standards Related to Engine Design

3.10.4 Guidance Information – Civil Certificated Propulsion Systems

1. As mandated by FAR 23.901, 25.901, 27.901 and 29.901, and the TCCA CARs Part V AWM corresponding requirements, the airframe manufacturer is responsible for addressing the airworthiness requirements for the installation of an engine type into an airframe, with the close collaboration of the engine original equipment manufacturer (OEM). The airframe manufacturer will design the aircraft interface for the engine, based on the engine limitations published in the engine OEM's interface document (commonly known as the Installation Instruction or Manual). FAR 23.903, 25.903, 27.903 and 29.903, and the CARs Part V AWM corresponding requirements, require that the engine selected be Part 33 (or Chapter 533) certificated.

3.10.5 Guidance Information – Civil Certificated Engines

1. With civilian aircraft certification, a FAA or TCCA Engine Type Certificate may list multiple engine variants so long as they are derivatives of the initial type certificated engine shown on the certificate. In such a case, the Type Certificate Data Sheet (TCDS) would partition pertinent data for each variant.

2. The Type Certification data for a FAA or TCCA certificated engine must be read carefully. There are two requirements in FAR Part 33 and AWM Chapter 533 in which the engine's capability to ingest foreign objects may be deferred or waived. Firstly, as per FAR 33.76(a)(6) and AWM 533.76(a)(6), a certificated engine may have no demonstrated capability to withstand bird strikes. The engine type certification documentation would then limit the installation into an airframe in which it can be demonstrated that a bird could not strike or be ingested in the engine, or adversely restrict the engine's airflow.

3. The second case concerns FAR 33.77(d) and AWM 533.77(d). Sections 33.77 and 533.77 mandate a capability to ingest foreign objects, more specifically an ice slab, without causing a power loss or requiring the engine to be shut down. This case is similar to 3.10.5.2 above but the caveat does not conclude with a limitation in the installation documentation. In the case where an engine incorporates a protective device, the capability to ingest foreign objects need not be demonstrated. It must however be shown that the foreign object could not pass through the device, that the device could withstand the impact of the foreign object and that, if stopped by the device, the foreign object would not adversely restrict the engine's airflow.

3.10.6 Guidance Information – U.S. DoD Military Qualified Engines

1. Details of engines manufactured for U.S. military applications will be recorded in a document called an Engine Specification. Each specification covers a specific engine model. U.S. DoD engines differ from civilian engines; e.g., by operating with a military power rating structure (especially since few engines have been developed under the relatively flexible JSSG-2007). Additionally, since a military engine is developed for a specific airframe, the Engine Specification will reflect the provisions for meeting the requirements of that application.

2. As explained in 1.4.3 of the ADSM, military design standards combine performance and airworthiness requirements. Additionally, the engine qualification process differs from the civil approach. The specification and the means of compliance are negotiated between the engine OEM, the airframe manufacturer and the customer. There is no involvement of an independent regulatory body. The specification is negotiated and customized by using, generally, one of the standards listed in Figure 3-10-1. A military engine seldom meets verbatim a military design standard; instead, the engine will be required to meet its specific Engine Specification.

3.10.7 Guidance Information – Selection of Airworthiness Design Standards

1. The basic structure, strengths and weaknesses of the design standards listed in Figure 3-10-1 and Figure 3-10-2 are summarized in 1.4.3 and 1.4.4 of the ADSM.

2. FAR AC 33-2B "Aircraft Engine Type Certification Handbook" is an excellent introduction into the topic of engine certification and its perusal is strongly recommended, even for cases of military engine qualification.

3. Because they define more than an acceptable level of safety, care must be used when referring to military standards. For example, in a single document, DEF STAN 00-971 defines performance requirements for all types of gas turbines, of all sizes and all applications. A realistic approach requires the applicant to review the standard in detail and customize and specify the requirement for the specific end-use. Even though they represent a greater level of specialization, caution must also be used when referring to the U.S. DoD's MIL-E standards (Figure 3-10-1). For example, the application of MIL-E-008593E(AS) ranges from turbo-prop engines for fixed-wing maritime patrol aircraft to turbo-shafts installed on attack helicopters.

4. JSSG-2007 adopts the latest U.S. DoD approach to capital acquisition documentation. It is structured to provide flexible guidelines, along with descriptive text to cater for specific needs. Its content is a compendium of previously released U.S. DoD engine design standards; however, it excludes specific parameters. The procuring agency determines the performance parameters based on the included guidance material. This approach provides maximum flexibility to cater for differing turbine type and operating environments. The drawback is that the guidance material is often insufficient to determine the performance parameters. Other reference documents and Subject Matter Experts (SMEs) must be consulted in order to finalize the specification.

5. Propulsion expertise is provided by DTAES 7 SMEs, who can also call on the assistance of The Propulsion Laboratory of the Structures/Materials/Propulsion Laboratories Division at the National Research Council.

3.10.8 Guidance Information – Engine Structural Integrity Program (ENSIP)

1. In the case of a capital acquisition program where DND will become owner of the assets, it is strongly recommended that DND Project Authorities adopt ENSIP principles to allow for the proper in-service management of engines. This approach is easier to implement when the acquisition is for equipment originating from U.S. DoD programs.

2. MIL-HDBK-1783B describes ENSIP activities throughout a U.S. DoD engine development and acquisition program, in five major tasks. Tasks I to IV represent the Research and Developement (R&D) activities that lead to an engine qualification. Task V, entitled "Engine Life Management", enables the in-service management of the engines.

3. Since DND procures commercial-off-the-shelf (COTS) engines, it is highly recommended that a Project Authority places a contractual obligation on the contractor to develop an ENSIP plan to mirror the activities of Task V, to include:

a. a technical data package, including engineering data associated with the structural development of the engine.

b. a usage monitoring capability.

c. a recurring review of the actual usage against the design usage.

4. The content and level of detail specified for the technical data package will need to be carefully developed, since there is a significant cost associated with engineering data. The plan will require the definition of a usage monitoring capability. Refer to ADSM Part 3, Chapter 17 – Health and Usage Monitoring Systems (HUMS) for Rotorcraft for additional details. The three elements of 3.10.8.3, need to be developed, approved and validated before the beginning of the in-service phase.

5. The recurring review of the usage represents a feedback loop and confirms whether the propulsion system is being operated within the design usage. This activity is essential in order to demonstrate whether the actual usage deviates from the design usage. The determination that the actual usage is more demanding than the design usage

will allow due diligence to be applied through an intervention before structural failures start to occur. Conversely, in the case of a benign usage, a review of the data has the potential to yield an increase in engine component lives.

6. ENSIP, along with the usage monitoring program and technological progress, could also lead to the introduction of the retirement-for-cause philosophy, therefore yielding greater maintenance cost savings. SAE AIR 1872 provides some guidance material for the management of engine parts and also contains a brief summary of the retirement-for-cause approach in its Appendix I.

3.10.9 Associated Publications and Standards

1. The following source references in Figure 3-10-3 are associated with the design, installation, maintenance and in-service usage of aircraft engines.

Regulator or Organization	Number	Title
FAA	FAR 33	Airworthiness Standards: Aircraft Engines
	AC33-2B	Aircraft Engine Type Certification Handbook
JAA	JAR-E	Engines
SAE	AIR 1872	Aerospace Information Report – Guide to Life Usage Monitoring and Parts Management for Aircraft Gas Turbine Engines
TCCA	CAR 533	Airworthiness Manual Chapter 533 – Aircraft Engines
UK MoD	DEF STAN 00-971	General Specification for Aircraft Gas Turbine Engines
U.S. DoD	JSSG-2007	Engines Aircraft Turbine
	MIL-HDBK-1783B	Engine Structural Integrity Program (ENSIP)
	MIL-E-005007E	Engine Aircraft Turbo-Jet and Turbo-Fan General Specification
	MIL-E-008593E	Engine Aircraft Turbo-Shaft and Turbo-Prop General Specification

Figure 3-10-3 Associated Publications and Standards Related to Aircraft Engines

3.10.10 Powerplant Installation (To Be Promulgated)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 11 — AIRCRAFT FUEL SYSTEMS

3.11.1 Introduction

1. This chapter defines design standards and associated advisory material accepted by the Technical Airworthiness Authority (TAA) for aircraft fuel systems. It has been written to take into account that the DND acquires and operates a mix of military and civil pattern aircraft. Because of its focus, this chapter is a good starting point in defining a certification basis for design changes related to those systems.

3.11.2 Scope

1. This chapter provides fuel system design standards and advisory material.

2. This chapter is also meant to complement ADSM Part 3, Chapter 10 – Propulsion Systems. The engine manufacturer generates the bulk of the data required under Chapter 10. As the aircraft systems' integrator, the aircraft manufacturer will use the engine interface documentation, and design its installation into the aircraft. The engine(s) become(s) the powerplant.

3. **Terminology.** The powerplant and fuel systems are defined as follows:

a. Powerplant: (Termium Plus®) "Any source of power, together with its housing, installation and accessory equipment". In the context of the ADSM, it comprises the installed engines and, when it is integral to the engines, the reduction gearbox. Its primary function is to generate thrust or shaft power and it may also perform secondary tasks, such as driving hydraulic pumps and electrical generators and providing bleed air for engine starts and/or the Environmental Control System (ECS). Generally, the powerplant also includes a number of support systems, usually provided by the aircraft, such as: bleed air; air intake and exhaust; oil cooling; engine compartment draining, venting and cooling; structural support of the engine; fire protection and suppression; and the fuel feed interface.

b. The fuel system in particular comprises the tanks, pumps, filters, quantity gauges, refuelling/defuelling components and fuel feed up to, but excluding, the engine(s). Fuel consumption may cause the aircraft centre of gravity (CofG) to shift laterally or longitudinally throughout a flight. Thus, there may be a fuel management system, as a subordinate function of the fuel system, which will maintain the aircraft CofG within acceptable limits.

4. The terms 14 CFR Part XX, CS Part XX and AWM 5XX correspond to FAA Title 14 CFR Parts 23 to 29, EASA CS Part 23 to 29 and TCCA AWM Chapters 523 to 529, respectively.

3.11.3 Standards

1. The following airworthiness design standards of Figure 3-11-1, Figure 3-11-2 and Figure 3-11-3 are applicable to DND/CAF aircraft fuel systems.

Military Airworthiness Design Standards	
1.	**DEF STAN 00-970,** Part 1, Section 5, Issue 2.
2.	**U.S. DoD MIL-HDBK-516C,** Airworthiness Certification Criteria, Section 7 – Propulsion and Propulsion Installation
3.	**European Military Airworthiness Certification Criteria (EMACC),** Section 7 – Propulsion and Propulsion Installation

Figure 3-11-1 Military Airworthiness Design Standards Related to Aircraft Fuel Systems

Civil Airworthiness Design Standards	
1.	**AWM 5XX,** Subchapter E
2.	Regardless of the specification or standard used as a certification basis, the aircraft must have a demonstrated capability to operate in falling or blowing snow, in accordance with the requirement of AWM 5XX.1093(b), for “Snow Clearance” level (refer to TCCA AC 500-008)
3.	**14 CFR Part XX,** Subpart E – Powerplant
4.	**CS Part XX,** Subpart E – Powerplant

Figure 3-11-2 Civil Airworthiness Design Standards Related to Aircraft Fuel Systems

DND/CAF-Ratified International Design Standards	
All Aircraft	
1.	Regardless of the specification or standard used as a certification basis, all aircraft shall have electrical bonding jacks located adjacent to all refuelling points compliant with STANAG 3632.
Aircraft Fitted with a Pressure Refuelling System	
1.	The aircraft shall have a pressure refuelling system compliant with STANAG 3105.
Rotorcraft Earmarked to Conduct Hover-in-Flight-Refuelling (HIFR) Operations	
1.	The aircraft shall have a refuelling system compliant with STANAG 3847.

Figure 3-11-3 DND/CAF-Ratified International Design Standards Related to Aircraft Fuel Systems

3.11.4 Guidance Information – Propulsion System Certification

1. The airframe manufacturer is traditionally responsible for addressing the airworthiness requirements for the installation of the engine into the airframe, with the close collaboration of the engine original equipment manufacturer (OEM). The airframe manufacturer will design the aircraft interface for the engine with the standards listed at 3.11.3 above. While doing so, the airframe manufacturer must adhere to the engine design parameters published in the engine OEM’s interface document (referred to, in 14 CFR Part 33, as the Installation Instruction). 14 CFR XX.903 and AWM 5XX.903 both require that the engine selected for installation be Part 33- or Chapter 533-certificated, respectively. Unlike the civil airworthiness codes, the military codes treat the engine certification and the engine installation as part of the entire aircraft certification.

2. The DND/CAF can neither afford, nor justify the efforts required to sustain unique and indigenous airworthiness design standards for powerplants. Consequently, the certification basis of a new type design or design change regulated by the DND/CAF Airworthiness Program will normally comprise civil or military design standards established by aviation regulatory authorities recognized by the TAA.

3. As explained in FAA AC 33-2B, Chapter 3, Paragraph 47i, the capability to operate in heavy snow conditions must be demonstrated at the aircraft level, rather than at the engine level.

3.11.5 Guidance Information – Fuel System Certification

1. **Fuel Tank Crashworthiness.** For many years, the U.S. DoD mandated that fuel tanks should meet the demanding requirements of its free-fall drop test. Briefly, MIL-T-27422B, Section 4.6.7.9, specified the following for fixed and rotary wing aircraft:

a. each tank is to be filled at 100% with water.

b. the tank must withstand a 65 feet drop without rupturing.

2. However, the current version of the 14 CFR/CS/AWM XX.952 for normal and transport category rotorcraft requires the following:

a. each tank is to be filled to 80% capacity.

b. the tank is to be enclosed in a representative portion of the airframe.

c. the tank is to be dropped from a minimum height of 50 feet without rupturing.

3. In 1998, the U.S. Department of Defense issued the new standard JSSG-2009, titled Aircraft Vehicle Subsystems. Annex E to the JSSG addresses fuel subsystems. JSSG-009 used a very different approach compared to the old fuel system standard, MIL-T-27422B. The JSSG is a specification guide and, as such, is informative, rather than prescriptive. Despite the fact that JSSG-2009 refers to a similar military drop test requirement as described in MIL-T-27422B, the resulting design may, in some cases, yield lower overall levels of crashworthiness.

4. It is common occurrence during a DND procurement of civilian pattern rotorcraft to mandate the incorporation of the ballistic self-sealing protection on the fuel tanks, to enhance the aircraft survivability. Since this causes a redesign effort and consequently a retest of the fuel tanks, it is strongly recommended to use this opportunity to mandate the better crashworthiness requirements of MIL-T-27422B.

3.11.6 Associated Publications and Standards

1. The following source references in Figure 3-11-4 are associated with the design, installation, maintenance and in-service usage of powerplants and fuel systems.

Regulator or Organization	Number	Title
FAA	AC 20-29B	Use of Aircraft Fuel Anti-Icing Additives
	AC 20-53A	Protection of Aircraft Fuel Systems Against Fuel Vapour Ignition Due to Lightning
	AC 20-73	Aircraft Ice Protection
	AC 20-119	Fuel Drain Valves
	AC 20-147	Turbojet, Turboprop, and Turbofan Engine Induction System Icing and Ice Ingestion
	AC 23-16A	Powerplant Guide for Certification of Part 23 Airplanes and Airships (nearly 200 pages of guidance material dedicated to Subpart E)
	AC 25.981-1B	Fuel Tank Ignition Source Prevention Guidelines
	AC 25.981-2	Fuel Tank Flammability Minimization
	AC 27-1B	[Large Aircraft] Certification of Normal Category Rotorcraft [All changes incorporated]
	AC 29-2C	[Large Aircraft] Certification of Transport Category Rotorcraft [All changes incorporated]

Figure 3-11-4 (Sheet 1 of 2) Associated Publications and Standards Related to Powerplants and Fuel Systems

Regulator or Organization	Number	Title
FAA (Cont)	14 CFR Part 23, 25, 27 and 29 Subpart E	Powerplant
U.S. DoD	MIL-HDBK-516C	U.S. DoD Airworthiness Certification Criteria
	European Defence Agency (EDA)	European Military Airworthiness Certification Criteria (EMACC)
	JSSG-2001	Air Vehicle
	JSSG-2009, Annex E	Aircraft Vehicle Subsystems, Fuel Subsystem
	MIL-F-8615	Fuel System Components; General Specification for
	MIL-F-17874B	Fuel Systems: Aircraft, Installation and Test of
	MIL-F-87154	Fuel Systems: General Design Specification
	MIL-I-87239	Installation, Engine
	MIL-T-5578C	Tank, Fuel, Aircraft, Self-Sealing
	MIL-T-27422B	Tank, Fuel, Crash & Resistant, Aircraft
UK MoD	DEF STAN 00-970, Vol 1, Issue 1, Part 7	Design and Airworthiness Requirements for Service Aircraft, Aeroplanes, Installations
	DEF STAN 00-970, Vol 2, Issue 1, Part 7	Design and Airworthiness Requirements for Service Aircraft, Rotorcraft, Installations
	DEF STAN 00 970,Part 1, Section 5, Issue 2	Design and Airworthiness Requirements for Service Aircraft, Powerplant
NATO	STANAG 3105	Pressure Refuelling Connections and Defuelling for Aircraft
	STANAG 3632	Aircraft and Ground Support Equipment Electrical Connections for Static Grounding
	STANAG 3847	Helicopter In-Flight Refuelling (HIFR) Equipment
TCCA	AC 500-008	Induction System Snow Protection (formerly AMA 500/7A)
	AWM 523, 525, 527 and 529 Subpart E	Powerplant

Figure 3-11-4 (Sheet 2 of 2) Associated Publications and Standards Related to Powerplants and Fuel Systems

3.11.7 Flexible Fuel Cells

1. This section identifies the airworthiness design standards and associated guidance accepted by the TAA for application to aircraft flexible fuel cells.

2. **Aerospace Elastomeric Materials**

   a. Although “elastomer” is synonymous with “rubber”, it is more formally “*a high polymer that can be or has been modified to a state exhibiting little plastic flow and quick or nearly complete recovery from an extending force.*” Such material, before modification, is frequently referred to as crude rubber. Common aerospace elastomeric materials are aircraft tires, aerospace flexible hose assemblies, fuel cells and “O-ring” seals.

   b. A Fuel Cell is a flexible container, usually of rubber, rubber and nylon, or all nylon construction, which can be removed from an aircraft. Fuel Cells are subdivided into two categories, those that are self-sealing, and those, namely bladder and nylon cells, which are not self-sealing.

3. **Airworthiness Design Standards for Flexible Fuel Cells.** The standards identified in Figure 3-11-5 and Figure 3-11-6 assist engineering staff with the type design of aircraft flexible fuel cells. Whenever possible, the benefits of the more stringent specifications should be considered.

Military Design Standards	
1.	**MIL-DTL-27422,** Rubber Property – Effects of Liquids – Standard Test Method for Ref B
2.	**MIL-DTL-27422C,** Rubber Property – Effects of Liquids – Standard Test Method for Ref B
3.	**MIL-DLT-5578,** Detail Specification, Tank, Fuel, Aircraft, Self-Sealing
4.	**MIL-DLT-6396,** Tanks, Aircraft Propulsion Fluid System, Internal, Removable, Non-Self Sealing

Figure 3-11-5 Military Design Standards Related to Flexible Fuel Cell

Civil Design Standards	
1.	**American Society for Testing and Materials (ASTM) D381,** Fuels, Gum Content – Standard Test Method by Jet Evaporation (U.S. DoD adopted)
2.	**ASTM D412,** Rubber, Vulcanized and Thermoplastic Elastomers-Tension (U.S. DoD adopted)
3.	**ASTM D413,** Rubber Property – Adhesion to Flexible Substrate – Standard Test Methods (U.S. DoD adopted)
4.	**ASTM D471,** Rubber Property – Effects of Liquids – Standard Test Method for Ref B (U.S. DoD adopted)
5.	**ASTM D910,** Gasoline, Aviation (U.S. DoD adopted)
6.	**FED-STD-191,** Textile Test Methods
7.	**FED-STD-601,** Rubber, Sampling and Testing
8.	**FED-STD-791,** Testing Methods of Lubricants, Liquid Fuels, and Related Products

Figure 3-11-6 Civil Design Standards Related to Flexible Fuel Cell

4. **Guidance Information – Flexible Fuel Cells.**

a. MIL-DTL 27422 covers the requirements and verification testing for crash-resistant, ballistic-tolerant fuel cell for use in rotorcraft and tilt rotorcraft. Exact design criteria, such as fuel cell dimensions, total weight, and interface requirements, will be dependent upon the aircraft specified in the contract or purchase order.

b. MIL-DTL 5578 covers the specifications for self-sealing and partially self-sealing fuel tanks for use on aircraft. A tank consists of a cell, or a group of cells interconnected, and the components attached directly thereto, to form a complete tank or reservoir.

c. MIL-DTL 6396 covers the specifications for internal, removable, non-self-sealing fuel tanks, including tank fittings for use on aircraft.

d. Crash-resistant, ballistic-tolerant, fuel cells will be in one of the following classes, types and protection levels:

(1) **Class A.** Flexible fuel cell construction.

(2) **Class B.** Semi-rigid or self-supporting fuel cell construction.

(3) **Type I.** Self-sealing or partially self-sealing.

(4) **Type II.** Non-self-sealing.

(5) **Protection Level A.** The fuel cell is completely self-sealing against .50 calibre and 20mm (entry wound only for 20 mm).

(6) **Protection Level B.** Part of the fuel cell is non self-sealing and part is self-sealing against .50 calibre and 20mm (entry wound only for 20 mm).

(7) **Protection Level C.** Part of the fuel cell is self-sealing against .50 calibre and part is self-sealing against 14.5 mm.

(8) **Protection Level D.** The fuel cell is completely self-sealing against 14.5 mm and 20 mm (entry wound only for 20 mm).

(9) **Protection Level E.** Part of the fuel cell is self-sealing against 14.5 mm and 20 mm (entry wound only for 20 mm) and part of the cell is non-self-sealing.

e. Self-sealing and non-self-sealing fuel cells manufactured under these specifications are intended for use as a means of carrying fuel (including aromatic constituents) under all prescribed operating conditions. Additionally, self-sealing and partially self-sealing fuel cells manufactured under these specifications will be used to prevent an excessive loss of fuel under gunfire conditions and provide a significant reduction in post-crash fires. It is desired that the service life of a fuel cell covered by these specifications be equivalent to the aircraft life in which they are installed.

5. **Associated Publications and Standards Related to Flexible Fuel Cells.** The reference material in Figure 3-11-7 is associated with the design and testing of aircraft flexible fuel cells.

Regulator or Organization	Number	Title
American Society for Testing and Materials (ASTM)	D381 D413 D471 D910	Standard Test Method for Gum Content in Fuels by Jet Evaporation Standard Test Methods for Rubber Property – Adhesion to Flexible Substrate Standard Test Method for Ref B Rubber Property – Effects of Liquids Standard Specification for Aviation Gasolines
DND/CAF	C-12-010-040/TR-014	Standard Repair Procedures, Description and Maintenance of Aircraft Fuel Cells and Tanks
USAF	TO 1-1-3	Inspection and Repair of Aircraft Integral Tanks and Fuel Cells
U.S. DoD	MIL-DTL-27422C	Detail Specification, Tank, Fuel, Crash-Resistant, Ballistic Tolerant, Aircraft
U.S. Office of Federal Supply Services, General Services Administration	FED-STD-191 FED-STD-601 FED-STD-791	Textile Test Methods Rubber, Sampling and Testing Testing Methods of Lubricants, Liquid Fuels and Related Products
USN	NAVAIR 01-1A 35	Maintenance Instructions Organizational, Intermediate and Depot, Aircraft Fuel Cells and Tanks

Figure 3-11-7 Associated Publications and Standards Related to Flexible Fuel Cells

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 12 — FIRE DETECTION AND SUPPRESSION (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 13 — AIRCRAFT TIRES

3.13.1 Introduction

1. This chapter identifies the airworthiness design standards and associated guidance accepted by the Technical Airworthiness Authority (TAA) for military and civil aircraft tires.

3.13.2 Aerospace Elastomeric Materials

1. Elastomers are commonly used in aerospace applications. Examples can be found in the aircraft tires, flexible hose assemblies, fuel cells and “O-ring” seals.

2. Aircraft tires must withstand a wide range of operational conditions. Heavy loads with high speed and high percent deflections make the operating conditions of aircraft tires extremely severe. High-speed taxi speeds and improper inflation pressure will reduce the tire life substantially.

3.13.3 Airworthiness Design Standards for Aircraft Tires

1. Standards identified in Figure 3-13-1 and Figure 3-13-2 provide Military and Civil Airworthiness Design Standards to assist engineering staff with proposed type design changes to aircraft tires. It should be noted that, whenever possible, the benefits of the more stringent specifications should be considered.

Military Airworthiness Design Standards
1. **D-13-001-001/SF-001,** Tires, Aircraft, Re-Treading
2. **MIL-T-5041H,** Tires, Aircraft, Military

Figure 3-13-1 Military Airworthiness Design Standards Related to Aircraft Tires

Civil Airworthiness Design Standards
1. **SAE AIR 5697,** Aerospace Landing Gear-FAA Regulatory History – Aircraft Wheels, Tires and Brakes
2. **SAE ARP 4834,** Tires, Aircraft, Re-Treading Practice – Bias and Radial
3. **SAE AS 4833,** Aircraft New Tire Standard – Bias and Radial
4. **SAE AS 50141A,** Tube, Pneumatic Tire, Aircraft

Figure 3-13-2 Civil Airworthiness Design Standards Related to Aircraft Tires

2. MIL-T-5041H covers the requirements for aircraft tube-type and tubeless tires. The document also refers to several MIL-STDs that form part of the MIL-T-5041 requirements.

3. SAE AIR 5697 contains regulatory and guidance information related to aircraft wheels, tires and brakes. It contains relevant TCCA Canadian Airworthiness Manual (AWM) and Title 14 Code of Federal Regulations (14 CFR) airworthiness standards in current and historic versions.

4. SAE ARP 4834 sets forth criteria for the selection, inspection, retread and repair of worn civil aircraft tires, and the means to verify that the re-treaded tire is suitable for continued service. This document establishes the recommended requirements for re-treaded tires used on civil aircraft.

5. SAE AS 4833 recommends performance standards and sets forth criteria for the selection and verification processes to be followed in providing tires that will be suitable for civil aircraft. This document encompasses new and re-qualified radial and bias aircraft tires. All new or re qualified tires are certified to these standards.

6. SAE AS 50141A establishes requirements for manufacturing, testing, identification, packaging and quality of aircraft tubes for application in commercial and military aircraft wheel assemblies.

3.13.4 Guidance Information – General

1. Figure 3-13-3 contains military and civil guidance material for aircraft tires.

Regulator or Organization	Number	Title
DND/CAF	C-13-010-001/AM-001	Maintenance Policy
	C-13-010-001/AM-002	Maintenance Policy, Dismounting, Mounting and Inflation of Aircraft Tires and Tubes
	C-13-010-001/AM-003	Maintenance Policy, Repair of Aircraft Tires And Tubes
	C-13-010-001/VP-000	Storage Instructions, Aircraft Tires and Tubes
	C-13-020-001/AM-000	Maintenance Policy, Inspection of Aircraft Tires and Tubes
U.S. DoD	MIL-PRF-5041	Tires, Ribbed Tread, Pneumatic, Aircraft, General Specification for
	JSSG-2009 (Appendix A)	Joint Service Specification Guide – Air Vehicle Subsystems
FAA	TSO-C62e	Aircraft Tires (for Commercial Aircraft)

Figure 3-13-3 Guidance Related to Aircraft Tires

2. The CAF uses strict guidelines for shelf life and re-treading of aircraft tires. This information can be found in the CAF technical publications listed in Figure 3-13-3.

3. MIL-PRF-5041 covers requirements for aircraft pneumatic tube type and tubeless ribbed tread tires intended for use on military aircraft wheels.

4. JSSG-2009 (Appendix A) provides guidance on item definition, performance, operating characteristics, reliability, maintainability, physical characteristics, general design, installation, and interface requirements.

5. FAA TSO-C62e is a Technical Standard Order (TSO) for manufacturers applying for a TSO authorization or letter of design approval. It contains minimum performance standards that an aircraft's tires must meet before their approval and identification with the applicable TSO marking.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 14 — CABIN SAFETY AND CRASH PROTECTION

3.14.1 Introduction

1. This chapter identifies the airworthiness certification requirements and aircraft design standards related to cabin safety and crash protection that are acceptable to the Technical Airworthiness Authority (TAA). The chapter also provides advisory material for those involved in the design or design change of cabin interiors for DND/CAF aircraft.

3.14.2 Scope

1. The aim of cabin safety design is to enhance the survivability of the occupants in the event of a survivable emergency. This chapter references the cabin safety objectives defined in the DND Aircraft Occupant Safety Policy (OSP) and identifies the certification standards related to cabin safety that are available from the TAA-recognized civil and military airworthiness codes. These standards are intended to be used to develop the certification basis for aircraft acquired by DND/CAF and to augment the certification basis for design changes to existing DND/CAF aircraft. Where practical, DND/CAF aircraft fleets are encouraged to adopt the latest standards as an improvement activity during the fleet's service life.

2. This chapter does not address Powerplant Fire Protection.

3. The cabin safety certification standards and advisory material in this chapter are grouped into four subject areas: Fire Protection, Crashworthiness, Emergency Evacuation and Additional Safety Provisions, as illustrated in Figure 3-14-1.

3.14.3 DND Aircraft Occupant Safety Policy

1. The A-GA-005-000/AG-001 – *DND/CAF Airworthiness Program* publication, which is the DND/CAF airworthiness policy manual, includes a sub-section titled 'DND Aircraft Occupant Safety Policy' (OSP) in Part 2, Section 1 – Safety Criteria, paragraphs 16 – 22. Further details on the implementation of the OSP are found in the joint OAA-TAA Advisory 2019-06 – DND Aircraft Occupant Safety Policy - Implementation Guidance.

2. **Policy Statement.** All DND aircraft shall be equipped to optimize the safety and survivability of the occupants, while safeguarding operational capability and minimizing implementation costs. Occupants are defined as both crew and passengers.

3. **Policy Context.** In the event of a survivable crash, the DND has a duty of care to provide occupants of DND aircraft with an acceptable level of safety and survivability. This policy minimizes risks to occupants of DND aircraft, by ensuring that the aircraft meet appropriate cabin safety and crash protection standards. The OSP requirements address the following factors:

a. impact protection;

b. aircraft evacuation; and

c. pre- and post-evacuation survival.

4. **Applicability.** This policy applies to Non-Ejection Seat Equipped, DND-Owned Aircraft (Fixed Wing and Rotary Wing), newly acquired and legacy fleets included. These aircraft fleets are certified to case-specific airworthiness standards at the time of their acquisition. The certification basis at the time of acquisition may not have included the full set of contemporary Occupant Safety standards set out in the Airworthiness Design Standards Manual (ADSM). Therefore, these aircraft fleets are subject to an Occupant Safety Assessment, in order to identify opportunities for Occupant Safety improvement.

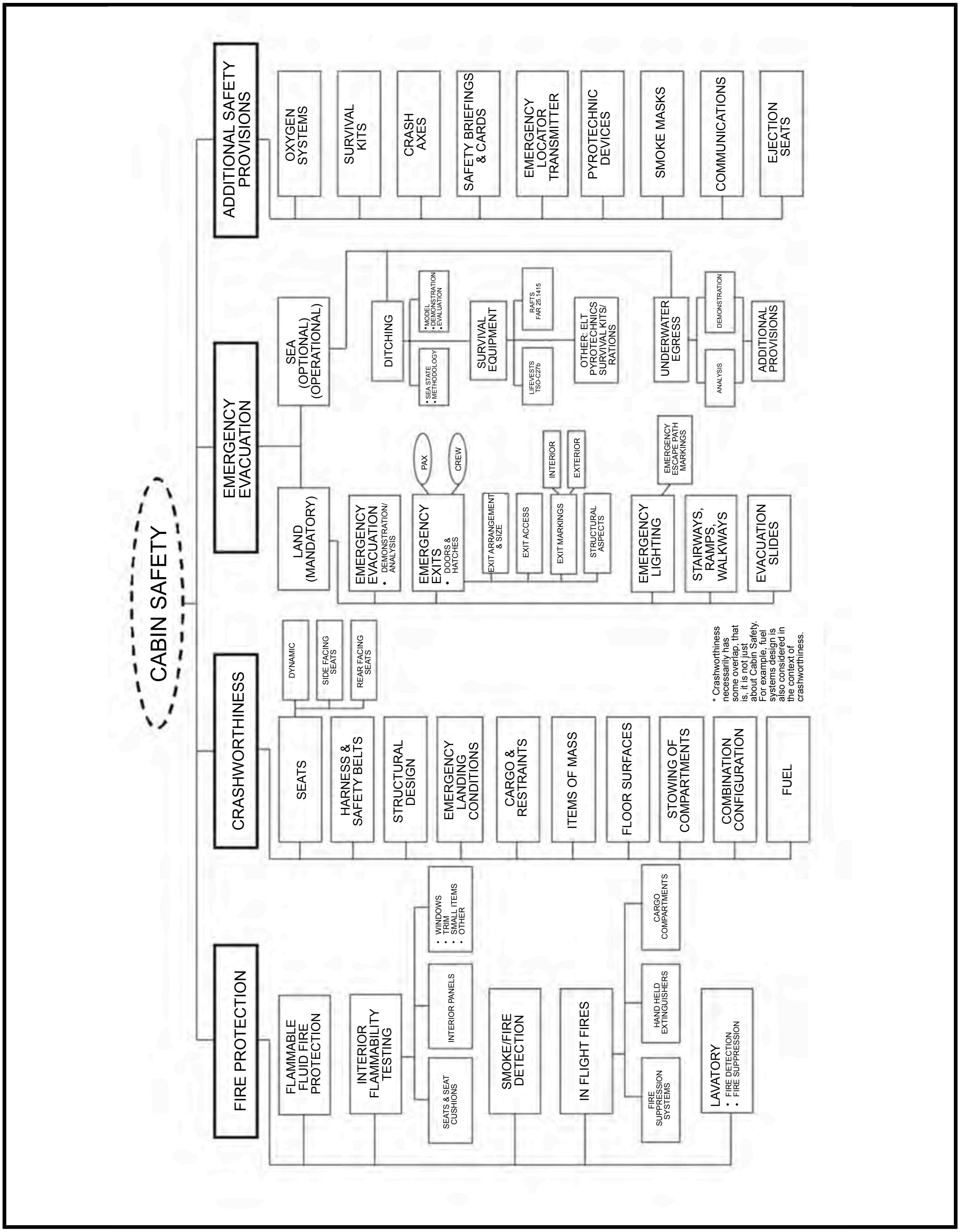

Figure 3-14-1 Cabin Safety

3.14.4 Standards – Fire Protection

1. The Fire Protection aspects of cabin safety design involve the protection of the occupants from the potential effects of: flammable materials in the cabin and cargo compartments, combustion heater fires and flammable fluids. This includes the means to fight fire, should it occur, and mitigation of the effects of fire on aircraft component parts.

2. The following standards and specifications are deemed acceptable to the TAA with regards to the cabin safety of DND/CAF aircraft. The terms 14 CFR/AWM/CS (also known as FAR/CAR/CS) correspond to 14 CFR Part 23, 14 CFR Part 25 or 14 CFR Part 29, as indicated, or the corresponding AWM or CS.

Military Airworthiness Certification Design Standards – Fire Protection
Certification Requirements – General
1. **MIL-HDBK-516C,** U.S. Department of Defence Handbook – Airworthiness Certification Criteria, para 8.4 (includes subparas 8.4.1 through 8.4.21), paras 9.7.7 and 18.2.2
2. **DEF STAN 00-970,** UK MoD – Design and Airworthiness Requirements for Service Aircraft
3. **European Military Airworthiness Certification Criteria (EMACC) Handbook,** section 8.4
Certification Requirements – Fixed Wing Specific
1. **DEF STAN 00-970,** Design and Airworthiness Requirements for Service Aircraft – Part 1 Combat Aircraft, Issue 1 – Clause 4.26: Fire Precautions
2. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 86: Fire Precautions General Recommendations
3. **DEF STAN 00-970,** Part 1 Combat Aircraft –Clause 4: Design and Construction – Leaflet 87: Fire Precautions Combat Induced Fires
4. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 92: Explosion-Proofness
Certification Requirements – Rotary Wing Specific
1. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 712/1-3: Fire Precautions
2. **DEF STAN 00-970,** Part 7 Rotorcraft Leaflet 712: Fire Precautions
Methods of Compliance References – General
1. **JSSG-2009,** Air Vehicle Subsystems
2. **MIL-HDBK-221,** Fire Protection Design Handbook for U.S. Navy Aircraft Powered by Turbine Engines
3. **JSSG-2010-7,** Crew Systems Crash Protection
4. **JSSG-2010-13,** Crew Systems Survival, Search and Rescue Handbook
5. Other military references as specified in MIL-HDBK-516C para 8.4 (includes subparas 8.4.1 through 8.4.21), para 9.7.7 and 18.2.2

Figure 3-14-2 Military Airworthiness Certification Design Standards Related to Fire Protection

Civil Airworthiness Certification Design Standards – Fire Protection
Certification Requirements – General (14 CFR/AWM/CS Part 23)
1. **23.2325,** Fire Protection
2. **23.2330,** Fire Protection in Designated Fire Zones and Adjacent Areas
Certification Requirements – General (14 CFR/AWM/CS Parts 25, 29)
1. **xx.831,** Ventilation
2. **xx.851,** Fire Extinguishers
3. **xx.853,** Compartment Interiors

Figure 3-14-3 (Sheet 1 of 2) Civil Airworthiness Certification Design Standards Related to Fire Protection

Civil Airworthiness Certification Design Standards – Fire Protection	
4.	**xx.855,** Cargo and Baggage Compartments
5.	**xx.859,** Combustion Heater Fire Protection
6.	**xx.863,** Flammable Fluid Fire Protection
7.	**xx.1183,** Flammable Fluid-Carrying Components
8.	**xx.1187,** Fire Zones – Drainage and Ventilation
9.	**xx.1189,** Fire Zones – Shut Off Means
10.	**xx.1203,** Fire Zones – Fire Detection System
Certification Requirements – Fixed Wing Specific (14 CFR/AWM/CS Part 25)	
1.	**25.854,** Lavatory Fire Protection
2.	**25.856,** Thermal/Acoustic Insulation Materials
3.	**25.857,** Cargo Compartment Classification
4.	**25.858,** Cargo or Baggage Compartment Smoke or Fire Protection
5.	**xx.1185,** Flammable Fluids
6.	**25.859,** Combustion Heaters
7.	**25.1721,** Protection of EWIS

Figure 3-14-3 (Sheet 2 of 2) Civil Airworthiness Certification Design Standards Related to Fire Protection

Civil Airworthiness Guidance Material – Fire Protection	
Fixed Wing:	
FAA Advisory Circulars	
1.	**AC 25.853 1,** Flammability Requirements for Aircraft Seat Cushions
2.	**AC 25.856 1,** Thermal/Acoustic Insulation Flame Propagation Test Method Details
3.	**AC 25.856 2A,** Insulation of Thermal/Acoustic Insulation for Burn-through Protection
4.	**AC 25-869 1A,** Fire Protection Systems
5.	**AC 25 9A,** Smoke Detection, Penetration, Evacuation Tests and Related Flight Manual Emergency Procedures
FAA Technical Standing Orders	
1.	**TSO C1d,** Cargo Compartment Fire Detection Instruments
2.	**TSO C19B,** Portable Water-Solution Type Fire Extinguisher
3.	**TSO C79,** Fire Detectors (Radiation Sensing Type)
EASA Acceptable Means of Compliance	
1.	**AMC 25.851,** Fire Extinguishers
2.	**AMC 25.863,** Flammable Fluid Fire Protection
3.	**AMC 25.869(a)(1),** Electrical System Fire and Smoke Protection
4.	**AMC 25.1713,** Protection of EWIS
5.	**AMC 25.1723,** Flammable Fluid Protection EWIS
SAE Aerospace Recommended Practices and Information Reports	
1.	**SAE ARP 4712,** Hand-Held Cabin Fire Extinguishers Transport Aircraft
2.	**SAE ARP 1315(D),** Safety Considerations for Airplane Lavatories
3.	**SAE ARP 4001(A),** Lavatory Smoke Detectors
4.	**SAE ARP 4101/1,** Seats and Restraint Systems for the Flight Deck

Figure 3-14-4 (Sheet 1 of 2) Civil Airworthiness Guidance Material Related to Fire Protection

Civil Airworthiness Guidance Material – Fire Protection
5. **SAE ARP 4072,** Safety Considerations of Carry-on Baggage Relating to the Emergency Evacuation of Transport Category Aircraft
6. **SAE AIR 1903,** Aircraft Inerting Systems
7. **SAE AIR 4170,** Reticulated Polyurethane Foam Explosion Suppression Material for Fuel Systems and Dry Bays
8. **SAE AS 50881,** Wiring, Aerospace Vehicle
9. **SAE AS 5440,** Hydraulic Systems, Aircraft, Design and Installation Requirements for
Transport Rotary Wing:
FAA Advisory Circulars
1. **AC 29.851,** Fire Extinguisher
2. **AC 29.853,** Compartment Interiors
3. **AC 29.855,** Cargo and Baggage Compartments
4. **AC 29.855A,** Cargo and Baggage Compartments
5. **AC 29.863,** Flammable Fluid Fire Protection
6. **AC 120 80,** In-Flight Fire

Figure 3-14-4 (Sheet 2 of 2) Civil Airworthiness Guidance Material Related to Fire Protection

3.14.5 Crashworthiness

1. The classic approach to crashworthiness, as applied to cabin interiors, involves all basic design considerations for the protection of occupants in the event of a “survivable crash environment”. In this chapter, crashworthiness is restricted to those design requirements that are necessary to enhance crash survivability. Crashworthiness, in this context, includes seats, harnesses and belts, structural design, emergency landing conditions, cargo restraints, items of mass, stowage compartments, combination configurations and fuel system.

Military Airworthiness Certification Design Standards – Crashworthiness
Certification Requirements – General
1. **MIL-HDBK-516C,** U.S. Department of Defence Handbook – Airworthiness Certification Criteria – para 9.7 (includes subparas 9.7.1 through 9.7.10), subparas 18.1.1 through 18.1.3
2. **DEF STAN 00-970,** UK MoD – Design and Airworthiness Requirements for Service Aircraft
3. **EMACC Handbook,** section 9.7
Certification Requirements – Fixed Wing Specific
1. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4.21-4.2
2. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 75: Crash Landing, Ditching and Precautionary Alighting on Water Design for Crash Landing and Ditching
3. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 76: Crash Landing, Ditching and Precautionary Alighting on Water Seats and Stretchers (Litters)
4. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 77: Crash Landing, Ditching and Precautionary Alighting on Water Operational Recommendations for Cargo and Freight
Certification Requirements – Rotary Wing Specific
1. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 307: Crash Landing, Ditching and Precautionary Alighting on Water

Figure 3-14-5 (Sheet 1 of 2) Military Airworthiness Certification Design Standards Related to Crashworthiness

Military Airworthiness Certification Design Standards – Crashworthiness
2. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 307/2-4: Crash Landing, Ditching and Precautionary Alighting on Water
Methods of Compliance – General
1. **JSSG-2001,** Air Vehicle
2. **JSSG-2010-7,** Crew Systems Crash Protection Handbook
3. **JSSG-2010-9,** Crew Systems Personal Protective Equipment Handbook
4. **JSSG-2010-13,** Crew Systems Survival, Search, and Rescue (SSAR) Handbook
5. **MIL-STD-1290A,** Light Fixed and Rotary-Wing Aircraft Crash Resistance
6. **MIL-STD-1472F,** Design Criteria Standard – Human Engineering
7. **CFTO C-12-010-010/TP-000,** Refinishing of Aircraft and Aircraft Equipment
8. Other military references as specified in MIL-HDBK-516C para 9.7 (includes subparas 9.7.1 through 9.7.10)
Methods of Compliance – Fixed Wing Specific
1. **MIL-S-26688,** Seat; Passenger, Aft Facing, Transport Aircraft
Methods of Compliance – Rotary Wing Specific
1. **MIL-S-85510,** Military Specification: Seats, Helicopter Cabin, Crashworthy, General Specification for. Note: Superseded by JSSG-2010-7, however, has been used as the comparison basis for several RCAF helicopters.

Figure 3-14-5 (Sheet 2 of 2) Military Airworthiness Certification Design Standards Related to Crashworthiness

Civil Airworthiness Certification Design Standards – Crashworthiness
Certification Requirements – General (14 CFR/AWM/CS Part 23)
1. **23.2270,** Emergency Conditions (Structural Occupant Protection)
Certification Requirements – General (14 CFR/AWM/CS Parts 25, 29)
1. **xx.561,** General (Load Factors)
2. **xx.562,** Emergency Landing Dynamic Conditions
3. **xx.783,** Fuselage Doors
4. **xx.785,** Seats, Berths, Safety Belts and Harnesses
5. **xx.787,** Stowage Compartments / Cargo and baggage compartments
6. **xx.952,** Fuel System Crash Resistance
7. **xx.963,** Fuel Tanks: General
8. **xx.965,** Fuel Tank Tests
9. **xx.967,** Fuel Tank Installations
Certification Requirements – Fixed Wing Specific (14 CFR/AWM/CS Part 25)
1. **25.793,** Floor Surfaces
2. **25.789,** Retention of Items of Mass in Passenger and Crew Compartments and Galleys
3. **25.981,** Fuel Tank Ignition Prevention

Figure 3-14-6 Civil Airworthiness Certification Design Standards Related to Crashworthiness

Civil Airworthiness Guidance Material – Crashworthiness
General:
FAA Advisory Circulars 1. **AC 20-146,** Methodology for Dynamic Seat Certification by Analysis for Use in Part 23, 25, 27 and 29 Airplanes and Rotorcraft 2. **AC 21-25A,** Approval of Modified Seating Systems Initially Approved Under a Technical Standard Order 3. **AC 21-34,** Shoulder Harness-Safety Belt Installations 4. **AC 91-62A,** Use of Child Seats in Aircraft
FAA Technical Standing Orders 1. **TSO C22g,** Safety Belts 2. **TSO C25a,** Aircraft Seats and Berths 3. **TSO C114,** Torso Restraint Systems 4. **TSO C127a,** Rotorcraft, Transport Airplane, and Normal and Utility Airplane Seating Systems
SAE Aerospace Recommended Practices and Information Reports 1. **SAE ARP 5526,** Aircraft Seat Design Guidance and Clarifications 2. **SAE AS 8043(B),** Restraint Systems for Civil Aircraft 3. **SAE AS 8049(B),** Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft
Fixed Wing:
FAA Advisory Circulars 1. **AC 25-5,** Installation Approval on Transport Category Airplanes of Cargo Unit Load Devices Approved as Meeting the Criteria in AIA/NAS 3610 – Cargo Unit Load Devices – Specification For 2. **AC 25-8,** Ch.1-6 – Fuel System Installation Integrity and Crashworthiness 3. **AC 25-17A,** Transport Airplane Cabin Interiors Crashworthiness Handbook 4. **AC 25-562-1B,** Dynamic Evaluation of Seat Restraint Systems and Occupant Protection of Transport Aircraft 5. **AC 25-738-1A,** Fuselage Doors and Hatches 6. **AC 25.785-1A,** Flight Attendant Seat and Torso Restraint System Installations
EASA Acceptable Means of Compliance 1. **AMC 25.561,** General 2. **AMC 25.783,** Fuselage Doors 3. **AMC 25.785,** Seats & Safety Belts 4. **AMC 25.787,** Stowage Compartments
Transport Rotary Wing:
FAA Advisory Circulars 1. **AC 29.1413,** Safety Belts Passenger Warning Device – General

Figure 3-14-7 Civil Airworthiness Guidance Material Related to Crashworthiness

3.14.6 Emergency Evacuation

1. Emergency evacuation encompasses the proposition that appropriate design features are in place that enhance the prospect of successful occupant evacuation in the event of a survivable accident. This includes design features that reduce the risk of injury during egress.

2. There are two main egress environments: over land and over water. The over-water environment has two distinct egress challenges: ditching (on top of the water egress) and underwater egress.

a. Land evacuation regulations establish design criteria that ultimately attempt to negate post-crash injuries caused by fires and structural failure that develop from the occupant being present within the aircraft following a crash.

b. Overwater evacuation regulations attempt to minimize the effects of drowning and hypothermia on the occupant. Though there are regulations for ditching – a controlled water landing – there is no current set of regulations to address underwater evacuation.

Military Airworthiness Certification Design Standards – Emergency Evacuation
Certification Requirements – General
1. **MIL-HDBK-516C,** U.S. Department of Defence Handbook – Airworthiness Certification Criteria, para 9.1 (includes subparas 9.1.1 through 9.1.6)
2. **DEF STAN 00-970,** UK MoD – Design and Airworthiness Requirements for Service Aircraft
3. **EMACC Handbook,** section 9.1
Certification Requirements – Fixed Wing Specific
1. **DEF STAN 00-970,** Part 1 Combat Aircraft, Clauses 4.20 to 4.23, 6.8 and 7.4
2. **DEF STAN 00-970,** Part 1 Combat Aircraft, Clause 6: Equipment – Leaflet 34: Emergency Liferaft Installation General Recommendations
3. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 75: Crash Landing, Ditching and Precautionary Alighting on Water Design for Crash Landing and Ditching
4. **DEF STAN 00-970,** Part 1 Combat Aircraft – Clause 4: Design and Construction – Leaflet 78: Emergency Escape Jettisoning of Hoods, Hatches and Doors
Certification Requirements – Rotary Wing Specific
1. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 102: Emergency Escape
2. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 103: Operational Colouration and Markings
3. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 307: Crash Landing, Ditching and Precautionary Alighting on Water Clauses 2.1.1 and 3
4. **DEF STAN 00-970,** Part 7 Rotorcraft – Leaflet 721: Emergency Liferaft Installations
Methods of Compliance – General
1. **JSSG-2001,** Air Vehicle
2. **JSSG-2010-3,** Crew Systems Cockpit/Crew Station/Cabin Handbook
3. **JSSG-2010-7,** Crew Systems Crash Protection Handbook, paragraphs 3.7.3.5.1, 4.7.3.5, 3.7.5.3, 3.7.5.5, 3.13.4 and 3.7.3.5.2
4. **JSSG-2010-11,** Crew Systems Emergency Egress Handbook
5. **JSSG-2010-13,** Survival Search and Rescue – Survival Provisions, Transport Category Aircraft (I), Ground Test Evacuation Equipment Tests, paragraph 3.3.14: Operating Instructions Markings, paragraph 3.14.3: Emergency Lighting, Exterior Emergency Lighting, Ditching Assist Test, paragraph 4.14.3: Life Jacket/ Preserver Inflation Tests, Flotation Device Body
6. **MIL-STD-1472F,** Human Engineering Design Criteria Standard, paragraphs 5.7.7.1.3, 5.7.7.2.1, 5.7.7.2.2 and 5.9.11.5.6
7. **MIL-PRF-18494F,** Life Rafts, Inflatable, Multi-Place
8. **MIL-PRF-85676A(AS),** Lighting, Emergency Egress, Subassembly
9. **MIL-STD-1290A,** Light Fixed and Rotary-Wing Aircraft Crash Resistance, paragraph 5.4

Figure 3-14-8 (Sheet 1 of 2) Military Airworthiness Certification Design Standards Related to Emergency Evacuation

Military Airworthiness Certification Design Standards – Emergency Evacuation
10. **C-05-006-002/AG-001,** Aircraft Servicing, Maintenance, Hazard and Emergency Markings
11. Other military references as specified in MIL-HDBK-516C para 9.1 (includes subparas 9.1.1 through 9.1.6)

Figure 3-14-8 (Sheet 2 of 2) Military Airworthiness Certification Design Standards Related to Emergency Evacuation

Civil Airworthiness Certification Design Standards – Emergency Evacuation
Certification Requirements – General (14 CFR/AWM/CS Part 23)
1. **23.2315,** Means of Egress and Emergency Exits
2. **23.2320,** Occupant Physical Environment
Certification Requirements – General (14 CFR/AWM/CS Parts 25, 29)
1. **xx.801,** Ditching
2. **xx.803,** Emergency Evacuation
3. **xx.807,** Emergency Exits
4. **xx.809,** Emergency Exit Arrangement
5. **xx.811,** Exit Markings
6. **xx.812,** Emergency Lighting
7. **xx.813,** Emergency Exit Access
8. **xx.815,** Main Aisle Width
9. **xx.1411,** General
10. **xx.1415,** Ditching Equipment
11. **xx.1561,** Safety Equipment
Certification Requirements – Transport Rotary Wing Specific (14 CFR/AWM/CS Part 29)
1. **29.805,** Flight Crew Emergency Exit
2. **29.810,** Emergency egress assist means and escape routes

Figure 3-14-9 Civil Airworthiness Certification Design Standards Related to Emergency Evacuation

Civil Airworthiness Guidance Material – Emergency Evacuation
General:
FAA Advisory Circulars
1. **AC 20-60,** Accessibility to Excess Emergency Exits
2. **AC 20-118A,** Emergency Evacuation Demonstration
3. **AC 91-58A,** Use of Pyrotechnic Visual Distress Signaling Devices in Aviation
4. **AC 120-47,** Survival Equipment for Use in Overwater Operations
FAA Technical Standard Orders
1. **TSO-C13f,** Life Preservers
2. **TSO-C69c,** Emergency Evacuation Slides, Ramps, Ramp/Slides, and Slide/Rafts
3. **TSO-C70b,** Life Rafts (Reversible and Non-reversible)
4. **TSO-C72C,** Individual Flotation Devices
5. **TSO-C121A,** Underwater Locating Devices(Acoustic)(Self-Powered)
SAE Regulations and Aerospace Recommended Practices
1. **SAE ARP 1178(A),** Aircraft Evacuation Signal System

Figure 3-14-10 (Sheet 1 of 2) Civil Airworthiness Guidance Material Related to Emergency Evacuation

Civil Airworthiness Guidance Material – Emergency Evacuation
2. **SAE ARP 5526,** Aircraft Seat Design Guidance and Clarifications 3. **SAE ARP 711,** Illuminated Signs
Fixed Wing Specific:
FAA Advisory Circulars 1. **AC 25.803-1,** Emergency Evacuation Demonstrations 2. **AC 25.807-1,** Uniform Distribution of Exits 3. **AC 25.812-1A,** Floor Proximity Emergency Escape Path Marking 4. **AC 25.812-2,** Floor Proximity Emergency Escape Path Marking Systems Incorporating Photo luminescent Elements
EASA Acceptable Means of Compliance 1. **AMC 25.807,** Emergency Exit Access
SAE Regulations and Aerospace Recommended Practices 1. **SAE ARP 4072,** Safety Considerations of Carry-on Baggage Relating to the Emergency Evacuation of Transport Category Aircraft
Rotary Wing Specific:
FAA Advisory Circulars 1. **AC 29.1415,** Ditching Equipment 2. **AC 29.1541,** Marking and Placards

Figure 3-14-10 (Sheet 2 of 2) Civil Airworthiness Guidance Material Related to Emergency Evacuation

3.14.7 Additional Safety Provisions

1. Additional safety provisions refer to any area of concern not included in Fire Protection, Crashworthiness, or Emergency Evacuation. This includes survival kits, oxygen systems, smoke masks, etc. Additional survival kit standards are provided in the ALSE section of the ADSM, Part 3, Chapter 15, Annex G.

Military Airworthiness Design Standards – Additional Safety Provisions
Certification Requirements – General 1. **MIL-HDBK-516C,** U.S. Department of Defence Handbook – Airworthiness Certification Criteria – para 9.5 (includes subparas 9.5.1 through 9.5.7) 2. **DEF STAN 00-970,** UKMoD – Design and Airworthiness Requirements for Service Aircraft 3. **EMACC Handbook,** section 9.5
Certification Requirements – Fixed Wing: 1. **DEF STAN 00-970,** Part 1, Combat Aircraft, Clause 6.13.2: Concentration of Oxygen in Inspired Gas 2. **DEF STAN 00-970,** Part 1, Combat Aircraft, Clause 6.13.5: Types of System 3. **DEF STAN 00-970,** Part 1, Combat Aircraft, Clause 3: Structure, Leaflet 14: Pressure Cabins – Cabin Pressure Systems 4. **DEF STAN 00-970,** Part 1, Combat Aircraft, Clause 3: Structure, Leaflet 15: Pressure Cabins – Prevention of Cabin Air Contamination by Fumes from Fuel Tanks 5. **DEF STAN 00-970,** Part 1, Combat Aircraft, Clause 3: Structure, Leaflet 16: Pressure Cabins – Time Needed for Emergency Descent Following Loss of Cabin Pressure 6. **DEF STAN 00-970,** Part 1, Combat Aircraft, Leaflet 27: Oxygen Systems: Pressure Losses in Oxygen Delivery Systems

Figure 3-14-11 (Sheet 1 of 2) Military Airworthiness Design Standards Related to Additional Safety Provisions

Military Airworthiness Design Standards – Additional Safety Provisions
7. **DEF STAN 00-970,** Part 1, Combat Aircraft, Leaflet 29: Oxygen Systems: Physiological Requirement for Oxygen Systems
Methods of Compliance – General
1. **AIR-STD-61/-101/-15,** Smoke Protection Breathing Equipment Used by Mobile Aircrew In Non-Ejection Seat Aircraft at Pressure Altitudes up to 10,000 ft
2. **JSSG-2010-10,** Crew Systems Oxygen Systems Handbook, paragraph 3.10.2.1
3. **JSSG-2010-13,** Crew Systems Survival, Search and Rescue (SSAR) Handbook, paragraph 4.14.3

Figure 3-14-11 (Sheet 2 of 2) Military Airworthiness Design Standards Related to Additional Safety Provisions

Civil Airworthiness Certification Design Standards – Additional Safety Provisions
Certification Requirements – General (14 CFR/AWM/CS Part 23)
1. **23.2535,** Safety Equipment
Certification Requirements – General (14 CFR/AWM/CS Parts 25, 29)
1. **xx.1439,** Protective Breathing Equipment
Certification Requirements – Fixed Wing Specific (14 CFR/AWM/CS Part 25)
1. **25.1421,** Megaphones
2. **25.1423,** Public Address System
3. **25.1441,** Oxygen Equipment and Supply
4. **25.1443,** Minimum Mass Flow of Supplemental Oxygen
5. **25.1445,** Equipment Standards for the Oxygen Distributing System
6. **25.1447,** Equipment Standards for the Oxygen Dispensing Units
7. **25.1449,** Means of Determining Use of Oxygen
8. **25.1450,** Chemical Oxygen Generators
9. **25.1453,** Protection of Oxygen Equipment for Rupture
Certification Requirements – Other (14 CFR/AWM/CS)
1. **91.207,** Emergency Locator Transmitters
2. **121.309,** Emergency Equipment

Figure 3-14-12 Civil Airworthiness Certification Design Standards Related to Additional Safety Provisions

Civil Airworthiness Guidance Material – Additional Safety Provisions
General:
FAA Advisory Circulars
1. **AC 20-42C,** Hand Fire Extinguishers for Use in Aircraft
2. **AC 20-56A,** Marking of TSO-C72b Individual Flotation Devices
3. **AC 120-66A,** Aviation Safety Action Program (ASAP)
4. **AC 121-6,** Portable Battery-Powered Megaphones
5. **AC 121-24C,** Passenger Safety Information Briefing and Briefing Cards
6. **AC 121-27,** Guide for Air Carriers, Freight Forwarders, and Shippers in Obtaining Information Dealing with the Transportation of Hazardous Materials by Air
7. **AC 121-33B,** Emergency Medical Equipment
8. **AC 121-34B,** Emergency Medical Equipment Training

Figure 3-14-13 (Sheet 1 of 2) Civil Airworthiness Guidance Material Related to Additional Safety Provisions

Civil Airworthiness Guidance Material – Additional Safety Provisions
9. **AC 121-35,** Management of Passengers during Ground Operations without Cabin Ventilation 10. **AC 121-37,** Voluntary Disclosure Reporting Program – Hazardous Materials
FAA Technical Standard Orders 1. **TSO-C64B,** Passenger Oxygen Mask Assembly, Continuous Flow 2. **TSO-C78a,** Crewmember Demand Oxygen Mask 3. **TSO-C99,** Protective Breathing Equipment
SAE Regulations and Aerospace Recommended Practices 1. **SAE AS 861(B),** Minimum General Standards for Oxygen Systems 2. **SAE AS 8010(C),** Aviator's Breathing Oxygen Purity Standard 3. **SAE AIR 1069(A),** Crew Oxygen Requirements Up to a Maximum Altitude of 45,000 ft
General: 4. **SAE AS 1197,** Continuous Flow Oxygen Regulator 5. **SAE AS 1046(C),** Minimum Standard for Portable Gaseous, Oxygen Equipment 6. **SAE ARP 1282(A),** Survival Kit – Life Rafts and Slide/Rafts
Fixed Wing Specific:
FAA Advisory Circulars 1. **AC 25-22,** Certification of Transport Airplane Mechanical Systems.
Rotary Wing Specific:
FAA Advisory Circulars 1. **AC 29.1561,** Safety Equipment

Figure 3-14-13 (Sheet 2 of 2) Civil Airworthiness Guidance Material Related to Additional Safety Provisions

3.14.8 Guidance Information – Best Practices

1. **Establishing the Certification Basis.** The first step required in evaluating an aircraft design, or evaluating a change to the original design by implementing a modification, is establishing the certification basis. The importance of getting this correct cannot be overstated, since it influences the entire certification activity and its value.

   a. **Operating Intent the same.** If the operating intent for the already certified version of the aircraft is the same, then adopting the existing certification basis would likely be acceptable. For example, if a rotorcraft was certified to 14 CFR Part 29/CS Part 29, it would likely be sensible to adopt this civil certification basis. One of the distinct advantages of adopting this approach is that a competent authority has already surveyed the design of the aircraft and has verified the design against a known and robust standard.

   b. **Operating Intent different.** If the operating intent for the already certified version of the aircraft is significantly different from the operating intent for the DND/CAF version of the aircraft, there will be a need to identify appropriate standards to address the different configuration of the DND/CAF version of the aircraft; thus the certification basis will need to be revised. Examples include: using a civilian transport aircraft for Search and Rescue, or a civilian helicopter for armed escort purposes.

2. MIL-HDBK-516C is a U.S. DoD Handbook that contains airworthiness certification criteria recognized by DND's TAA. It is intended to be used when determining the airworthiness requirements of fixed and rotary wing aircraft, crewed or uncrewed. Since there are different types of aircraft, MIL-HDBK-516C can assist in tailoring the criteria required in the certification basis, but it is not a certification basis in and of itself.

3. **Consideration of Certification Criteria.** Because of the different functions of different aircraft in the DND/CAF, the choice of certification criteria for each fleet type depends on the type of occupants that are likely to

be onboard the aircraft, i.e., trained aircrew, mission operation troops, military passengers, or civilian passengers. The following guidance applies:

a. **All Aircraft Fleets.**

(1) Guiderails installed on the cabin ceiling that lead to the emergency exits have been shown be an appropriate safety measure for rotorcraft in a military operational role. This is particularly important for rotorcraft, because the rotorcraft readily roll over on their side. However, this applies only to aircraft whose ceiling height is within reach.

(2) To provide all classifications of occupants with crashworthy seating, all such seating should comply with 14 CFR 25/29.561-563 and 25/29.785. If, for reasons accepted by the TAA, the requirements of 14 CFR 29.561-563 cannot be met, then seat testing requirements in MIL-S-25073A – Seat, Aircraft, and MIL-S-26688 (USAF) – Seat, Passenger, AFT Facing, Transport Aircraft should be considered for pilot and passenger seats, respectively.

(3) Certification requirements that ensure an adequate level of safety for occupants in side facing seats have yet to be developed. The FAA has issued a policy letter (ANM-03-115-30 – Side-facing Seats on Transport. Category Airplanes) that outlines the approach for side facing seat certification, for both single and multiple side facing seats.

b. **Commercial Derivative Passenger Carrying Fixed Wing Aircraft.** Aircraft that are intended to carry civilian passengers should comply with the certification standards found in 14 CFR 25 for all aspects of cabin safety.

c. **Passenger and Cargo Carrying (Combination) Aircraft.**

(1) Passenger cargo combination aircraft have a different compartment classification than a passenger only or cargo only aircraft. For example, a combination aircraft may have different requirements for fire extinguishing, as detailed in 14 CFR 25/29.851-853.

(2) For configurations where the cabin has both passengers and cargo, certification can be much more complex. The cargo must be restrained in a manner that meets the requirements of 14 CFR 25.561; for example, via containment, tie down arrangements or netting, depending upon the design considerations. The passengers must have clear access to the number and types of exits that are appropriate for the number of passengers. In some cases, the cargo area may be large enough to require isolation from the passenger spaces. Firefighting provisions will have to be considered.

d. **Cargo-Only Aircraft.** Because there are no passengers in a cargo only cabin, there are reduced cabin safety requirements. The remaining cabin safety requirements pertain to the safety of the aircrew.

(1) AC 25-18 – *Transport Category Airplanes Modified for Cargo Service* addresses structural considerations, fire protection, emergency egress and ventilation for converted cargo fixed-wing aircraft.

(2) Oxygen systems are not required in the cabin, since only the aircrew will be required to have oxygen systems.

e. **Mission Fixed Wing Aircraft.** Although DEF STAN 00-970 Part 5 – Large Type Aircraft has yet to be published, DEF STAN 00-970 Part 1 currently contains provisions for large mission-type fixed wing aircraft and can be used as a certification basis for aircraft of that type.

f. **Fighter and Trainer Fixed Wing Aircraft.** DEF STAN 00-970 Part 1 is dedicated to combat aircraft. The requirements therein are applicable to both fixed-wing fighter and trainer aircraft. MIL-HDBK-516 has been used by the U.S. DoD.

g. **Maritime Rotary Wing Aircraft.** Since maritime helicopters operate mainly in an overwater environment, special considerations should be given in determining the certification criteria.

(1) Ditching provisions should be taken into consideration. Exit design should require exits to be placed above the water line, as described in 14 CFR 25.807(i). This also includes the requirement for flotation devices and life rafts, as described in DEF STAN 00-970 Part 7, Leaflet 34 and 307, or 14 CFR 29.1411, 29.1415 and 91.509.

(2) Search and rescue provisions are detailed in DEF STAN 00-970 Part 7, Clause 2.8, for approved winch installation and for handgrips above and below the entrance door.

(3) Underwater egress provisions are vital for maritime operations. The effectiveness of emergency lighting onboard aircraft reflects the ability of the occupants to egress successfully. This is especially important for underwater environments. 14 CFR 29.812 contains the requirements for emergency lighting, including emergency exit lighting. MIL-PRF-85676A requires an inverted U shaped light around the emergency exit, known as helicopter emergency egress lighting system (HEELS). HEELS provides the occupants with exit location and aircraft orientation by visual contact. It is common practice that maritime rotorcraft incorporate HEELS for all emergency exits in lieu of the emergency exit lighting requirements specified in 14 CFR Part 29.

(4) Occupants travelling over water may require a breathing apparatus to survive an emergency evacuation situation successfully. Research has shown that underwater escape is extremely difficult without supplemental breathing apparatus. In maritime rotary wing aircraft operations, a personal emergency underwater breathing apparatus may be an appropriate safety precaution for all crew members, in view of their high exposure rate to that environment.

h. **Transport Rotary Wing Aircraft.** Additional considerations need to be addressed when rotorcraft are intended to be used to transport troops for operational use. Design requirements should take into account that the troops being carried may not be familiar with the aircraft; this is especially important with respect to emergency escape provisions.

(1) DEF STAN 00-970 Part 7, Leaflet 714, provides requirements for rotorcraft that transport troops.

(2) The HEELS provides those troops, who are less familiar with the aircraft, with a quick and pragmatic exit indicator in any emergency evacuation situation. The HEELS should be incorporated in transport rotorcraft in lieu of the emergency exit lighting requirements specified in 14 CFR Part 29.

4. Example Scenario of a Rotary-Wing Aircraft Modification

a. **Rotorcraft Interior Modification.** A DND/CAF rotorcraft certified to 14 CFR 29 is required for Search and Rescue (SAR) missions. The SAR Technicians may have to deal with all sorts of trauma during rescue missions and the rotorcraft may have a long transit for medical help once the rescue has been made. It is considered desirable for a patient treatment area to be designed to cater for some of the most serious medical conditions in which patients may be found. It is decided that a heart monitor and defibrillation paddles should be part of a patient treatment area design.

b. **Task.** A modification to the cabin will be required, so a new design on the CH149 will be certified.

c. **Considerations**

(1) **Establish the Certification Basis.** Since the original design was civil certified, 14 CFR Part 29 was the certification basis. The guidance in FAA AC 29-2C, MG 6 – *Emergency Medical Service Systems* could be considered. The modification requirement is military-specific, so DEF STAN 00-970 and MIL-HDBK-516C should be consulted for possible guidance.

(2) **Technical Issues – Cabin.** The modification may introduce new hazards requiring an examination of the effects on the certification basis. The areas that might typically require examination in the cabin include the following:

(a) Item of mass becoming a projectile in an emergency.

(b) Installation becoming an obstruction during an emergency evacuation.

(c) Installation interfering with emergency exit access.

(d) Introduction of head strike hazards in the event of an emergency.

(e) Introduction of oxygen gas in the cabin.

(3) **Technical Issues – Other Aircraft Areas.** Other areas of the aircraft that may require consideration, as a result of the changes in the cabin include the following:

(a) Electromagnetic Environmental Effects (E3) with onboard radio and navigation equipment.

(b) Weight and centre of gravity (CofG) effects.

(c) Impact on aircraft electrical systems.

(d) Structural considerations due to the installation.

5. **Example Scenario of a Fixed-Wing Aircraft Modification**

a. **Fixed-Wing Air to Air Refuelling (AAR) Modification.** DND/CAF operates a fleet of CC150 Polaris aircraft. There is a requirement for the CC150 to be modified for an Air-to-Air Refueling (AAR) capability to support fighter operations. The original aircraft manufacturer has designed the AAR system.

b. **Task.** Since a modification has been made to the cabin and the operation of the aircraft has changed, the new design must be certified.

c. **Considerations.** The design must consider that there is still a requirement to carry passengers, but in two different modes: carriage of passengers while in-flight refuelling; and carriage of passengers while not in in-flight refuelling, but with refuelling equipment installed.

(1) **Establish the Certification Basis.** Since the original design was civil certified, 14 CFR Part 25 is the certification basis. In the AAR role, the certification basis will not need additional requirements, however, exemptions/deviations from 14 CFR 25 will be required, if the aircraft is to carry occupants while in the AAR configuration, because it is possible that not all of 14 CFR 25 requirements will be met in this case.

(2) **Technical Issues – Cabin.** The modification produces new hazards requiring an examination of the effects on the certification basis. Areas of the cabin that would require special consideration include the following:

(a) Additional flammability hazards.

(b) Obstructions in the cabin.

(c) Impediments to emergency exit access.

(d) Items of mass.

(3) **Technical Issues – Other Aircraft Areas.** Other areas requiring consideration for AAR system design include the following:

(a) Fuel system.

(b) Aircraft handling qualities.

(c) Weight and CofG.

(d) Electrical system.

(4) **Test Programs.** The various test programs will include: vendor component tests; system ground tests; and flight tests.

3.14.9 Additional Guidance Information – Flammability

1. 14 CFR 25, Appendix F contains extensive fire testing and flammability criteria for interior materials. DEF STAN 00-970 Part 1, Clause 4.26 and Part 7, Leaflet 712 quote JAR Appendix F as an approved method of flammability testing for interior materials.

NOTE

JARs have been replaced by EASA CSs.

2. Fire extinguishing and detecting regulations are dependent on the accessibility and ability of the crew to detect fire in a particular compartment.

3. For fixed-wing aircraft, 14 CFR 25.857 assigns a classification to compartments that meet a set of criteria and assigns fire extinguishing/detection requirements to each different classification in 14 CFR 25.853 and 25.855. MIL-HDBK-221 – *Fire Protection Design Handbook for U.S. Navy Aircraft Powered by Turbine Engines* does not classify compartments, but gives requirements for compartments meeting certain criteria. DEF STAN 00-970 Part 1, Clause 4.26.56 has a similar compartment classification as 14 CFR 25, but are placed under the guidance material, rather than under the requirements.

4. For rotary wing aircraft, 14 CFR 29 does not classify compartments. 14 CFR 29.853 describes the fire extinguishing requirements for compartments meeting certain criteria.

5. 14 CFR 29.855 requires that each non-sealed cargo and baggage compartment must be designed, or must have a device, to ensure detection of fires or smoke by a crewmember while at his station, and to prevent the accumulation of harmful quantities of smoke, flame, extinguishing agents and other noxious gases in any crew or passenger compartment. DEF STAN 00-970, Part 7, Leaflet 712 includes fire detection system regulations for rotary wing aircraft, similar to those for fixed wing found in DEF STAN 00-970, Part 1.

6. Flammable fluid fire protection is addressed in 14 CFR 25.863, 25.1183 and 25.1185. The military regulations are very similar to those given in 14 CFR 25/29. DEF STAN 00-970, Part 1, Clause 4.26 and Part 7, Leaflet 712 include fire zone locations and flammable fluid components routing. MIL-HDBK-221, paragraphs 2.2.1, 2.11, 2.19 and MIL-STD-1290A, paragraph 5.5.1.1 address fuel line location with regard to leaking from structural failure.

7. DEF STAN 00-970, Part 1, Clause 4.26 for fixed wing aircraft, Part 7, Leaflet 712 for rotary wing aircraft, and MIL-HDBK-221, paragraph 2.1.1 also include military specific fire precaution regulations for bomb bays and the placement of explosives that are not found in the 14 CFR 25 civil regulations.

3.14.10 Guidance Information – Crashworthiness

1. **General.** As stated in literature, crashworthiness can be separated into five areas of concern: the container, the restraint system, energy absorption, environmental effects and post-crash factors.

a. DEF STAN 00-970 provides a set of crash protection regulations relevant to crashworthiness concerns. One advantage found in DEF STAN 00-970 is that all these regulations are found in two sections and are inter-referenced, unlike the 14 CFR regulations (FARs), where the crashworthiness regulations are not always found in consecutive sections.

b. DEF STAN 00-970 and 14 CFR 25/29 share impact tolerance criteria.

c. JSSG-2010-7 – *Crew Systems Crash Protection Handbook* is a comprehensive guide to the crashworthiness certification process for both fixed wing and rotary wing aircraft. It also includes guidance for certification milestones. JSSG-2010-7 provides sufficient engineering background to aid in establishing the certification basis.

2. **Container.** The main concern of the aircraft frame or fuselage container is to protect the occupants within it from outside hazards while retaining the occupants within the container.

a. DEF STAN 00-970 Part 1, Clause 4.22 and Part 7, Leaflet 307 describe the aircraft structure surrounding the occupant as a protective shell guarding the occupant from structure buckling or penetration into the structure. Similarly, MIL-STD-1290A, paragraph 5.1.1.3 requires sufficient structural strength to prevent buckling and bending in occupant compartments under given impact conditions, position occupants away from likely fuselage fracture areas and minimize inward buckling into living space.

b. 14 CFR 25.305 and 25.561 contain requirements for the structure that ensures a reasonable chance to escape serious injury in a minor crash.

c. DEF STAN 00-970 Part 1, Clause 4.22 and Part 7 Leaflet 307 includes requirements for the aircraft as a whole to sustain different types of impacts, accounting for different types of landing terrain.

d. MIL-STD-1290A requires floor structure construction to withhold loads created by occupants and cargo in a crash situation. In the case were the floor cannot support the anticipated loads, load limiters must be installed to appropriately transmit the loads to the structure. Similar provisions are found in 14 CFR 25.561 and 25.562.

3. **Restraint System.** The underlying principle behind the restraint system is to minimize all occupant motion relative to their seat – this includes the flailing of extremities. The following are particular considerations:

a. The seat, belt and harness are meant to withstand and distribute crash inertial loads over a larger area along the occupant’s body, while minimizing the occupant strike envelope. Typically, the restraint system is composed of a safety belt and shoulder harness. 14 CFR 25.785 and 29.785 offer regulations specific to seat belts and harnesses, limiting the occupant’s contact with injurious objects.

b. Occupant injury is primarily concerned with head injury, which is quantified by Head Injury Criteria (HIC).

c. Side-facing seats. DEF STAN 00-970 Part 7 Leaflet 714 provides regulations for side-facing seats within rotorcraft in the event of a crash landing. This is relevant for certain helicopter configurations, such as utility or transport helicopters.

4. **Energy Absorption.** The airframe structure and occupant seat construction should be designed to absorb enough impact energy to allow for a survivable impact for the occupant.

a. Both 14 CFR 25/29 and MIL-STD-1290A require energy absorbing padding to be installed on occupant seating. These are installed primarily to reduce trauma injury, but the padding is not meant to attenuate the inertial loads to a survival level.

b. Requirements for fixed wing aircraft are found in DEF-STAN 00-970 Part 1, Clause 4.22 or Part 7 Leaflet 307 for rotary wing aircraft. Energy attenuators are used in seat design to absorb impact energy while distributing the impact loads over a longer time interval in order to reduce the maximum sustained load by the occupant.

c. DEF STAN 00-970 Part 1, Clause 4.22 requires seats be sled-tested under dynamic loading, which is not required by 14 CFR 25.

d. "Submarining" is the effect of the crash impact loads forcing the occupant downwards, causing their seat belt to rest above the pelvis which can cause severe damage to the internal organs in the abdomen. 14 CFR 25.562 requires the occupant’s lap safety belt be located on their pelvis during impact. DEF STAN 00-970 Part 1, Clause 4.21 further requires consideration given to prevent submarining while subjected to dynamic overshoot during an impact. Though no strict regulation is given, consideration to submarining is given.

e. DEF STAN 00-970 Part 1, Clause 4.22 also includes energy absorption for cargo and freight that may be a hazard to personnel. MIL-STD-1290A, paragraph 5.3 includes maximum static loads and velocity changes for cargo restraint.

5. **Environment.** The occupant's environment must be designed to ensure the occupant is protected from the equipment inside the aircraft.

a. 14 CFR 29.785 for rotary wing aircraft requires that the occupant's strike envelope be kept free of rigid objects that may cause injury upon impact. This includes objects such as handles and loose equipment, which may strike the occupant in a crash situation. 14 CFR 25.785 for fixed wing aircraft requires that the occupant's strike envelope be kept free of rigid objects that may cause injury upon impact for seating that faces 18° askew from the aircraft centerline.

b. Because of structural deformations that occur during a crash, consideration must be given to the altered strike envelope of the occupant.

c. MIL-STD-1290A paragraph 5.2 requires that items in the head strike envelope be frangible.

6. **Post-Crash Factors.** Post-crash factors are those that impede the occupant's safe evacuation, as follows:

a. Fire is the most significant post-crash factor, due to the heat it produces, which may burn the occupants, the smoke that restricts the occupants' vision, and the gases that may be poisonous to the occupant(s).

b. MIL-STD-1290A paragraph 5.5 requires fuel systems to retain fuel during and after crashes of a certain magnitude. 14 CFR 25.967 requires a fuel tank drop test to prove the fuel tank will retain its fuel in a crash scenario.

3.14.11 Additional Guidance Information – Emergency Evacuation

1. **General.** The definition of ditching in DEF STANs includes the occurrence of a propulsion system failure or a loss of aircraft control, whereas the 14 CFR definition of ditching is a controlled water landing. DEF STANs do not consider a controlled landing to be ditching; rather it is identified as a precautionary alighting.

a. Several requirements of emergency evacuation are shared by land and sea egress, such as emergency exits, emergency exit handles, emergency exit lighting. These are mostly found in 14 CFR 25/29.803-25/29.809 and DEF STAN 00-970, Part 1, Clause 4.23 and Part 7, Leaflet 102. JSSG-2010 11 – *Emergency Egress Handbook* offers pertinent guidance for land evacuation or ditching, but lacks provision for underwater egress.

b. 14 CFR 25.807, 29.805 and 29.807 provide categories and corresponding requirements for emergency exit sizes, and required number of exits, based on the number of passengers in the aircraft. DEF STAN 00-970 requires that exits be as large as practicable, and that not more than three persons need to use any one exit in any given emergency. In the case of transport fixed wing aircraft, there shall be one exit for every unit of 30 passengers.

2. **Evacuation Times.** Civil and military regulating bodies have different evacuation requirements. The required evacuation time given in 14 CFR 25/29.803 is 90 seconds, which begins once the aircraft comes to a stop following an emergency landing, and ends once the last occupant leaves the aircraft.

3. **Land Evacuation.** MIL-STD-1290A paragraph 5.4 requires that exits be of sufficient size to allow the maximum number of occupants carried to exit the aircraft within 30 seconds while some exits are blocked.

4. **Ditching.** MIL-STD-1290A paragraph 5.4 requires that, after ditching, personnel evacuate the aircraft and gather survival equipment before the aircraft sinks.

a. DEF STAN 00-970 Part 1, Clause 4.22.3 and Part 7 Leaflet 307 requires that the evacuation of the aircraft through half of the available exits be possible within 30 seconds, or within the flotation time, whichever is less, regardless of the aircraft attitude in the water.

b. JSSG-2010-13 paragraph 3.14.3 states: *"Emergency egress from the ditching of the aircraft to total abandonment by the flight crew alone must occur within 60 seconds. Total evacuation plus boarding flotation devices by a flight crew with other occupants must occur within a total of 180 seconds."*

5. Ground Egress and Ditching share four main areas of concern:

a. emergency exit identification;

b. emergency exit arrival;

c. emergency exit operation; and

d. environment survival and clearing.

6. Emergency exit identification on land depends on the quality of light provided around the exit. The design of the emergency exit marking and lighting must consider the presence of smoke or dark conditions, as stated in 14 CFR 25.811 and 25.812. MIL-PRF-85676A states that there must be emergency lighting around the exit in an inverted U shaped band.

7. **Emergency Exit Arrival.**

a. 14 CFR 25.807 and 29.813 require unobstructed passage ways to emergency exits.

b. 14 CFR 25/29.809 requires all emergency exits to provide an unobstructed opening to the outside.

c. After an emergency landing, equipment and cargo must be restrained to ensure that the evacuation pathways are unobstructed – 14 CFR 25.813 and DEF STAN 00-970 Part 7 Leaflet 102, Clause 3.3 regulate emergency exit access.

d. 14 CFR 25.785 requires that there be hand holds on the seat backs or railing to steady occupants while in air. These grips or hand holds can be used as escape aids in the event of an emergency evacuation. DEF STAN 00-970 Part 1, Clause 4.20 allows the presence of external handgrips as egress assists while Clause 4.22.53 provides hand grip load criteria. In the event of a side or inverted landing, hand and foot grips must be placed to allow the occupants to escape.

e. JSSG-2010-7 paragraph 3.7.3.5.2 requires that the aircraft system and structure maintain the freedom of obstruction and functionality of the escape routes in post-crash conditions.

8. **Emergency Exit Operation.** The emergency exit must be operable, regardless of the attitude of the aircraft, by incorporating no more than two simple motions to operate and by including a grab bar surrounding the exit.

a. 14 CFR 25.809 requires that, in a non-deformed fuselage, exits must be fully opened within 10 seconds of the actuation of the opening means.

b. 14 CFR 25.809(c) states: *"The means of opening emergency exits must be simple and obvious; may not require exceptional effort; and must be arranged and marked so that it can be readily located and operated, even in darkness."*

c. DEF STAN 00-970 Part 1, Clause 4.23 requires a single positive movement using one hand to open and jettison.

d. MIL-STD-1472F paragraph 5.7.7.2 requires a single motion of the hand or foot to open.

e. All emergency exits must be operable from inside and outside the aircraft according to DEF STAN 00-970 Part 1, Clause 4.22. 14 CFR 25.809 excludes flight crew exits from this requirement.

9. **Environment Survival and Clearing**

a. 14 CFR 25.809 requires all emergency exits to provide an unobstructed opening to the outside and a view outside the exit while still closed. 14 CFR 29.805 requires flight crew exits not to be obstructed by water.

b. 14 CFR 25.810 and 29.809 require self-supporting slides (or equivalent) be installed at each passenger emergency exit, which are erected in 10 seconds or less.

10. **Underwater Egress.** Evacuation requirements for rotorcraft underwater egress are provided in DEF STAN 00-970, Leaflet 307: *Crash Landing, Ditching and Precautionary Alighting on Water*, which also includes scenarios where the aircraft is inverted. There is a similar statement for fixed wing aircraft in DEF STAN 00-970, Part 1 – Combat Aircraft, Clause 4.22, although it is not classified as a requirement. Similarly to land evacuation, there are four main areas of concern for underwater egress: emergency exit identification; emergency exit arrival; emergency exit operation; and water environment survival. Emergency exit identification underwater, as for above ground, largely depends on the quality and quantity of light provided around the exit, as follows:

a. The emergency exit placement within the cabin must allow for each occupant to see the exit nearest them; this is further complicated while submerged underwater. Exit identification should also consider water turbidity and the aberration effect of the water in light and dark conditions, both from the lighting system and from the external environment (i.e., the sun).

b. MIL-PRF-85676A(AS) states that there must be emergency lighting around the exit in an inverted U-shaped band.

c. MIL-PRF-85676A(AS) includes requirements for the duration and minimum depth of lighting sub-assembly function underwater for rotary wing aircraft.

d. MIL-PRF-85676A(AS) includes requirements for the duration and minimum depth of emergency illumination function underwater for fixed wing aircraft.

11. Emergency exit arrival is dependent on the occupant's maneuverability underwater in addition to the obstacles present within the cabin. In most submerged aircraft situations, especially rotorcraft, the cabin will invert causing occupant disorientation. Research has shown that occupants may be aided in reaching the exit by a tactile or illuminated guide bar, which is attached to the ceiling along the cabin aisle and leads to the main emergency exit. JSSG-2010-7 paragraph 3.7.3.5.2 contains egress route provisions for post-crash conditions, including aircraft submersion.

12. **Emergency Exit Operation.** The effects of suspension in water are detrimental to emergency exit operation. Accordingly, there must be a means for the occupants to support themselves, such as a grab bar, while operating the exit handle, to avoid turning themselves rather than the handle. DEF STAN 00-970, Part 7 Leaflet 105, Clause 11.4 imposes the requirement for all emergency handles to allow operation by gloved hands. If this is taken into account with the requirement for underwater escape provision of DEF STAN 00-970, Leaflet 307, Clause 3.3, it follows that emergency exits must be shown to be operable with gloved hands underwater.

13. **Water Environment Survival.** Survival in an underwater scenario is focused on the occupant's ability to breathe. In the cold, dark and disorienting underwater egress setting – further research, conducted separately by Dr. MJ Tipton and Dr. CJ Brooks, has shown – no evacuee is able to hold their breath for longer than 30 seconds even though research considers an egress time of over 60 seconds (Source: NATO RTO-AG-341 – *Requirements for an Emergency Breathing System (EBS) in Over-Water Helicopter and Fixed Wing Aircraft Operations)*. Thus, an Emergency Underwater Breathing Aid (EUBA), such as the Helicopter Emergency Egress Device System (HEEDS), is necessary to allow occupants to egress the aircraft before drowning. Rafts and life preservers are also required once the occupants have evacuated the aircraft and reached the water surface. 14 CFR 25/29.1411, 1415, 1561 and DEF STAN 00-970, Part 1, Clause 4.23 and Part 7, Leaflet 721 contain TAA-acceptable requirements. DEF

STAN 00-970 provides some underwater egress provisions under Emergency Evacuation and Ditching. DEF STAN 00-970 – *Flight Tests Installations and Structures*, Leaflet 1012 – *Escape Systems and Flotation Gear General Flight Test Requirements* recommends conducting a separate underwater escape demonstration in addition to the full-scale escape test that is conducted in a water tank facility.

3.14.12 Guidance Information – Additional Safety Provisions

1. JSSG-2010-10 – *Oxygen Systems Crew Systems Handbook* offers sufficient background and insight to inform the regulator of the important issues surrounding oxygen systems, especially their effects on occupant survivability. Paragraph 3.10.2.1 includes requirements for oxygen provision for occupants in pressurized aircraft at various altitudes.

2. The requirements given in 14 CFR 25.1439 are more descriptive of the oxygen systems' technical performance. The requirements in DEF STAN 00-970 are physiological requirements directly related to the survival of the occupants. For the acquisition of military aircraft, it is preferable that the design adheres to military requirements that have been developed through experience of military operations.

3. 14 CFR 91.207 requires all aircraft to have an Emergency Locator Transmitter (ELT). DEF STAN 00-970 requires aircraft to have two sonar locator beacons installed.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 15 — AVIATION LIFE SUPPORT EQUIPMENT (ALSE) AND ESCAPE SYSTEMS

3.15.1 Introduction

1. This chapter identifies the airworthiness design standards and associated guidance information accepted by the Technical Airworthiness Authority (TAA) for compliance with the TAA's policies and regulations applicable to Aviation Life Support Equipment (ALSE).

2. **Definition of ALSE.** For the purpose of this manual, ALSE is defined as all equipment and clothing primarily intended for the preservation of life, prevention of injury to and environmental protection of aircrew and passengers during flight, emergency egress, survival activities and rescue operations. This definition is inclusive of life rafts, life preservers, survival kits and other equipment used only for survival after an aircraft has crashed or ditched. The design of the aircraft and ALSE must be systemic and holistic such that occupants can safely and effectively perform their mission functions and, if necessary, safely evacuate the aircraft and get into a survivable state in minimum time. Operational requirements may dictate the need for additional equipment to enhance survival following egress in a threat area; for that purpose, Survival, Evasion, Resistance and Escape (SERE) equipment may be carried on board tactical fleets.

3. This chapter covers generic standards applicable to all ALSE as well as specific design requirements for individual equipment which may be aircraft-installed or aircrew-worn. The ALSE covered in this chapter includes the following:

a. Helmets (see Annex A of this chapter)

b. Life Rafts (see Annex B of this chapter)

c. Life Preservers/Survival Vests (LPSV) (see Annex C of this chapter)

d. Emergency Breathing Systems (EBS) (see Annex D of this chapter)

e. Immersion Suits (see Annex E of this chapter)

f. Anti-G Suits (see Annex F of this chapter)

g. Survival Kits/First Aid Kits (see Annex G of this chapter)

h. Chemical Defence Equipment (see Annex H of this chapter)

i. Harnesses (see Annex I of this chapter)

j. Escape Systems (see Annex J of this chapter)

k. Parachutes (see Annex K of this chapter)

l. Oxygen Systems and Masks (see Annex L of this chapter)

3.15.2 General Standards – ALSE General

1. Figure 3-15-2 through Figure 3-15-5 include general standards applicable to more than one category of ALSE and shall be used to form a part of the certification basis for ALSE.

General Airworthiness Design Standards
1. N/A

Figure 3-15-1 General Airworthiness Design Standards Related to ALSE

Military Airworthiness Design Standards
1. **MIL-HDBK-516B,** Airworthiness Certification Criteria
2. **JSSG-2010-X,** Joint Service Specification Guide for Crew Systems

Figure 3-15-2 Military Airworthiness Design Standards Related to ALSE

Civil Airworthiness Design Standards
1. **TCCA Airworthiness Manual Standard 525/529,** Article 52X.1301 – Function and installation

Figure 3-15-3 Civil Airworthiness Design Standards Related to ALSE

DND/CAF-Ratified International Standards
1. **ASCC ADV PUB 61/116/18,** Human Engineering Test and Evaluation Procedures for Systems, Equipment and Facilities

Figure 3-15-4 DND/CAF-Ratified International Standards Related to ALSE

Commercial Standards and Specifications
1. **CAN/CGSB-155.20-2000,** Workwear for Protection Against Hydrocarbon Flash Fire
2. **CAN/CGSB 4.2, No. 27.10-2000,** Flame Resistance – Vertically Oriented Textile or Fabric Assembly, Edge Ignition Procedure
3. **ASTM F1930-12,** Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin
4. **Federal Test 191A-Method 5931,** Determination of Electrostatic Decay of Fabrics

Figure 3-15-5 Commercial Standards and Specifications Related to ALSE

3.15.3 Guidance Information – General

1. The intention of DND should be to follow, where possible, the rules issued by the FAA and TCCA; however, the specific constraints placed on military aircraft and operations due to unique operational roles and missions can often result in deviations from these civilian rules. In addition, *National Defence Flying Orders* (B-GA-100-001/AA-000), 1 Cdn Air Div Orders and *Flight Safety for the Canadian Armed Forces* (A-GA-135-001/AA-001) may mandate the use of specific ALSE under certain circumstances.

2. This document refers to some approved specifications for in-service equipment. However, most of these are manufacturing specifications rather than design specifications, and do not address design and performance criteria. In most cases, original design specifications are unavailable. When new equipment is required, there may be a need to “reverse engineer” existing designs to baseline the new design specifications describing the performance requirements for the end product.

3.15.4 Guidance Information – Flame Resistance

1. Personalized ALSE and clothing (i.e., the complete ensemble worn by the aircrew) must meet CAN/CGSB-155.20-2000. This specification requires that each element in the ensemble be flame resistant (FR) as per CGSB-4.2 No. 27.10 – *Textile Test Methods Flame Resistance - Vertically Oriented Textile Fabric or Fabric*

Assembly Test, and achieve an average Thermal Protection Performance (TPP) of 6.0 or greater when evaluated in accordance with ASTM D4108-87 – *Standard Test Method for Thermal Protective Performance of Materials for Clothing by Open-Flame Method*. The TPP is a calculated value for a particular garment based on the fabric used; when various garments with different textiles are worn, TPP cannot be calculated.

2. As an alternative to CAN/CGSB-155.20-2000, a flash fire test as per ASTM F1930 – *Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin or "Thermo-Man test"* (i.e., the Thermo-Man test) may be used to provide an indication of the performance of the whole system (which may incorporate non-FR elements). The flash fire performance of a new system must match or exceed the performance of the previously-approved garments.

3. The TCCA fire requirement for fabric (AWM 525.853/529.853) is primarily for aircraft furnishings. The FAA and TCCA have no fire protection standards for aircrew worn clothing or equipment, but aircraft interiors must meet 14 CFR 25.853 and Appendix F of 14 CFR Part 25.

4. **Lessons Learned:**

a. Flash-fire testing of aircrew clothing/ALSE ensembles (under ASTM F1930) is usually carried out at a heat flux of 2 cal/cm^2. In the past, a two-second exposure was typically used. The Clothing and Equipment Millennium Standard (CEMS) project produced the Advanced Crew Ensemble (ACE) clothing system, which was designed and tested to a four-second flash fire exposure. These tests are not implicitly pass/fail tests but rather predict the level of injury sustained in the standardized test conditions. The outcome of this test is an estimate of the percentage of body that would sustain a first degree burn, second degree burn and third degree burn. Burn test results from in-service clothing systems should be used as the minimal performance requirement, i.e., the level of safety must be similar to, or better than, current designs. Other testing methods for FR textiles, such as vertical and horizontal burn tests (CSA/CGSB-4.2 No 27.10-2000 or ASTM D 6413-08 – *Standard Test Method for Flame Resistance of Textiles [Vertical Test]*), provide an indication of how a system will perform and can be used as screening tests for suitable materials for a design. As the Thermo-Man test (ASTM F1930) is a full system test, not all material needs to be fire resistant for the system to perform well. It is however important that burning material self-extinguish once the heat flux is removed and that no dripping of molten material be produced. Some fabrics and leather do not burn but may shrink when exposed to heat and may cause injuries by severely impeding blood flow. This is not an issue on most clothing, but it can be on tight fitting clothing, such as gloves and anti-g suits.

b. Some textiles that do not intrinsically meet the FR requirements may have coatings applied for improved performance. However, such coatings can be inadvertently depleted or removed during normal wash cycles and may, therefore, require special cleaning processes or regular maintenance to maintain their integrity. If coated fabrics are used, their performance after multiple cleaning cycles must be verified. Logistics support for special cleaning or maintenance must be considered. Most coatings used on fabrics are designed to absorb some of the energy and may consequently produce toxic gases after exposure to heat flux.

c. Aircrew clothing may be exposed to Petroleum, Oils and Lubricants (POL). To maintain the clothing's flame-resistant qualities, common POL products must be removed from the clothing during normal cleaning.

3.15.5 Guidance Information – Static Dissipation/Anti-Static

1. The clothing system must be designed to prevent and dissipate static electrical charges. Static electricity is produced when non-conductive fabric (i.e., synthetic fabrics) and similar materials are rubbed together. Localized, highly charged areas can be created on the clothing, which is then discharged when grounded. To prevent these localized-charged areas from forming, synthetic materials may have coatings applied to reduce friction or to make the material slightly conductive to neutralize the charged areas. Conductive filaments such as carbon fibres can be added to dissipate the static charge as it is created.

2. Fed-STD-191A, Method 5931 – *Determination of Electrostatic Decay of Fabrics* verifies that the fabric will dissipate static. Aircrew clothing must have been tested for compliance with this specification or an equivalent standard. More stringent specifications for anti-static clothing exist, but these are for specialized applications such as working in explosive atmospheres, e.g., aircraft fuel tanks.

3.15.6 Guidance Information – Windblast

1. ALSE that could be exposed to windblast, such as an ejection event, must be tested for its ability to survive the event and, at the same time, not result in injury to the crew. Windblast testing verifies the integrity of the system and can be used to estimate the loads experienced by the ALSE, as well as the loads transferred from the ALSE to the crew during an actual event.

2. **Lessons Learned:** Windblast testing should be conducted up to the maximum anticipated ejection velocity, and used to determine the maximum recommended ejection velocity. Windblast can cause the loss of survival equipment or other essential contents from the aircrew's pockets, which can result in aircrew injury and reduced survival prospects. The initial windblast load applied during ejection can push the ejectee's head with significant force against the seat headrest. This has caused loss of consciousness and injury to aircrew in past incidents. Furthermore, the aerodynamic loads applied via the helmet to the neck may be significant. Any change to the helmet mass or shape must be evaluated and may require retesting to quantify the effect of the change. Dayton T. Brown Inc. and the U.S. Navy have facilities that can simulate windblast effects on an entire ejection seat at speeds exceeding 600 knots. Not all equipment currently in service in the CAF has been windblast tested.

3.15.7 Guidance Information – Installation/Compatibility Testing

1. ASCC's ADV-PUB 61/116/18 – *Human Engineering Test and Evaluation Procedures for Systems, Equipment and Facilities* provides guidance on the Human Engineering Test and Evaluation methodology for aircraft workstations and tasks. However, for more detailed guidance, the Human Factors Engineering chapter (Part 2, Chapter 2) of the ADSM should be consulted. Proper testing of the compatibility of ALSE requires detailed knowledge of all the possible ALSE configurations flown by aircrew and knowledge of their environment and tasks. Operational requirements may dictate that aircrew, on specific fleets, fly with cumbersome gear such as, Chemical Defence (CD) ensemble and respirator, immersion suits, body armour, helmet mounted systems, etc. These configurations can be heavy and bulky and can seriously affect the ability of the aircrew to operate the aircraft, to conduct mission specific tasks or to egress the aircraft in an emergency. Testing of a representative sample of the aircrew population is required to validate that the operationally required configurations are safe and do not prevent the conduct of mission tasks. As some ALSE is designed to provide a survival capability post-crash/ditching, the equipment must be tested to ensure that survivors can safely evacuate the aircraft and reach their end-survival state on the ground or in a life raft in a reasonable amount of time.

NOTE

Generally, the Aerospace Engineering Test Establishment (AETE) conducts all ALSE compatibility verification for CAF design changes and can act as DND representative to witness third party testing.

3.15.8 Guidance Information – Physiological Compatibility (MIL-HDBK-516B Para 9.5.2)

1. Most physiological requirements for flight, such as oxygen requirements, anti-g systems, etc., are covered in the applicable FAA/TCCA rule or military equipment design requirements. However, military requirements often change and may dictate adding cumbersome equipment on aircrew, operating in adverse weather (both very hot and very cold), etc., such that medical expert advice or medical testing for human suitability may be required. This may be referred to as the "human rating" of the system. Medical expert advice may be required for protection from hypoxia, hypothermia, acceleration heat stress and dehydration, and to establish safe human limits for ejection and parachute systems.

2. **Lessons Learned:** New anti-g suit designs must be centrifuge tested, using a representative sample of the aircrew population to ensure proper fitting and performance under high G. The testing of the Joint Helmet Mounted Cueing System (JHMCS) for the CF188 required that new standards be developed for neck loads to determine

the acceptability of the system in ejection seat equipped aircraft. The additional neck loads created by the JHMCS created unforeseen ejection risk, which resulted in the decision to replace the ejection system with a more stable seat. Other helmet-mounted systems, such as Night Vision Goggles, also have implications on neck load and strain, especially if worn over extended periods of time. Breathing system design changes are often verified to ensure the flow and breathing impedance are satisfactory. DRDC Toronto's advice and expertise, or other national expertise, may be required to define the acceptability limits for new designs.

3.15.9 Guidance Information – Joint System Specification Guide

1. The 2010 series Joint Service Specification Guide provides advice on the design and testing of most crew systems. These documents can assist in selecting elements for a specification and provide sound advice. The existing Canadian specifications, JSSGs and operational requirements are essential documents for the drafting of equipment specifications for particular applications.

ANNEX A

HELMETS

3.15A.1 Introduction

1. This annex identifies the airworthiness design requirements for helmets.

2. **Requirements:** Helmets are mandated for use in some military aircraft by Flying Orders. Helmets have the following functions:

   a. provide impact and penetration protection;

   b. provide sound attenuation;

   c. provide an interface with the aircraft communications system;

   d. provide means of attaching and supporting Night Vision Goggles (NVG), helmet mounted cuing systems or other optics;

   e. provide eye protection from elements, sun and lasers; and

   f. provide means of attaching an oxygen mask.

3. Additional requirements that must be met by some helmets:

   a. be compatible with ejection system (Ejection seat aircraft);

   b. be compatible with parachute (SAR, Ejection seat aircraft);

   c. provide for installation of an aural altitude warning device (SAR);

   d. permit attaching signaling device for multiple parachutist jumps (SAR); and

   e. permit attaching full face protector (Helo FE).

3.15A.2 General Specification/Guidance for Helmet Systems

1.	AIR STD 61/102/8	Evaluation Procedures for Flight Helmets
2.	AIR STD 61/102/25	Methods to Measure the Mass Properties of Flight Helmets
3.	AIR STD 61/113/15A	The Optical and Material Requirements for Aircrew Helmet Visors
4.	C-02-040-009/AG-001	Chapter 10, Noise control and Hearing Conservation
5.	MIL-DTL-87174	HGU-55 Specifications
6.	MIL-V-43511D	Visors, Flyer's Helmet, Polycarbonate
7.	MIL-V-85374(AS)	Visors, Shatter Resistant
8.	MIL-C-83409	Coatings, Visor, Polycarbonate, Flying Helmet
9.	MIL-V-22272D (AS)	Visors, Neodymium Laser, Protective for Aircrewman's Helmet Visors
10.	ANSI Z90.1	Specifications for Protective Headgear for Motor Vehicular Users
11.	ANSI 3.5-1997	Speech Intelligibility Index
12.	ANSI 12.6-1997 (R2002)	Methods for the Measuring of Real-Ear Attenuation of Hearing Protectors
13.	JSSG-2010-9	Personal protective Equipment Handbook
14.	MIL-H-43925D	Helmet Flyers Protective SPH-4
15.	MIL-H-85047A	Helmet Assembly HGU 34/P
16.	AS1270-1988	Acoustic Hearing Protective Equipment
17.	MIL-STD-27796D	Connector Bayonet, Three Pin, Oxygen Mask

18.	DEF STAN 00-970, Pt 1, Section 4, Issue 2, Supp 66	Requirements for Human Exposure to Noise and Vibration in Cockpits and Cabins, General Procedures for Acoustic Measurements
19.	Defence Research Report R-87-2B	Draft Specification for Head Protection System for Canadian Forces Aircrew for Aircraft with Ejection Seats, Volume 1, Sep 87 (internally, within DND, available at AEPM RDIMS #887941)
20.	Defence Research Report R87-3	Draft Specification for Head Protection System for Canadian Forces Aircrew for Aircraft without Ejection Seats, Volume 2, Mar 87 (internally, within DND, available at AEPM RDIMS #887942)
21.	Defence Research Report R87-4	Draft Specification for Head Protection System for Canadian Forces Aircrew – Rationale, Volume 3, Mar 87 (internally, within DND, available at AEPM RDIMS #887943)
22.	Defence Research Report R86-2	Development of a Specification for Head Protection Systems for Canadian Forces Aircrew – Background Review, Apr 86 (internally, within DND, available at AEPM RDIMS #887945)
23.	Defence Research Report R86-10	Test Procedure Documentation, May 86 (internally, within DND, available at AEPM RDIMS #887955)
24.	Defence Research Report R86-22	Development of a Specification for Head Protection Systems for Canadian Forces Aircrew – Testing to Draft Specification, Dec 86 (internally, within DND, available at AEPM RDIMS #887959)
25.	Defence Research Report R87-7	The Development of a Facial Protection System for the Model 190 Aircrew Helmet – Final Report, Mar 87 (internally, within DND, available at AEPM RDIMS #887960)
26.	Generic Helmet Certification Basis Table (internally, within DND, available at AEPM RDIMS #1130565 and a sample Technical Note, at RDIMS #1420857)	

3.15A.3 Lessons Learned/Guidance

1. **Impact Protection.** Helmets must provide sufficient protection to the head in a survivable crash. As aircraft are built to different specifications, helmets should be different from fleet to fleet. However, in practice this is not typical as worst case scenarios are used for the design. In the case of fighters, crashes are not a design concern; ejection loads, windblast loads, parachute riser interference and head protection on parachute landing drive the specification requirements.

2. **ICS Compatibility.** All older designs of ICS were compatible with a standard of headset using 20ohm speakers. On most new fleets, ICS impedance varies significantly. Many fleets have specific impedance requirements for microphone and earphones which require fleet specific modifications. Some fleets have a TEMPEST system that requires special connectors to improve system shielding. In addition, some mission specialists may require binaural capability.

3. **Noise Attenuation.** Helmets must provide sound attenuation for hearing protection and effective communications. C-02-040-009/AG-001 – *General Safety Program General Safety Standards* Chapter 10 provides the CAF regulations for hearing conservation in the workplace, which should be used as guidance for helmet design. Either passive or active methods may be used to attenuate sound in the ear cup. Passive damping utilizes material to absorb or deflect noise. Generally, this works very well with high frequency noise but performs poorly for low frequency noise. The use of in-ear speakers surrounded by damping material was recently demonstrated to improve low-frequency sound attenuation. Laboratory testing of this technology has shown that it can substantially reduce the in-ear noise level and significantly improve communications. The use of small in-ear speakers has an impact on the impedance of the helmet and testing with the aircraft ICS is required. Active Noise Reduction (ANR) technologies may also be used to acoustically cancel most unwanted sounds. This technology works well with medium and high frequencies that tend to be constant. It has difficulty coping with rapid changes in frequency and with lower frequencies. Testing in the laboratory using the target aircraft sound spectrum is required to properly assess the performance of an ANR system in an aircraft. ANR systems with a slow response can increase the noise level if the frequency, phase and amplitude are not matched to the incoming sound.

4. **Night Vision Goggle (NVG) Integration.** Adding NVGs to a helmet significantly shifts the Centre of Gravity and changes the helmet's mass properties. Generally, the effects are accurately calculated and counter-weights can be added to restore the CofG. However, even with a perfectly balanced installation any variation in seating position and posture will have an exaggerated physiological effect. The added mass of the NVG installation, combined with the effects of aircraft vibration can result in both short-term and long-term impact on the wearer. To minimize risk of injury and ensure effective NVG operation, fitting a helmet for NVGs requires a higher degree of rigour in order to achieve a good close fitting helmet, appropriate NVG eye relief and proper helmet balance. Most helmets have some retro-reflective tape applied to them to assist in finding downed aircrew. This tape is not NVG compatible and must be used sparingly. It should not be applied to the front portion of the helmet as it will hamper NVG Ops. Approved patterns for the reflective tape are included in the applicable helmet CFTO. If the reflective pattern is changed, it must be evaluated using NVG Ops. NVGs are not compatible with standard helmet visor systems, i.e., aircrew cannot fly with one visor down at all times. A laser visor compatible with NVGs has been developed and authorized. This visor must be clipped onto the NVGs.

5. **Optics Integration.** Adding optics to a helmet significantly affects its mass properties and wiring between the helmet and the aircraft avionic system is likely required. The JHMCS is an example of such a system. In addition, if the optic system modifies the helmet shape, testing is required to assess the impact of windblast loads upon ejection.

6. **Visors.** Generally, flying orders require that aircrew always fly with one visor down. Helmets normally have two visors, one clear and one neutrally tinted to accommodate all flight conditions. Current visors are made of polycarbonate which is pliable and strong and are coated to provide scratch resistance. Laser Eye Protection (LEP) visors can be worn in lieu of the neutrally tinted visor to provide for operationally required protection. Gradient tinted visors (MIL-V-43511D, Class 3) are also available, but not widely used. NVGs are not compatible with helmet visors but compatible protective glasses may be worn.

7. **SAR Helmets.** SAR technicians must be capable of operating from various aircraft on short notice. Their helmet must be compatible with multiple aircraft communication systems (ICS), must be suitable for static line and freefall parachuting and may require NVG compatibility. In addition, SAR helmets may require provisions for accommodating mission specific equipment such as, a dither (altitude aural warning device), external lighting for twilight jumping, compatibility with mobile radio, etc. In order to achieve compatibility with various aircraft ICS, SAR Techs may require an ICS adaptor to match the impedance of the helmet to the aircraft ICS requirement.

8. **Helmet Physical Characteristics.** Helmet weight, CofG and moments of inertia are the key characteristics to determine how the helmet will behave dynamically and will provide an indication of the comfort and long-term physiological impact of the helmet on the user.

9. **Ejection System Compatibility.** Ejection Seats impose additional requirements, such as wind blast and parachute riser compatibility. In addition, some aircraft use a canopy fracturing system which demands additional protection to the aircrew from the fracturing system, as well as canopy fragments.

ANNEX B

LIFE RAFTS

3.15B.1 Introduction

1. This annex identifies the airworthiness design requirements for life rafts.

2. **Requirements:** Life rafts are mandated by TCCA flight rules and by military Flying Orders. Life rafts have the following functions:

a. provide flotation, isolation from water and shelter from the environment; and

b. provide for some survival equipment.

3.15B.2 General Specification/Guidance for Life Raft

1.	TSO-C69c	Emergency Evacuation Slides, Ramps, Ramp/Slides, and Slide/Rafts
2.	TSO-C70b	Life Rafts (Reversible and Non-Reversible)
3.	AWM	Part 6, Para 602.63 Life Rafts and Survival Equipment – Flights over Water
4.	14 CFR 25/29.1411 and 1415	Ditching Equipment
5.	14 CFR 135.167	Emergency equipment: Extended overwater operations
6.	A-A-59682	Valve Inflation 25-person life raft
7.	MIL-PRF-18494F	Life Raft Multi-Place (8, 12 & 20 person)
8.	MIL-H-9131H	Twenty Person Life Raft
9.	MIL-PRF-81542B	Performance Specification Life Raft Inflatable Single Person, 5 Feb 2007
10.	D-22-305-000/SF-004	Life Raft General Specification
11.	DRDC Technical Note TN 2001-144	CF188 Life Raft Replacement Study, Sep 2001 (internally, within DND, available at AEPM RDIMS #524931)
12.	DRDC Technical Report TR 2003-109	Thermal resistance and estimated survival for the equipment in the CT156 Harvard II aircraft seat survival kit, Jul 2003 (internally, within DND, available at AEPM RDIMS #505799)
13.	DRDC Technical Report TR 2001-125	Thermal Resistance of Inflatable and non-inflatable floors of one-man life rafts for the CF188 Escape System, Jul 2001 (internally, within DND, available at AEPM RDIMS #525727)
14.	DRDC Technical Report TR 2009-065	Evaluation of Inflatable Single Place Life Raft (ISPLR), Jan 2009 (internally, within DND, available at AEPM RDIMS #897018)

3.15B.3 Lessons Learned/Guidance

1. **Installation characteristics and evacuation times.** 14 CFR Part 25/29 provides guidance on installing life rafts in the aircraft which covers location, placarding and evacuation times. The emergency evacuation times specified under 14 CFR Parts 25 and 29 is 90 seconds and should be used only on very large aircraft carrying passengers. On smaller military aircraft, a shorter evacuation time should be specified. The implications of evacuation times are expanded upon in the section covering inflation times.

2. **Inflation Times.** Life rafts are generally inflated using a mixture of nitrogen and CO_2 or with nitrogen alone. Smaller rafts may use only CO_2, which generally results in slower inflation times. Life rafts stored in wings or sponsons may require longer inflation times as they may be cold soaked. For example, the recently developed Joint Inflatable Single Place Life raft (MIL-PRF-81542B), which uses CO_2, allows 60 seconds for the life raft to reach its design shape at 71 ºC and up to 5 minutes at -18 ºC. 14 CFR Part 25/29 allows 90 seconds to evacuate an aircraft, so a life raft that inflates in 5 minutes is not acceptable for an aircraft in compliance with the regulation. Life rafts

should inflate sufficiently to permit boarding in 30 seconds or less to permit a 90 second evacuation; for a particular military aircraft, a suitable requirement should be specified based on the evacuation time specification.

3. **Survival Kit.** TSO-C70b lists some survival contents required in the life raft. TCCA and FAA have requirements under operating rules for minimal survival kit contents in a life raft. The FAA rules are under Title 14 CFR Part 135.167, and TCCA rules are at AWM 602.61 and Standards 724.84. It should be noted that these are operating rules and guidance should be provided by the operational staff as military requirements may dictate different or supplemental equipment. Annex G of this document contains additional guidance of survival kits.

4. **Quantity and Sizing.** Aircraft certified under 14 CFR 25/29 must have a minimum of two life rafts with sufficient "overload" capacity such that, if the largest one is lost, the remaining can accommodate the full passenger load in its overload capacity rating. It should be noted that the FAA rates the capacity based on an average sized passenger. For the military, it may be required to stipulate higher weights and space requirements for operationally kitted aircrew or soldiers in fighting order. On maritime helicopters, the crew fly with a one-person life raft attached on their back. In this case, it was agreed that the aircraft could only have one aircraft installed life raft as it meets an equivalent safety level. However, for overwater flight with passengers, the installation of a second life raft is required to meet the certification requirement.

5. **Shelter.** Though aircrew are typically issued life preservers (LP) and immersion suits, the life raft provides the best survival option. Life rafts provide shelter from wind, water and some insulation from the cold. Larger life rafts are composed of two large tubes with the floor located in between the tubes. This design provides for insulation and some protection from hypothermia. Smaller one-person life rafts must have insulated or inflated floors. Current six and ten-person life rafts are non-reversible as they have a self-erecting superstructure. If they inflate upside down, they must be flipped to the right side up. Larger life rafts are reversible in that the outer structure can be erected irrespective of the raft position.

6. **Aircraft Evacuation on Ditching.** 14 CFR 29 requires a minimum of two life rafts installed on either side of the helicopter. Life rafts on aircraft certified for ditching should be installed on the outside of the helicopter near the primary emergency exit. If this is not possible, the life raft should be in the interior near the emergency exit. Ditching experience has shown that, for optimum survival, the life raft must separate from the aircraft once filled with survivors. Life rafts have water pockets and sea anchors that deploy to enhance their stability; these also limit their drift velocity. The aircraft with its larger surface area will drift faster than the life raft; thus the life raft on the windward (upwind) side will experience less difficulty separating from the aircraft. The life raft on the leeward side (downwind) may need to be pushed past the nose or tail to escape from the downed helicopter. Through the years, the operators have developed their evacuation procedures to minimize risks and improve effectiveness. The CH124 Operational community has developed such a procedure for life raft deployment: the life raft is tied to one aircrew member who swims outside the main rotor area, where the life raft is then inflated. Other crew members swim to the inflated life raft. This process can only be used by trained personnel who wear immersion suits.

7. **Life Raft Stability.** Life rafts must be stable once inflated. To achieve this, water pockets, sea anchors or other means may be used. The life raft should be tested in rough seas to ensure it is difficult to overturn.

8. **Life Raft, Mooring Lines, etc.** TSO-C70b requires multi-person life rafts to have a mooring line (sometimes referred to as a painter line), a trailing line, a grasp line and a life line. The TSO specifies the requirement for these lines. On a single-person life raft, only a securing line is required to permit securing the life raft to the survivor.

ANNEX C

LIFE PRESERVERS/SURVIVAL VESTS

3.15C.1 Introduction

1. This annex identifies the airworthiness design requirements for Life Preservers (LPs) and Survival Vests (SVs).

2. **Requirements:** FAA/TCCA state requirements for life preservers. However, because of operational requirements or aircraft interface requirements, commercial LPs may not be suitable for use in military aircraft. Basic requirements are the following:

a. provide flotation (LP);

b. provide minimal survival kit (LP or SV).

3.15C.2 General Specification/Guidance for Life Preserver/Survival Vests

1.	AWM	Part 6 Subpart 2, 602.62 Life Preserver and Flotation Device
2.	TSO-C13f	Life Preserver
3.	TSO-C72c	Individual Flotation Devices
4.	AIR STD 61/102/14A	Armour Protection for Aircrew
5.	AIR STD ACS (ASMG) 4065	Aircrew Inflatable Life Preservers: Flotation and Related Requirements
6.	AIR STD 61/102/20	Methodology for the Measurement of Inherent Buoyancy of Aircrew and Passenger Clothing Systems
7.	CAN/CGSB 65.7-2007	Life Jackets
8.	U.S. Coast Guard Title 46	Art 160.176
9.	D-22-521-000/SF-001	Survival Vest Specification
10.	D-22-521-000/SF-002	Life Preserver Specification
11.	D-22-521-000/SF-003	Universal Carrier Specification
12.	MIL-I-23145B	Inflation Assemblies, Life Preserver
13.	MIL-O-81375B	Oral Inflation Assemblies
14.	MIL-PRF-25370	Inflator Assy, Life Preserver
15.	MIL-H-85478	Beaded Handle
16.	MIL-L-24611	Life Preserver Support Package for Life Preserver, Mk 4
17.	MIL-L-81561G	Life Preserver Assy, Inflatable, Aircrew and Passenger, Cemented and Heat Sealed
18.	MIL-L-85347	Life Preserver LPU-23 A/B
19.	MIL-S-44095	Survival Kit, Individual, Vest Type
20.	MIL-V-44416	Vest Aircrew Survival
21.	MIL-DTL-32087A	Inflation Device, Automatic, FLU-8B/P and FLU-9B/P
22.	MIL-DTL-32088A	Inflation Device, Automatic, FLU-12/P
23.	Sample Certification Basis and Compliance Matrix for Life Preservers and Survival Vests (LPSVs) (internally, within DND, available at AEPM RDIMS #717696, and 1086580, respectively)	

3.15C.3 Lessons Learned/Guidance

1. **Buoyancy Requirement.** FAA/TCCA requirements are covered by TSO-C13f. The minimal requirements for a military LP are stated in AIR STD ACS (ASMG) 4065. Generally, a military LP requires a minimum of 35 lb buoyancy; more buoyancy may be required to offset the use of body armour and additional contents in the Survival Vest.

2. **Floating Angle and Freeboard.** The floating angle and freeboard are good indicators of the adequacy of an LP design. The optimal floating angle should be about 45 degrees. The USCG recommends that it be 20 to 65 degrees from vertical. It should be noted here that wearing an immersion suit will adversely impact this flotation angle. Most regulatory bodies have hence developed alternate requirements for buoyancy angles when immersion suits are worn. The freeboard must be a minimum of 2 inches (5 cm). Most regulatory agencies require that this be about 4 inches (120 mm); however, given the military requirement to wear extra equipment such as body armour that does not float, 4 inches may not be possible in all configurations. The LP must be tested with all operational clothing configurations; it should be optimized for the most commonly worn configuration. Clothing with more inherent flotation will have a greater effect on the system, in particular the immersion suit. Ideally, the user should be able to achieve the proper floating angle and freeboard without having to conduct any actions. If some operator input is required, it must be simple and achievable in cold water with very little feeling remaining (i.e., numb hands and feet).

3. **Self-Righting.** CAN/CGSB 65-7-2007 provides guidance for testing the self-righting capability of an LP that is manually inflated. For ejection seat aircraft, the self-righting should be tested by entering the water at 18 to 24 ft/sec with both the LP inflated (conscious aircrew) and deflated (unconscious aircrew).

4. **Auto-Inflation.** Automatic Inflation Devices (AIDs) are only used on ejection seat-equipped aircraft. AIDs are highly reliable devices made to MIL-DTL-32087A or equivalent specifications and must be packed in the LP in such a manner as not to impede water from reaching it. Current AIDs are electronic devices that sense water through conduction; however, other devices that use dissolving pills are used by some nations.

5. **Colour.** LPs are normally constructed of highly visible colours, such as yellow or orange; however, for tactical reasons subdued colors may be required.

6. **Survival Equipment.** Military pilots are often fitted with a LPSV combination. The LPSV must contain a strobe light, whistle and sea dye marker (or See-Streamer) as minimal contents. On aircraft where space is extremely limited, the survival vest may be used to store items normally contained in a survival kit. Operational staff may also wish to include mission kit or SERE equipment in the vest. As the survival vest contents will add bulk and weight, aircraft integration testing is required for new configurations to verify suitability for flight use. Civilian pattern aircraft only carry LPs with the minimum contents required by the FAA/TCCA.

7. **Inflation Times.** LPs usually employ CO_2 cylinders for inflation. Carbon Dioxide is solid at temperatures colder than -56 ºC; thus, it will not perform well if cold soaked to -40 ºC. If a cold cylinder is used, the rapid expanding gases cool down the cylinder and the CO_2 will become solid. At normal cockpit temperature, this is not a concern. If operations involve extended work at cold temperatures, consideration should be given to using a different gas that will not freeze, such as nitrogen.

8. **LP Size.** The LP packed size may be critical particularly if worn by aircrew during flight. Restrictions in head movement or poor downward visibility may be created by larger LPs. Newer LPs are packed very tightly and some are vacuum packed to permit a smaller volume; however, to maintain this very small pack size, the oral inflation valve must not leak under vacuum and must remain undamaged.

9. **Infant LP (sometimes referred to as infant COTS).** TSO-C13f includes specification requirements for child and infant life preservers. Military aircraft certified under 14 CFR 25 and 29 or equivalent which can be tasked to carry children or infants should carry these LPs. Infant LPs are used on military transport aircraft, such as the CC130. Historically, a ratio of one infant LP (or cot) per 10 adult-sized LPs has been used.

10. **Installation.** On most military aircraft, aircrew will fly all missions with a LPSV. For aircraft/missions on which all personnel do not wear an LP, Universal Carrier Life Preserver (UCLP) survival vests and TSOLPs are normally installed in the aircraft and worn only in emergencies. In such cases, an LP must be installed in the aircraft at each flight station and near each passenger seat. TCCA mandates the wearing of LPs when flying helicopters over water. Given the role of some fixed wing aircraft, the wearing of LPs may be mandated by Operational Staff for particular missions (e.g., SAR).

11. **Other Requirements.** Survival vests may have modifications to fit the particular aircraft system. For example, on some ejection seat-equipped aircraft, the life raft is secured to the survival vest. This ensures that, post ejection,

the life raft and survival kit may be deployed prior to water entry. For each of these modifications, the strength and requirement for breakable links (if required) must be evaluated and be acceptable to the TAA.

12. **Troop LP.** When carrying troops in military helicopters, the standard issue passenger LP may not fit over some mission-specific equipment/clothing. Troops cannot use standard issue Army constant flotation gear in the aircraft, as it would hamper egress and may not be compatible with the seat restraint system. The LP used by troops must be of the inflating type and be aircraft compatible.

ANNEX D

EMERGENCY BREATHING SYSTEMS

3.15D.1 Introduction

1. This annex identifies the airworthiness design requirements for Emergency Breathing Systems (EBSs).

2. An EBS is mandated by Flying Orders for helicopters operating over water. The EBS provides sufficient breathing air to conduct an emergency egress from submerged, possibly inverted, aircraft following an emergency ditching occurrence.

3.15D.2 General Specification/Guidance for EBS

1.	ADV PUB 61/102/23	Emergency Underwater Breathing Device
2.	D-87-003-000/SG-001	Quality of Compressed Air and Gases for Divers
3.	Survival Systems Training Ltd. Study	Functional Task Analysis of Helicopter Underwater Escape Training for the Land Force Element of the Standing Contingency, Dartmouth (internally, within DND, available at AEPM RDIMS #577838)
4.	STANAG 7078AMD	Use of Helicopter Emergency Underwater Breathing Apparatus (HEUBA)
5.	CAN/CSA B339- (latest version)	Cylinders, spheres and tubes for the transportation of dangerous goods
6.	BS EN 250:2000	Respiratory Requirements – Open-circuit self-contained compressed air diving apparatus – Requirements, testing, markings
7.	CAP 1034	Development of a Technical Standard for Emergency Breathing Systems, May 2013 (internally, within DND, available at AEPM RDIMS #1340595)

3.15D.3 Lessons Learned/Guidance

1. Aircrew flying over water in helicopters require an EBS to improve the likelihood of successfully conducting an underwater emergency egress. Helicopters certified for ditching (14 CFR 29.801) must show that they can ditch and stay upright to permit a controlled aircraft emergency exit. However, military experience with the CH124 and other helicopters that meet the requirements of 29.801 shows that limitations associated with controlled ditching certification are often exceeded. The nature of military operations has resulted in numerous accidents in which the helicopter capsized very rapidly after ditching, hence the requirement for EBS.

2. The first system adopted for service use was the HEED (Helicopter Emergency Egress Device) which had several flaws. The regulator used a single stage system to bring high-pressure air to breathing pressure and did not function smoothly. The HEED also did not function well at all attitudes. The initial HEED had the regulator mounted directly on the bottle which added the risk that the bottle could be lost by contact with the seat harness or airframe during exit. This latter flaw was remedied by mounting the bottle on the aircrew and by using a high pressure hose to link the bottle to the regulator.

3. The current EBS is a dual-stage design where the high pressure or first-stage regulator is mounted on the high pressure reservoir, while the lightweight second stage mouth piece is connected to the first-stage regulator by a flexible low-pressure hose. The mouth piece is mounted on the upper torso making it easy to find by feel alone.

4. **EBS Duration.** The EBS should provide sufficient air to last approximately two (2) minutes underwater (in accordance with ref 1 Air Standard). It should be noted that, because of the stress, cold water and workload, estimating the duration time can be difficult. DND currently uses 2.5 cubic feet cylinders on the CH124; however, experience has shown that these large EBS can be depleted by aircrew in less than two minutes.

5. **Mounting of EBS.** The EBS must be mounted such that the mouthpiece can be easily reached and used. The EBS must be integrated into the Life Support System. Inflating the LP underwater must not affect the availability or hinder the proper use of the EBS. Proof of the correct performance of the complete system is usually done in

the Modular Egress Training Simulator (METS™) configured to resemble the target aircraft internal layout. This test will ensure that the integration with the seat restraint and ALSE are acceptable, and verify that the system permits proper underwater emergency egress. Engineering Test and Evaluation (ET&E) and Operational Test and Evaluation (OT&E) in the aircraft are also required to ensure proper Human Factors Engineering (HFE) integration.

6. **EBS for Smoke Protection.** Though EBS is provided to enhance the survivability in a ditching case, there have been cases where the EBS has been used to protect aircrew from smoke in the cockpit. As helicopters are not normally fitted with oxygen systems or smoke masks, there is no protection for the aircrew in the event of smoke. The EBS can provide one or two minutes of protection but must be fully replenished after each use to provide maximum survivability benefits should the helicopter ditch and capsize.

7. **Lessons Learned.** An EBS is required by helicopter crews when flying over water and is mandated by flying orders. Recent modification of the CH124 for carriage of troops over water has raised the issue of the safety of the troops. A U.S. Marine Corp accident in which a helicopter ditched is a case in point. All the troops aboard were killed, however, all aircrew survived because their ALSE included an EBS. The study done by Survival Systems at reference 3 demonstrates that the availability of EBS to troops onboard a helicopter would greatly reduce the likelihood of death due to drowning. Therefore, consideration should be given to provide non-aircrew with EBS for overwater operation in helicopters.

8. **Training.** The users of the EBS must receive proper training on the use of the system including in-water use of the system. The training must be proportionate with the perceived risk:

a. Crew and frequent flyers must undergo underwater simulator/dunker training;

b. Non-frequent, but planned, flyers should receive some form of pool training with the device prior to overwater flight; and

c. Ad hoc flyers should receive practical familiarization training prior to overwater flight.

ANNEX E

IMMERSION SUITS

3.15E.1 Introduction

1. This annex identifies the airworthiness design requirements for Immersion Suits.

2. Immersion suits are mandated by Flying Orders when operating some aircraft types overwater. Immersion suits are designed to:

   a. protect from hypothermia by shielding the body from water by keeping the water completely out of the suit or by limiting the water ingress; and

   b. provide insulation to limit the loss of body heat.

3.15E.2 General Specification/Guidance for Immersion Suits

1.	AWM	Part 6 Subpart 2, 602.63 Life Rafts and Survival Equipment – Flights over Water
2.	ADV PUB 61/101/23	Methodology for Assessment of the Thermal Performance of Immersion Protective Clothing
3.	AIR STD 61/102/19	Cold Water, Prediction of Survival Times
4.	CAN/CGSB 65.17-12	Helicopter Passenger Transportation Suit System
5.	U.S. Coast Guard Title 46, Art 160.171	
6.	D-22-522-000/SF-001	Clothing Outfit, Flyer's, Anti-Exposure Quick Donning Type
7.	D-22-536-000/SF-000	Specifications for Coverall, Flyers, Anti-Exposure, Immersion, Polytetrafluoroethylene
8.	D-22-536-001/SF-001	Specifications for Coverall, Flyers, Anti-Exposure, Immersion, Polytetrafluoroethylene (PTFE), MSF 751
9.	ETSO-2C502	Helicopter crew and Passenger Integrated Immersion Suits
10.	ETSO-2C503	Helicopter crew and Passenger Immersion Suits for Operations to or from Helidecks Located in Hostile Sea Areas
11.	ISO 15027-1	Immersion Suits, part 1, Constant Wear Suits, requirements
12.	B-22-050-278/FP-000	Manual of Aviation Life Support Equipment and Techniques
13.	Tech Note DAEPM(FT) 6 2014-002 (internally, within DND, available at AEPM RDIMS #1437014)	

3.15E.3 Lessons Learned/Guidance

1. Civilian regulation put forth by Transport Canada (AWM 602.63) requires that Helicopter Transportation Suits made to CAN/CGSB 65.17-99 be used when operating helicopters over water. In the military, 1 Cdn Div Orders mandate the use of constant-wear immersion suits on various fleets and operational requirements have mandated the installation of quick-don immersion suits on other fleets. The CAF currently uses constant-wear suits designed to CAF specifications (D-22-536), which are not performance-based but based on a specific CAF design.

2. Currently, two types of immersion suits are in use in the CAF:

   a. **Constant-wear immersion suits.** These suits are designed to be dry but can permit some minor water ingress while remaining effective. Aircrew must wear a special liner under the suit to provide the required insulation. These suits must be well fitted to the aircrew as they must be worn in flight with other required ALSE and must be aircraft/workstation compatible.

   b. **Quick-Don Immersion Suits.** These are of a one-size-fits-all design and are installed in fixed-wing aircraft to respond to a ditching or bail-out emergency. These suits are typically made of a single layer of thick insulating material, such as neoprene, and are relatively easy and fast to don. Other equipment (e.g., LP, parachute harness) will be required to be worn on top of the Quick-Don suit.

3. **Testing Requirement.** New immersion suit designs must be tested for insulating properties. These properties are referred to as Clo values, which are directly related to body heat loss. Typically, Clo values are determined by testing the immersion suits with live subjects or instrumented manikins in a cold water tank. These tests are done with a perfect fitting suit both in the dry condition and then repeated with some water in the suit, in both calm and stirred water. To determine the quantity of water that enters in the suit, in-water testing with different subjects is required. The testing must strive to reflect the actual conditions in which the suit will be used to accurately reflect the expected water ingress. CAN/CGSB 65.17-12 provides a methodology that simulates a jump water entry followed by in-water survival. This procedure is not suitable for current CAF use. When entering the water following an ejection, potential dragging by the parachute must be considered. Similarly, the helicopter worse case would be a ditching followed by the aircraft overturning. Therefore, some tailoring of the procedure is required to match the forecasted operational scenario. Current in-service constant wear immersion suits were designed to protect for a maximum of six (6) hours survival, in 0 ºC water. Immersion suits must not provide too much insulation, as this would be detrimental during every day use. Therefore, testing under normal and expected hot weather is required to ensure aircrew will not be affected by heat stroke. It should be noted that operational requirements could dictate different survival times which would alter the design. The quick-don immersion suit should meet similar survival requirements but be easy and quick to don. The current CP140 quick don suit has a reduced Clo value when compared to the constant wear immersion suit, as the storage space in the CP140 dictated the use of thinner material. The Tech Note drafted by DAEPM(FT) 6 (reference 3.15E.2.13) summarizes most of the work done on immersion suits in DND and other relevant papers for the design and evaluation of immersion suits.

4. **Survival Times and Functional Times.** Immersion suits are tested and achieve a quoted functional time. The functional time is defined as the time required for the core body temperature to drop to 34 °C. B-22-050-278/FP-000 provides a table with functional times for various clothing Clo ratings. It should be noted that, at that temperature, some body functionality may not be usable as localized cooling will affect strength of limbs and will render extremities numb. Survival time is defined as time for the core body temperature to drop to approximately 28 °C. Survivor that are colder than 34 °C will not be able to perform simple tasks to help them survive; thus, a survivor floating in a life preserver may drown by ingesting water due to waves.

5. **Flotation Characteristics.** Immersion suits provide increased buoyancy because of the inherent design of the suit and air trapped in the suit. It is important to test the suit with the issued ALSE to ensure aircrew achieve an adequate flotation angle and that they can perform the required survival tasks. The flotation angle requirement for immersion suits issued by the U.S. Coast Guard (SOLAS) requires that the user’s head be 30 º to 80 º above the horizontal. The CGSB has no such requirement for flotation angle but has a requirement for FOV and the ability of achieving a vertical position to permit life raft boarding. The Quick-Don suit is a one-size-fits-all design and will exhibit poorer flotation characteristics on smaller individuals.

6. **Ancillary Items.** CAF immersion suits are typically provided with insulated mitts, as aircrew normally wear flying gloves. Unprotected hands will cool down quickly, which will severely impede the conduct of survival tasks in cold water.

7. **Colour.** Immersion suits should be of highly visible colours and have reflective tape applied to assist in finding survivors in the water.

ANNEX F

ANTI-G PROTECTION SYSTEMS

3.15F.1 Introduction

1. This annex identifies the airworthiness design requirements for an anti-G suit.

2. Anti-G suits are mandated by Flying Orders. Requirements:

   a. provide protection from acceleration (G+); and

   b. can also provide protection for High-Altitude Depressurisation.

3.15F.2 General Specification/Guidance for Anti-G Protection Systems

1.	ADV PUB 61/103/17	Methodology for Evaluation of PBG Assembly for High-G Protection
2.	D-22-564-000/SF-001	Specification for Sustained Tolerance to Increased G (STING) Anti-G Garment Assembly
3.	MIL-V-87223	Valves, Pressure, Anti-G Suit, MXU-804/A and MXU-805/A
4.	MIL-V-9370	Valve, Automatic, Pressure Regulating, Anti-G Suit
5.	MIL-DLT-83406	Anti-G Garment, Cutaway, CSU-13B/P

3.15F.3 Lessons Learned/Guidance

1. **Design.** The current system in use in the CAF is the STING (Sustained Tolerance to Increased G). It provides increased G protection compared to the older CSU-13B/P or CSU-15/B/P due to increased bladder coverage. However, since the bladder is larger, it takes longer to inflate and the external fabric shell is exposed to greater stresses. Both MIL-DLT-83406 and D-22-564-000/SF-000 mandate a 1,000 cycle endurance test carried out by the manufacturer to demonstrate the durability of the design as an indicator that the item will have an adequate service life. The CF188 employs only a lower anti-G suit, i.e., trousers, whereas newer or more capable fighters demand better protection. Newer systems use pressure breathing for G and a vest (pressure jerkin) that applies a pressure on the upper-torso to allow aircrew to breathe with less difficulty. Such a system was fully tested at DRDC Toronto for the CF188 and was proven feasible. The USAF designed a system called “Combat-Edge” which was successfully tested and fielded.

2. **Fit.** The design must provide sufficient sizes to achieve a proper fit on all users. The anti-G suit must be close fitting to ensure it performs effectively. As a result, many sizes are required as adjustability is important.

3. **Human Testing.** New anti-G suit designs or significant changes to existing designs will require testing in a centrifuge under controlled conditions to ensure it provides the required protection.

4. **Anti-G Valve.** The anti-G valve used in most aircraft is inertia activated. When acceleration (G_Z) is detected, pressurized air from the engine compressor is sent to the anti-G system. These valves are slow in reacting and, consequently, the time required to inflate the dead space in the suit results in the system being about one second behind the required pressure curve. For systems with such a lag in suit pressurization, a good anti-strain manoeuvre is required by the aircrew to compensate for the lag in the system. The electronic anti-G valves have been demonstrated to provide pressurized air sooner and at a faster rate.

5. **High-Altitude Depressurisation Protection.** An anti-G system with a pressure jerking and pressure breathing for G regulator (such as Combat Edge) can provide additional protection in a high-altitude depressurisation incident. Such a system would require an anti-G valve to react to the loss of cabin pressure, which current valve specifications do not require; however, the feasibility of incorporating such a system and its effectiveness have been demonstrated. This is a desirable feature as the time of useful consciousness at altitudes higher than 40,000 ft is

short. Providing both leg and torso counter-pressure and maximum pressure breathing are required to keep the aircrew conscious.

6. **Lessons Learned.** Testing of better anti-G system was conducted at DRDC Toronto. A full coverage anti-G trouser was used in conjunction with a pressure jerkin on the torso to provide pressure on the body and improve performance of the system. The anti-G valve provided pressure to the anti-G trouser while the oxygen regulator provided pressure to both the jerkin and the mask. An occipital bladder was also installed in the helmet to increase the mask retention onto the face and prevent helmet rotation. Such a system requires fine tuning and testing with medical supervision. The regulator must be connected to the anti-G valve to ensure they work in harmony. One of the problems noted with the system was the slow reacting mechanical anti-G valve that was always approximately one second behind the ideal curve. In newer aircraft, this could be remedied by the use of an electronic anti-G valve that predicts upcoming G+ by monitoring the stick input. Partially inflating the anti-G trousers could reduce the inflation time of the anti-G trousers. The regulator which supplies the pressure to the upper torso cannot do so until the trousers are inflated, otherwise it would negatively affect the user.

ANNEX G

FIRST AID KITS/SURVIVAL KITS

3.15G.1 Introduction

1. This annex identifies the airworthiness design requirements for aircraft-installed survival kits and first aid kits.

2. Requirements:

   a. provide workplace-required first aid; and

   b. provide basic survival equipment for the crew.

3.15G.2 General Specification/Guidance for First Aid Kits/Survival Kits

1.	TC Standard 724.84	Equipment Standards and Inspection/Emergency Equipment
2.	AWM Part 6, 602.61	Survival Equipment – Flights over Land
3.	AWM Part 6, 602.63, Para 6(c)	Life Rafts and Survival Equipment – Flights over Water
4.	14 CFR 135.167	Emergency equipment: Extended overwater operations
5.	Aviation Occupational Safety and Health Regulations, Part X, Schedule II, Type A First Aid Kit	
6.	ASCC Air Standard 45/21, 18 July 1991, Location Aids for Survivors of Aircraft Accidents	

3.15G.3 Lessons Learned/Guidance

1. Transport Canada Civil Aviation mandates the carriage of some survival items on board aircraft under CARs 602.61 and 602.63. These operating rules require that the following be provided: means of starting a fire, providing shelter, providing or purifying water and visually signalling distress. It is also specified that the content must be adequate for the seasonal weather in the geographical area.

2. **Climatic Requirement.** The survival kit must meet the climatic requirements of the anticipated operational area. On some aircraft, this is achieved with add-on kits. Historically, transport fleets had a basic survival kit that could be augmented by an arctic or desert kit when required. However, on the CC130 aircraft the decision was made to keep all three kits present, because the aircraft was often tasked on short notice and not necessarily departing from their home base. Similarly, fighter aircraft have most of their survival kit located in the seat pack which cannot easily be reconfigured to allow for geographical specific contents. Thus, for military aircraft, the most effective approach has been to design survival kits that cater to the climates of all geographical areas of operation.

3. **Survival Equipment Location.** 14 CFR 25.1411 and the U.S. Army Aircraft Crash Survival Design Guide state that the survival equipment should be readily accessible. An emergency egress should not be slowed down by the need to get the survival kit out of the aircraft. The first priority in an emergency is to save lives, so all must exit the aircraft quickly. If time permits, the survival kit may be taken out on initial egress. In a time-critical emergency, all aircrew and passengers should exit the aircraft and, if possible, return later to retrieve the survival kits. This decision would need to be taken by the crew.

4. **Minimum Survival Equipment.** In order to survive for 24/48 hours, particularly in very cold or very hot climates, the following equipment is required:

   a. **Shelter.** This may be in the form of a tent or, where space is limited, a ground sheet or tarp that will provide cover and allow a shelter to be fabricated. When operating above the tree line, a snow saw should be added. Consider: Sleeping bag, tent, tarp, bivy bag, axe or similar to cut branches, rope/twine, snow saw.

   b. **Clothing.** On many aircraft, aircrew fly with helmets and flying gloves. These do not provide sufficient protection in severe cold. Additional clothing is required. Consider: Tuque/balaclava, glove/mitts, socks.

c. **Heat/Fire.** In very cold weather, heat is required to survive. Above the tree line, there is little or no fuel available for burning. Consider: matches, fire starter, stove, fuel tablets/sterno, pot, knife, axe.

d. **Food/Water.** Food is not critical for short duration survival; however, water is essential. Consider: water purifying tablets, reverse osmosis hand pump, pot, water pouches, food/jujubes, fishing kit, snare wire.

e. **Other.** Items required for comfort or medical reasons. Eye protection for sun to prevent snow blindness may be required. Consider sun glasses, mosquito repellent or net, first-aid kit, sun screen.

5. **Minimum Signalling Equipment.** ASCC Air Standard 45/21 requires that the following equipment be provided:

a. **Personal Locator Beacon.** A Personal Locator Beacon such as the PLB-1000 or PRC-112.

b. **Pyrotechnic Signal.** The flare and/or smoke signals shall provide a red colour display to denote distress.

c. **Dye Marker.** Dye marker shall provide a vivid greenish-yellow slick on the water surface. This item is being replaced with a floating streamer that is effective for both water and land use.

d. **Distress Light.** Flashing type distress lights shall flash at a rate of at least 40 flashes per minute; the flashing duration shall be at least .000010 second (10 microseconds). The following colours of light are recommended:

(1) Blue – for heavily defended combat areas (to distinguish from gunfire).

(2) White – for peacetime use and for areas remote from combat.

(3) Infra-red – for covert distress signalling (requires aircraft receiver).

e. **Signalling Mirror.** The mirror shall have an aiming capability and should have waterproof operating instructions clearly displayed.

f. **Whistle.**

g. **Light.** A light affixed to the life preserver, which is automatically switched on during a water entry, but which can be switched off at the survivor's discretion (this is currently not provided on military LPs as aircrew carry a flash light).

6. **Survival, Evasion, Resistance and Escape (SERE).** In addition to this content, operational requirements may dictate a need to carry SERE equipment. This equipment is defined by operational staff.

7. **Survival Kit Container.** It is important that the survival kit be packed in a fire resistant container. This container should be clearly identified and placed near an aircraft exit. The colour of the container should be of a visible/ contrasting colour, unless tactical requirements dictate otherwise.

8. **Survivability.** On larger aircraft, the kits should be placed in two separate aircraft locations to enhance post crash survivability.

9. **First Aid Kits.** First aid kits are to be carried on all helicopter and transport aircraft.

ANNEX H

CHEMICAL DEFENCE EQUIPMENT

3.15H.1 Introduction

1. This annex identifies the airworthiness design requirements for Chemical Defence (CD) equipment. CD equipment is required to meet operational requirements on operational fleets.

2. Requirements:

a. provide protection against a gas, liquid and/or biological threat; and

b. permit mission to be carried out with as little impact as possible on aircrew performance.

3.15H.2 General Specification/Guidance for CD Equipment

1.	AIR STD 61/112/01A	Measurement of Protection Provided to the Respiratory Tract and Eyes against NBC Agents in Particulate, Aerosol and Vapour Form
2.	AIR STD 61/112/02B	Minimum Physiological Requirements for Aircrew NBC Protective Headgear
3.	AIR STD 61/112/03	Filter-Blower Performance for Aircrew NBC Headgear
4.	AIR STD 61/112/04 (Confidential)	The Measurement of Protection Provided by Aircrew NBC Equipment Against Chemical Warfare Agents in Liquid Form
5.	JSSG 2010-9	Joint System Guide Specifications – Personal Protective Equipment
6.	STANAG 4155	NBC Protective Mask and Filter Canister Screw Threads
7.	QSTAG 695	Standards for General Service Respirators/Masks

3.15H.3 Lessons Learned/Guidance

1. **ALSE and CD Individual Protective Equipment (IPE) Integration.** The CD protective equipment must meet the requirements of the guidance documents above; however, it may also need to meet the requirements of any ALSE it replaces. For example, a chemical defence respirator used on a fighter aircraft must also meet the oxygen mask requirements. At times, it may be cost prohibitive to meet all ALSE and CD requirements with a unique system and some mission analysis and risk analysis may be required.

2. **Protection Factor.** Aircrew may require significantly more protection than ground crew from some threats to enable them to perform adequately in the threat environment. AIR STD 61/112/01A describes how the protective equipment is to be tested and how the performance factors are measured. The protection required is generally at the 10^{-4} level for gaseous threat.

3. **System Component Testing.** The level of protection against different standard threats must be tested and the threat needs to be well defined, as it will drive the design of the protective equipment.

4. **Chemical Testing.** All CD equipment must be tested against normal battlefield contaminants. If the equipment is designed to be reusable, fluids or powders used to decontaminate the equipment must also be tested on the equipment.

ANNEX I

HARNESSES

3.15I.1 Introduction

1. This annex identifies the airworthiness design requirements for harnesses and restraints used in seats or for operational reasons. Operational restraints include harnesses for securing gunners and other mobile personnel when the doors are open for gunnery, parachuting, aerial delivery and hoisting ops.

2. Requirements:

   a. provide adequate restraint to the occupant of the seat; and

   b. provide operational restraint required for other reasons.

3.15I.2 General Specification/Guidance for Harnesses

1.	TSO-C167	Personnel-Carrying Device Systems (PCDS), also known as Human Harnesses
2.	National Fire Protection Association (NFPA) 1983, "Standard on Fire Service Life Safety Rope and System Components," 2001 edition, for a life safety harness Class III	
3.	FAA AC 29.865B	External Loads Human Cargo
4.	MIL-R-81729A	Aircrewman's Restraint System
5.	MS16070F	Belt Aircraft Safety Crewman's (Gunner's belt)
6.	TSO-C22g/SAE AS 8043	Restraint System for Civil Aircraft
7.	SAE ARP 4101/1	Seats and Restraint Systems for the Flight Deck
8.	TSO-C114	Torso Restraint Systems
9.	TSO-C127	Rotorcraft, Transport airplane, and Normal and Utility Airplane Seating Systems
10.	SAE AS 8043	Aircraft Torso Restraint Systems
11.	CSA Z259 series	
12.	14 CFR 29.562	Emergency Landing Dynamic Conditions
13.	14 CFR 29.337	Limit Manoeuvring Load Factor
14.	QETE Report 10081-A024207 (QETE 2-2) (internally, within DND, available at AEPM RDIMS #705901)	
15.	QETE Report 10081-A016806 (Q2-7-5) (internally, within DND, available at AEPM RDIMS #614704)	
16.	QETE Report 10081-A024207-3 (QETE 2-2) (internally, within DND, available at AEPM RDIMS #862612)	

3.15I.3 Lessons Learned/Guidance

1. Aircraft seats and harnesses are tested to meet or exceed the emergency landing conditions stipulated in the aircraft certification basis. Usually, aircraft seats are certified to TSO-C127 or an equivalent military specification as an assembly (seat, cushions and harness). Generally, TSO and MILSPEC harnesses can be replaced with other TSO or MIL SPEC harnesses without difficulty, as the geometry and strength will be similar. However, there are specific mission requirements of military aircraft that may justify special harnesses. For example, passengers seated near open doors in flight must use buckles that cannot be opened too easily or accidentally. For this reason, the use of civilian style lap belts has been forbidden on the CH146 and helicopters performing similar type of missions.

2. **Harness Material.** Most civilian harnesses use polyester webbing as it has limited stretch and ensures the occupant will have limited movement under load. Military harnesses generally use nylon webbing, which has greater elongation and which will somewhat limit the maximum load felt by the occupant. Material selection should consider the maximum G force required and the available space to limit post-crash impacts and flailing injuries.

3. **Harness construction.** Generally, military harnesses use webbing that has a minimum breaking strength of 6000 lbf or higher and are sewn using Box-X stitching patterns and, where more strength is required, Double-W patterns are used. Experience has shown that the strength of these harnesses was more than adequate and their service lives were very good. Commercial aircraft harnesses adhere to the requirements of SAE AS 8043, which does not specify how to construct the harness; however, the standard does specify minimum strength for the webbing and specific testing requirements to ensure the harness will be suitable for aircraft use. In all cases, the harness design must be tested to ensure it can withstand the worst case loads (e.g., crash or ejection loads) and survive. All attachment points used to secure equipment or having any critical function should also be tested. All the load carrying webbing and stitching should be undamaged following such testing. The colour of the stitching usually matches the webbing for aesthetics; however, it may be desirable to use contrasting thread to assist in the inspection of the harness.

4. **Mobile Restraints.** In some aircraft, the crewmembers are required to conduct in-flight tasks with the aircraft door open. These tasks are essential to military operations and include aerial cargo delivery, parachuting, hoisting, repelling, gunnery, etc. and require that crewmen be restrained. If the restraint harness is worn during low flying operations or during take-off and landings, it should strive to meet the restraint requirements of the aircraft seats. As a minimum, the aircraft emergency landing loads should be met. However, as most helicopter seats are designed with crash attenuation capabilities, a restraint harness alone will not provide an equivalent level of safety. If the harness is only worn during higher flying and not during take-off and landing, only manoeuvring loads and accidental fall loads need be considered. To limit injuries to the crewmember in case of accidental fall or crash landing, the mobile restraint harness must use the shortest tether possible and keep the crewmen inside the aircraft. Some active systems that shorten the tether in case of crash have recently been developed. The U.S. DoD uses the “Gunner’s Belt” (MS16070F) on many aircraft to fulfill this restraint requirement; however, this belt must be well adjusted so as not to slip during a fall or hard landing. Leg straps and shoulder straps are mandatory in civilian designs to keep the harness in place and spread the loads to limit injuries. The securing tether must be easily removable so as not to impede egress. The location of the tether attachment point both on the aircraft and the harness should be chosen to limit the injuries to the crewman in case of fall or hard landing and to keep the user inside the aircraft.

5. **Tether Strength.** The current tether design uses 6000 lbs webbing to hold the occupant. However, dynamic testing of the harness and tether system has shown that the system was capable of withstanding 4000 lbs (see ref. QETE report). The tether release system was also tested at QETE. The design target was 3500 lbs and the system proved capable of withstanding 4000 lbs and of safely releasing. Drop testing with different tethers has also shown that nylon tethers will greatly reduce the peak load as it stretches significantly.

6. **Hoisting Harnesses.** Hoisting harnesses are designed to attach to the aircraft winch and permit lowering and recovery of aircrew as required. These harnesses must be easily attached and detached from the hoist hook by the user. Also note that operational requirements dictate a requirement for anchoring points on the aircraft to secure operators near open doors and hoist users prior to disconnecting from the hoist.

7. **Hoisting Harnesses’ Strength.** Harnesses used for hoisting should meet TSO-C167, which uses a National Fire Protection Association (NFPA) 1983 Class III as the base design. Generally, the FAA requires a safety factor of 3.5 for manoeuvring loads (14 CFR 29.865). Given that harnesses are made of webbing and are subject to wear and degradation by UV radiation, dirt, etc., a further safety factor of two (2.0) should be used for “emergency use harnesses”, such as the ones mounted in LPSVs that are primarily intended for the rescue of downed aircrew. For harnesses designed for routine use, a minimum safety factor of three (3.0) is recommended. The NFPA harnesses are designed to hold up to 450 lbs, as it is a rescue harness and may exceed the operational requirement of the user community.

Examples of limit load calculations:

Casual use harness:	350 lbs max rating (max weight one aircrew with body armour)
	3.5 manoeuvring Safety Factor
	2.0 design Safety Factor (emergency use)
	2350 lbs limit load

SAR Harness:	600 lbs max rating
	3.5 manoeuvring Safety Factor
	3.0 design Safety Factor (constant use)
	6300 lbs limit load

ANNEX J

ESCAPE SYSTEMS

3.15J.1 Introduction

1. This annex identifies the airworthiness design requirements for Automated Aircraft Escape Systems (i.e., Ejection Systems [ES]). Generally, the escape system is designed as part of the aircraft and is contained in the aircraft certification basis. Commercial aircraft are not designed with ESs and no specific civilian regulations exist for ejection systems.

2. Requirements:

a. provide restraint up to specified emergency landing loads;

b. provide automated escape from aircraft;

c. provide acceptable deceleration/loads from initiation of ejection to landing;

d. provide oxygen during descent; and

e. provide minimal survival equipment.

3.15J.2 General Specification/Guidance for Ejection Systems

1.	JSSG-2010-11	Emergency Egress Handbook
2.	PS 74-800200 rev. D 2 Nov. 78	Procurement Specification for Seat System, Aircraft Ejection – Aircrew Automated Escape (internally, within DND, available at AEPM RDIMS #771580)
3.	U.S. Navy Ejection Seat Performance Evaluation Process [Draft], March 2005 (internally, within DND, available at AEPM RDIMS #444768)	
4.	DEF STAN 00-970 Part 1, Section 4, Escape System and Leaflet 82, Escape System Testing	

3.15J.3 Lessons Learned/Guidance

1. Ejection systems must be designed to provide safe restraint up to the emergency landing loads stipulated in the aircraft design requirements. Once initiated, the system must be fully automatic such that no other input from the occupant is required during the process. The aircraft canopy removal will be automatic and fully synchronized with the seat. Should the aircraft have two or more ejection seats installed, an inter-seat sequencing system will time the events to minimize any chance of post ejection collisions. JSSG-2010-11 provides good guidance on the design of ejection systems and refers to the specification for ejection seats, pyrotechnics design, and contains most of the design and performance requirement. The latest document from the U.S. Navy titled U.S. Navy Seat Performance Evaluation Process has added guidelines for neck tension, compression and bending limits not currently in the JSSG. These new limits were developed to enable the certification of expanded weight envelopes that would enable smaller females and larger males to fit ejection systems and to permit the certification of heavier helmets equipped with optronic systems.

2. **Ejection Seat Modifications.** Modifications to ejection seats are thought at times to be simple and minor; however, ejection seats are highly reliable systems with weight and CofG limits. Any design change must be considered in depth and may require extensive and very costly testing.

ANNEX K

PARACHUTES

3.15K.1 Introduction

1. This annex identifies the airworthiness design requirements for a Parachute System. In the military, parachutes have a variety of uses, such as: aircraft drag chute, cargo aerial delivery and emergency egress (bail-out and ejection seats). Parachutes are also used as individual mission equipment by SAR techs and troops.

2. Parachutes are designed to provide the following requirements:

   a. provide deceleration and stability; and

   b. provide an adequate final velocity.

3.15K.2 General Specification/Guidance for Parachutes

1.	JSSG-2010-12	Deployable Aerodynamic Decelerator (DAD) Systems Handbook
2.	TSO-C23d / SAE AS 8015	Emergency Parachute
3.	AIR STD 61/102/2C	Restraint and Parachute Harnesses for Aircrew
4.	The Parachute Recovery Systems Design Manual, Knacke TW, ISBN 978-0-915516-85-8	
5.	MIL-P-85710(AS)	Parachutes, Personnel, Emergency Escape General Design Specification (internally, within DND, available at AEPM RDIMS #593953)

3.15K.3 Lessons Learned/Guidance

1. There are few civilian regulatory requirements for parachutes. TSO-C23d is the main document used for all emergency parachutes and is also used for the reserve canopies by sport parachute jumpers. This TSO is a performance-based document that covers both individual parachute units (220 lbs/150 knots max) and tandem parachute units (400 lbs/175 knots max).

2. **Parachutes have multiple uses.** They are used to decelerate aircraft (drag chute), to extract and stabilize cargo for aerial delivery, and to reduce the velocity of a person or cargo to a survivable velocity. JSSG 2010-10 and *The Parachute Recovery Systems Design Manua*l, as referenced above, provide excellent advice on the selection and testing of parachutes for different applications. Many of the parachutes in current use are of well-known design, such as flat-circular, aero-conical, ribbon chute, cruciform, etc., with well-documented behaviour and performance. It should be noted that most of the equations identified in *The Parachute Recovery Systems Design Manual* that describe parachutes are mainly theoretical and may not produce the range of outcomes seen in real use. Therefore, they are suitable to establish a rough performance spectrum, but testing will be required to provide the exact performance of a parachute at a given weight, speed and air density. Parachute technology is changing as new designs are more akin to aircraft wings than traditional parachutes. Newer fabrics with little or no porosity can provide high drag, good strength and reliable performance.

3. **The basic parachute performance indicators** are snatch force, opening force, opening time/distance, oscillation, turning rate, and vertical & horizontal velocities. It should be noted that these performance indicators will vary greatly with suspended weight (mass), initial velocity and air density.

4. **Emergency Parachutes.** Emergency parachutes are installed in aircraft where bail-out may be required. In addition, these parachutes may be issued to personnel that have to operate in aircraft unrestrained near open doors or an open ramp. The use of these parachutes can be seen as a once-in-a-lifetime event where some risk is accepted when compared to a personnel parachute. These parachutes must meet FAA/TSO-C23d or similar specifications. These parachutes are typically a one-size-fits-all harness and contain a single canopy. These do not have reserves and, as far as TSO-C23d is concerned, they should be packed by a rigger or equivalently trained individual. These parachutes are designed to be used by untrained parachutists and must be simple to use and are generally non-

steerable, i.e., have limited performance characteristics. Emergency parachutes are not to exceed 24 fps descent rate. Emergency parachutes should have little forward drive and the total vector in ground must not exceed 30 fps.

5. **Personnel Parachutes.** Parachutes are used in the military to accomplish various missions. The type used varies depending on the mission and the skill of the user. Personnel parachutes must accommodate the mission requirements of the operator, which may include very high suspended weights and, at times, some very specific performance requirements. The reserve parachute in these systems must meet TSO-C23d. Generally, personnel parachutes should not exceed 18 fps landing velocity.

6. **Reliability.** Parachute systems must be highly reliable. Any new design or modification to a design will require that reliability testing and basic performance indicators be measured. Generally, emergency escape parachutes must meet or exceed 98% reliability (at 90% confidence level). Personnel/mission parachute systems used for regular parachuting should exceed 99.9% reliability (at 90% confidence level).

ANNEX L

OXYGEN SYSTEMS AND MASKS

3.15L.1 Introduction

1. This annex sets out the minimum standards for airworthiness and guidance for the design and installation of aircraft oxygen storage and distribution systems. This annex was written to take into consideration both civilian and military pattern aircraft and for all systems that could be used, either gaseous, liquid or On-Board Oxygen Generating Systems (OBOGS). In addition, supplemental oxygen systems for passengers, troops or medical use are also covered.

2. **Aircraft Oxygen System.** The aircraft oxygen system consists of a generating or storage system, a distribution system and a dispensing system. Stand-alone systems may also be required for cabin crew to move in the cabin to perform their duties.

3. **Requirement Rationale.** Human physiology requires that sufficient oxygen be provided to the lungs to remain alert and capable of operating an aircraft and its systems at a high cabin altitude. In the past, National Defence Flying Orders required that all crews operating over 10,000 ft cabin altitude use oxygen. Recently, this limit was further reduced to 8,000 ft for prolonged exposure, as aircrew operating at this altitude have experienced symptoms of acute mountain sickness (AMS). Civil regulations also govern the requirement for oxygen use for pressurized and unpressurized aircraft.

4. Civil regulations, such as 14 CFR and AWM, define the minimum design requirements for civilian operated aircraft. The civil regulations address oxygen duration requirements for cockpit crews, mask design requirements and passenger oxygen requirements for aircraft that are used in conformance to the civil role for which it was certified. However, it may be necessary to use military standards in lieu of, or in addition to, the civil standards for civil pattern aircraft that will be operated in more demanding military roles and/or environments (see Part 1, Chapter 4 of this manual). It should be noted that the civil regulations, unlike those of the military, typically do not identify any design standards for equipment, only general requirements for the system.

3.15L.2 General Standards

1. Figure 3-15L-1 through Figure 3-15L-4 include general standards applicable to more than one category of ALSE and shall be used to form the certification basis for the applicable equipment.

	General Airworthiness Design Standards
1.	N/A

Figure 3-15L-1 General Airworthiness Design Standards Related to Oxygen Systems & Masks

	Military Airworthiness Design Standards
1.	**MIL-HDBK-516B,** Airworthiness Certification Criteria
2.	**JSSG 2010-10,** Crew Systems – Oxygen System Handbook
3.	**MIL-D-8683,** Design and Installation of Gaseous Oxygen Systems in Aircraft, General Specification for
4.	**MIL-D-19326,** Design and Installation of Liquid Oxygen Systems in Aircraft, General Specification for
5.	**MIL-D-85520,** Design and Installation of On-Board Oxygen Generating Systems in Aircraft, General Specification for

Figure 3-15L-2 Military Airworthiness Design Standards Related to Oxygen Systems & Masks

Civil Airworthiness Design Standards	
1.	**525.1439,** Protective Breathing Equipment
2.	**525.1441,** Oxygen Equipment and Supply
3.	**525.1443,** Minimum Mass Flow of Supplemental Oxygen
4.	**525.1445,** Equipment Standards for the Oxygen Distributing System
5.	**525.1447,** Equipment Standards for Oxygen Dispensing Units
6.	**525.1449,** Means for Determining Use of Oxygen
7.	**525.1450,** Chemical Oxygen Generators
8.	**525.1453,** Protection of Oxygen Equipment from Rupture
9.	**AC 25-20,** Pressurisation, Ventilation and Oxygen Systems assessments for subsonic flights
10.	**TSO-C64a,** Oxygen Mask Assembly, Continuous Flow, Passenger
11.	**TSO-C78,** Crewmember Demand Oxygen Mask
12.	**TSO-C89,** Oxygen Regulators, Demand
13.	**TSO-C99,** Protective Breathing Equipment
14.	**TSO-C103,** Continuous Flow Oxygen Mask Assembly (For Non-Transport Category Aircraft)
15.	**SAE AIR 822,** Oxygen Systems for General Aviation
16.	**SAE AIR 825,** Oxygen Equipment for Aircraft
17.	**ASTM G 63,** Standard Guide for Evaluating Non-metallic Materials for Oxygen Service
18.	**ASTM G 94,** Standard Guide for Evaluating Metals for Oxygen Service
19.	**CAN/CSA B339 - (latest version),** Cylinders, spheres, and tubes for the transportation of dangerous goods
20.	**CAN/CSA B340 - (latest version),** Selection and use of cylinders, spheres, tubes, and other containers for the transportation of dangerous goods, Class 2

Figure 3-15L-3 Civil Airworthiness Design Standards Related to Oxygen Systems & Masks

DND/CAF Ratified International Standards	
1.	**AIR STD 15/14A,** Breathing Oxygen Characteristics (Including Supply Pressure and Hoses)
2.	**AIR STD 25/27B,** Aircraft Liquid Oxygen Replenishment Connections
3.	**AIR STD 25/34A,** Aircraft Gaseous Oxygen Replenishment Connection
4.	**AIR STD 61/101/1C,** Minimal Protection for Aircrew Exposed to Altitude Above 50,000 Feet
5.	**AIR STD 61/101/2C,** Physiological Evaluation of Aircraft Oxygen Delivery Systems
6.	**AIR STD 61/101/5A,** Physiological Requirements for Aircrew Oxygen Masks for Use at High Breathing Pressures
7.	**AIR STD 61/101/6A,** Minimum Physiological Requirements for Aircrew Demand Breathing Systems
8.	**ADV PUB 61/101/10,** The Minimum Quality Criteria for On-Board Generated Oxygen
9.	**AIR STD 61/101/15,** Smoke Protection Breathing Equipment Used by Mobile Aircrew In Non-Ejection Seat Aircraft at Pressure Altitudes up to 10,000 ft
10.	**STANAG 3976,** Lubricants for Use in Oxygen Systems with Oxygen Rich Environments – AEP-15(C)
11.	**STANAG 3978,** Purging Liquid Oxygen Storage and Transport Tanks and Aircraft Converters – AEP-8(E)
12.	**STANAG 7046,** Guide to Methods of Tests for the Compatibility of Materials used in Oxygen Enriched Environment – AEP-33(B)

Figure 3-15L-4 (Sheet 1 of 2) DND/CAF-Ratified International Standards Related to Oxygen Systems & Masks

DND/CAF Ratified International Standards	
13.	**STANAG 7106,** Characteristics of Gaseous Breathing Oxygen, Liquid Breathing Oxygen and Supply Pressure, Hoses and Replenishment couplings
14.	**STANAG 7124,** Guide to Use of Materials in Oxygen Enriched Environment – AEP-42
15.	**STANAG 7187,** On Board Oxygen Generating Systems (OBOGS) Performance Standards
16.	**STANAG 7211,** Aviation Oxygen Equipment Cleaning and Verification Process
17.	**C-22-010-004/AG-001,** Guide to use of Materials In Oxygen Enriched Environments
18.	**C-22-010-010/MF-000,** Aircraft Oxygen Systems – General
19.	**C-22-040-001/TS-000,** Aviator's Breathing Oxygen
20.	**C-22-010-009/VP-000,** Liquid Oxygen (LOX)
21.	**C-94-010-003/MG-000,** Compressed Gas Cylinders
22.	**D-22-003-003/SF-000,** Oxygen, Aviator's Breathing Liquid and Gaseous

Figure 3-15L-4 (Sheet 2 of 2) DND/CAF-Ratified International Standards Related to Oxygen Systems & Masks

3.15L.3 Guidance Information – General

1. The intention of DND should be to follow, where possible, the rules issued by the FAA and TCCA; however, unique operational capability requirements have resulted in military oxygen system design requirements. In addition, *National Defence Flying Orders* (B-GA-100-001/AA-000); 1 Canadian Air Division Orders; and Flight Safety for the CAF (A-GA-135-001/AA-001) mandate equipment or usage of oxygen that differs from FAA/TCCA requirements. JSSG 2010-10 provides excellent guidance on oxygen system design, as well as lessons learned by the U.S. DoD. The JSSG lists all applicable military standards and specifications (active and cancelled), details of the design requirements for oxygen systems for aircrew, passengers, medical evacuations, parachuting, etc. The JSSG provides many examples of oxygen system designs based on current technology and materials. Most of the advice provided in JSSG 2010-10 is based on current designs and materials that are known to be oxygen compatible. Furthermore, these designs are known to be maintainable. Any design diverging from the JSSG will need to prove it can meet or exceed current JSSG requirements to the satisfaction of the TAA.

2. **Oxygen Quantity.** On most aircraft, the oxygen system is a back-up system in case of decompression. However, in fighters, the oxygen system is used on every flight. The oxygen system quantity requirement is calculated based on the typical missions, i.e., altitude, aircrew exertion, concentration required, endurance, etc. Examples of such methodology are provided in the JSSG 2010-10, MIL-D-8683, MIL-D-19326 and MIL-D-85520. In the case where the oxygen system is a back-up system, the oxygen quantity calculations need to consider decompression events at maximum flying altitude and smoke emergency where 100% oxygen is required until a safe landing can be made. Since newer transport aircraft have extended capability with single engine inoperative, the oxygen system must be sized to ensure the flight crew can reach an alternate landing area. For passengers, oxygen need only be provided for decompression incidents and the system must be sized accordingly.

3. **Emergency System.** In fighters, where the oxygen system is a primary system, a back-up system (emergency) is required. This back-up system must be sufficient to permit the crew to descend to a safe altitude (below 10,000 ft) from the maximum altitude and must consider time to detect, react and receive ATC clearance to proceed with the emergency descent.

4. **Bail-Out System.** Ejection seats are also equipped with an oxygen system to protect the ejectee during an emergency egress from the maximum ejection altitude. The bail-out system must provide sufficient oxygen to protect the ejected aircrew from hypoxia following a high-altitude ejection. The bail-out system and emergency system may be combined; however, the quantity and functionality will need to be such that the combined system will cater to all emergency scenarios.

5. **Cylinders.** Cylinders used on tactical aircraft must be shatter resistant. Cylinders made of steel to specification DoT-3AA or TC-3AAM/CTC-3AA, MIL-C-7905 and MIL-C-29576 are acceptable designs. These designs are known to resist damage by gunfire whereas most composite cylinders cannot meet this requirement. Composite cylinders

are currently made of very thin aluminum bodies wrapped with composite material. Development of newer composite cylinders that meet the shatter resistance of steel cylinders is on-going and may permit their use in tactical aircraft in the future.

6. **Oxygen compatible materials.** Materials used in oxygen systems must be oxygen-compatible. Current designs use aluminum tubing and aluminum components on low-pressure systems. In high-pressure of up to 2,000 PSI, 316 corrosion resistant steel has been used. However, CRS 316 testing has shown that it is not fully compatible with oxygen at pressure higher than 1,000 PSI. Newer designs use Monel or other more compatible material for such applications. Older systems used annealed copper, which is oxygen-compatible to very high pressure; however, the material properties of copper degrade with time and copper is relatively heavy. ASTM G63 and ASTM G94 provide guidance for the selection of materials in oxygen systems.

7. **System cleanliness.** An oxygen system must be kept clean as many oxygen incidents and accidents have been attributed to particulate or contamination in the system. The system must be assembled clean, and kept clean by ensuring the oxygen entering the system is free from impurities. Only approved oxygen cleaned parts and oxygen compatible materials and lubricants are to be used. Filters of 12.5 microns or less must be used at the outlet of the filler valve and the entrance of pressure reducers. Regulators should also be protected by suitable filters at their inlet ports.

8. **Liquid Oxygen Converters.** Stabilized liquid oxygen converters shall be used in aircraft where the converters cannot be readily removed for replenishment.

9. **Pressure Reducing Valves (PRV).** The fitment of pressure reducing valves as an integral part of the cylinder valve in both main and portable high-pressure gaseous oxygen systems is highly desirable. Where this is impractical, the PRV is to be positioned as close as possible to the supply source. MIL-D-8683 states that pressure reducing valves may be fitted if required. Past experiences have shown there is a definite requirement for pressure reduction prior to the oxygen regulator in high-pressure gaseous oxygen systems.

10. **Lessons Learned.** Gaseous oxygen systems are more widely used than liquid oxygen systems in fixed wing aircraft; however, there are many exceptions, including fighter aircraft. Oxygen systems that utilize both high and low pressures should be designed to minimize the length of the high pressure system, thus minimizing the need for heavy and exotic material in the system. For example, the CP140 Aurora uses a system with both high and low pressure and a stainless steel high-pressure manifold to feed the different branches of the system. Following an aircraft fire, it was found to be necessary to change the design of the manifold to use Monel and change the polymer material of the poppet valve to ensure better oxygen compatibility in the high pressure section. This situation would have been avoided by using a pressure reducing valve near the cylinder to keep most of the aircraft system operating at a lower pressure.

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 16 — RESCUE AND SURVIVAL EQUIPMENT (TO BE PROMULGATED)

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 17 — HEALTH AND USAGE MONITORING SYSTEMS (HUMS) FOR ROTORCRAFT

3.17.1 Introduction

1. HUMS typically consist of a variety of onboard sensors and data acquisition systems. The acquired data may be processed onboard the rotorcraft, at a ground station or by a combination of both, to provide a means of measuring against defined criteria and generate intervention instructions for the flight crew or maintenance staff. HUMS outputs may be used for electronic logbooks, usage tracking, performing stand-alone or rotorcraft system analysis, component management and for contractual performance measurement matrices.

2. This chapter identifies and provides guidance on operational specific considerations for the procurement, qualification and TAA certification of HUMS for rotorcraft. The application for certification begins with a comprehensive Statement of Operating Intent (SOI), which will be used to determine the criticality of the system, qualification and certification effort. There are three basic aspects for certification of HUMS applications: installation, credit validation and Instructions for Continued Airworthiness (ICA). These actions can be interdependent with varying interactions with each other.

3.17.2 Definitions

1. The following definitions are applicable to HUMS:

a. **Advanced Usage Monitoring.** Flight regime recognition capability used to support Aircraft Structural Integrity Management Programs (ASIMP) and/or Engine Structural Integrity Management Programs (ENSIP).

b. **Application.** A HUMS process implemented for a distinct purpose.

c. **Basic Usage Monitoring.** Operational usage such as flight hours, the number of flights and component cycles. This is typically in line with the cycle counts required by the ICA activities.

d. **Credit.** To give approval to a HUMS application that adds to, replaces, or intervenes in industry accepted maintenance practices or flight operations.

e. **End-to-End.** The term used to define the qualification and certification boundaries of the HUMS application and any effect on the rotorcraft. As the term implies, the boundaries are the starting point that corresponds with the airborne data acquisition to the result that is meaningful in relation to the defined end use of the information.

f. **Health Monitoring.** The means and methods by which selected incipient failure or degradation can be determined.

g. **Health and Usage Monitoring System (HUMS).** Equipment, techniques, and/or procedures by which selected incipient failure or degradation and/or selected aspects of service history can be determined for Rotorcraft.

h. **Integrity.** This is an attribute of a system or a component that can be relied upon to function, as required by the criticality determined by a Functional Hazard Assessment (FHA).

i. **Usage Monitoring.** The means and methods by which selected aspects of service history can be determined.

3.17.3 Standards

1. The following standard is acceptable to the TAA for HUMS in the DND/CAF.

Civil Airworthiness Design Standards
1. **FAA AC 29–2C MG 15,** Airworthiness Approval of Rotorcraft Health and Usage Monitoring Systems (HUMS). **NOTE** *In the absence of acceptable regulatory material, the MG 15 has been selected by the aviation industry and the TAA as the compliance approach for HUMS certification. The MG 15 is not prescriptive of the technology to be employed but focuses on the demonstration of capability and end-to-end integrity of the system to perform its intended function.*

Figure 3-17-1 Civil Airworthiness Design Standards Related to HUMS

3.17.4 Guidance Information – Certification of HUMS

1. FAA AC 29-2C MG 15 provides guidance for achieving airworthiness approval for rotorcraft HUMS installation, credit validation, and ICA for the full range of HUMS applications. Consideration should be also given to the guidance information in CAP 693 (CAA AAD 001-05-99 – *Acceptable Means Of Compliance Helicopter Health Monitoring*), DEF STAN 00-970 (Volume 2, Chapter 727 to 727/5 inclusive – *Health And Usage Monitoring Systems*) and AAP 7001.054 (ADRM, Section 2, Chapter 19 – *Health Monitoring Systems*).

2. Other objectives of HUMS certification, in addition to design and installation, are to validate the integrity of HUMS data and the HUMS program (ICA, etc.) to a level commensurate with its intended end use. Atypical to traditional airborne systems certification, HUMS boundaries extend beyond the physical confines of the rotorcraft to the supporting ground stations. Certification needs to address the complete system, from the airborne sensor to the subsequent intervening actions resulting from the ground processing of the airborne data. Figure 3-17-2 contains a suggested compliance requirements checklist.

NOTE

Unless the output data has been qualified and certified, the data cannot be used or consulted to assist in determining an intervening action.

Suggested Compliance Checklist	
Regulation	**Subject**
14 CFR 29.1301	Function and Installation
14 CFR 29.1309	Equipment, Systems and Installations
14 CFR 29.1331	Instruments Using a Power Supply
14 CFR 29.1355	Distribution System
14 CFR 29.1529	Instructions for Continued Airworthiness
14 CFR 29.1585	Rotorcraft Flight Manual – Operating Procedures
14 CFR Part 43	Maintenance Program Requirements for Data Integrity of Maintenance Records
14 CFR 29.571	Fatigue Evaluation of Flight Structure (applicable to Usage Monitoring)

Figure 3-17-2 Suggested Compliance Checklist for HUMS

3. The certification process should begin with the declared application intent and determination of the resultant criticality. The end-to-end criticality needs to be determined by performing a Functional Hazard Assessment (FHA) and System Safety Assessment (SSA). For systems that employ ground stations consideration needs to be given in the HUMS design for maintenance program requirements. For example, for HUMS that will be relied upon as

an accurate record of usage, the HUMS design will also need to comply with the approved maintenance program requirements for technical records. On-board data storage and providing for data transfer of a copy of the onboard data (technical record) is two ways to mitigate a potential loss of data. The integrity of the ground station software should be equal to or commensurate with that of the rotorcraft software and the end use of the data.

4. Compliance with the criticality level established by the FHA needs to be demonstrated. This may be achieved by a combination of application qualification plus appropriate mitigating actions.

5. Best practice for HUMS design is to perform, to the maximum extent possible, all HUMS functional calculations and data manipulation in the airborne components. The HUMS and data management design should reduce, to the greatest extent possible, the sensitivity of a HUMS program to human and organizational factors. (e.g., data transfer from the rotorcraft to the ground station and interpretation of the data).

6. HUMS capability procurement needs to document the end use of the system outputs and the standards by which the system will be certified should be included in the requirements specification and SOW.

NOTE

HUMS output data available to a maintenance organization (to assist in determining the operating condition of a component or system) falls under the category of maintenance intervention.

3.17.5 Guidance Information – Certification Plan

1. **Supplemental Information Certification Plan Format.** In addition to the certification plan requirements of the TAM, the certification plan should include the following basic information:

a. The HUMS description.

b. The intended end use of the HUMS outputs.

c. Functional Hazard Assessment (FHA).

d. HUMS management program items:

(1) Program (Administration and Management).

(2) In service program management, roles and responsibilities.

e. Technical Training (Initial and Continuing).

f. Validation activities extending from the field to the component overhaul.

g. Maintenance and calibration of HUMS sensors and equipment.

h. A general description of the computer-based recordkeeping and data management system including the following:

(1) The facilities, hardware, and software to be utilized.

(2) The data and backup system to be used.

(3) The data download means and methods.

(4) Digital or electronic signature type(s) and processes if used.

(5) Access and security procedures to ensure data integrity.

(6) Basic procedures for data entry personnel.

(7) A general description of any special procedures and capabilities including loss of primary system.

i. Deployed operations capability.

j. MEL/MMEL related items.

k. ICA related items.

NOTE

The MMEL/MEL should be determined considering the criticality of the HUMS application and substantiated by the FHA.

2. **Selection of Monitored Components.** The selection of monitored components or systems should be derived by top-down and bottom-up Failure Modes and Effects Criticality Analysis (FMECA). Critical components of the rotorcraft can thereby be identified and the benefit of monitoring these components quantified. Ideally the Original Equipment Manufacture (OEM) would conduct a full requirements analysis and identify those components whose health and/or usage need to be monitored for airworthiness reasons and also those which, due to time and cost of replacement, would benefit from an effective HUMS program.

3. **Maintenance Credits.** Collecting data for its own sake has been a common pitfall of many projects. HUMS that will pursue operational or maintenance credits will require a clear plan and concurrence from the regulatory authority and the OEM before the collection of data process is initiated. In the case of procurement or the development of a new capability, the end use of the HUMS outputs will need to be the stated in the SOW. This will scope the HUMS system requirements, as well as define the depth and level of certification effort. The applicant should clearly identify the “end use” of the data that certification is being applied for and the means and methods to support the data (e.g., HUMS program and management issues).

3.17.6 Guidance Information – Data Analysis Management

1. There are three significant aspects to data analysis. The first relates to the maximum permitted period between downloads, an issue often linked with MELs. The second concerns access to the historical data when analyzing HUMS data. The third relates to the level of effort or expertise required and the time required to interpret the data. In practice, while a WSM is accountable for determining if a helicopter is airworthy, the responsibility for this task rests with the technician who signs for the HUMS download analysis and/or the certificate of release to service. The added difficulty of dealing with the subjective fault criteria that characterizes HUMS needs to be balanced by a structured diagnostic approach.

2. Successfully downloading and analyzing data on a regular basis will only be a safety benefit if there is an effective response to any HUMS warnings. An inadequate response to interpretation of the warning can undermine the effectiveness of a warning system. HUMS output data that requires a high degree of interpretation will pose a significant challenge to achieving a consistent diagnosis. Indeed, highly subjective data may offset any intended HUMS benefits. While specialized training may mitigate inconsistent interpretation, it should not be used to compensate for inadequate data output. Moreover, highly subjective data that requires a high degree of interpretive training may become increasingly convoluted, difficult to manage logistically and place an unnecessary manpower constraint on field units.

3. A number of strategies may be employed to minimize the impact of human and organizational influences, outside the validation activities that help quantify the accuracy of the technology, and facilitate timely, accurate and repeatable intervening actions:

a. **Automated Analysis Tools.** Automated tools, for use in the examination of data collected by a HUMS leading to the identification of potential fault-related trends, should be part of the initial specification as well as part of the continuous improvement validation program. For certification, it should be demonstrated that the interpretation of a HUMS output would be consistent and accurate. The more critical the output, the greater the degree of repeatability that would need to be demonstrated.

b. **Data Transfer, Download and Analysis Frequency.** To gain any safety benefit there needs to be timely review of HUMS data. If a HUMS does not provide onboard warnings or if there is no adequate warning of failure or degradation until after download and post processing of the data, the download periodicity must be sufficiently frequent. One solution would be to incorporate HUMS downloads with post flight checks. Download and analysis frequencies would therefore need to be specified in the appropriate airworthiness technical manual. Any warnings would need to be assessed and, where appropriate, investigated with further inspections. Only when HUMS data has been reviewed and sufficient data has been acquired to provide confidence that a non-conformity has not been identified, should the rotorcraft check be signed off as completed or the required paperwork generated as per the appropriate technical manual. This has the added advantage of automatically backing up the data and providing indications of fleet trends. A rotorcraft-mounted HUMS processor that will indicate to maintenance personnel that a warning was generated could potentially reduce the frequency of downloading. However, this may offset the advantage of automatically backing up the data and providing fleet trends.

3.17.7 Guidance Information – HUMS Management Program

1. Regardless of the size and complexity of a HUMS capability, a HUMS management program will be required. As identified in AC 29 MG 15, the program management boundaries extend from end to end.

2. The applicant should develop a plan that demonstrates a system for tracking components and systems monitored by HUMS, including: identification, recording requirement, tracking procedure, and other related activities. There should also be organization charts with clearly defined responsibilities for collection, analysis and resulting action, and procedures for: managing historical HUMS data to ensure it is traceable when components/assemblies are transferred between rotorcraft or new or overhauled or modified HUMS monitored components are introduced into the system; addressing inoperative HUMS; implementing the training program specified; Configuration Management (CM) and maintenance of the ground-based systems and equipment; troubleshooting and testing of the HUMS; and revising and using the operator’s Minimum Equipment Procedures to manage the MEL and the Master MEL for HUMS.

3. Output data validation activities should be embedded and fully integrated into the rotorcraft approved maintenance and overhaul program. For new systems, system integration rigs and dynamic system models should be used at an early stage of HUMS development and qualification activities wherever possible, using recorded rig test data or other rotorcraft data where appropriate. Validation of fully integrated systems should be undertaken on rotorcraft. For monitored components subject to fixed Time Between Overhaul (TBO) maintenance, evidence of component condition at overhaul should be used to validate the HUMS algorithms and sensor installations.

4. HUMS thresholds and condition indicators are integral to the design activity that should be initially derived in consultation with the helicopter OEM and the HUMS OEM with consideration of the rotorcraft intended usage spectrum and statement of operation intent. One of the functions of the in service HUMS output validation process should be refinement of the HUMS thresholds and condition indicators. Changes or modifications to thresholds and condition indicator algorithms are considered to be design changes.

5. False alarms can be defined as warning indications of a monitoring threshold being exceeded that cannot be directly related to a developing fault or the need for near-term maintenance action. False, nuisance or spurious HUMS warnings or alarms can erode operator and maintainer confidence. This could seriously undermine the safety and economic benefits of a HUMS program and therefore become a flight safety hazard in itself. HUMS programs are required to have a continuous validation process in place to investigate and reduce the number of false alarms without compromising the fundamental objective of the HUMS.

6. If in-flight annunciation of HUMS information is to be provided to the pilot, a hazard assessment must cover the potential for HUMS to give misleading information and the consequences of this. The level of safety criticality depends on what the HUMS displays to the pilot, what the pilot is expected to do and the possible consequences of that action. System criticality will be determined by the worst result produced from this analysis.

7. Flight manual limits cannot be directly translated to HUMS thresholds that are exceeded. For example, transients that occur during One Engine Inoperative (OEI) would not normally be addressed in the flight manual but

would be considered by the operators as normal. However, HUMS without appropriate logic controls will generate alarms based on the discrete sensor measurements.

8. The CAF deploys and operates all over the world. A HUMS therefore needs to be maintainable and supportable in remote locations. The operational and maintenance characteristics of the HUMS should match the rotorcraft Statement of Operating Intent (SOI) (e.g., considerations of data download duration during hot re-fueling). When developing the HUMS specifications, deployment needs, including deployed personnel (maintenance and operators) qualifications, are required elements of the HUMS supportability planning. Issues related to deployed operations are often overlooked; for example: providing sufficient memory capacity to download multiple flights; specifying or providing for the means and methods to send data to the main repository; quantity of software and hardware resources to be able to accommodate multiple deployments; software licence issues; propriety security devices if required to download and transfer data and maintain Configuration Management (CM) control for deployed operations.

9. Any item for which the HUMS gives a fault indication should have an associated maintenance action. This could range from increased monitoring to removal of the item or system. Items adjusted, replaced, or repaired require the HUMS-identified fault to be confirmed as a continuous validation exercise in order to improve continuously the accuracy and reliability of the HUMS output.

10. Typically, HUMS use a process of regime recognition to trigger the collection of data. The HUMS regime recognition parameters should reflect the rotorcraft usage spectrum to ensure that adequate data is collected.

NOTE

Most HUMS applications use regime recognition software to trigger the collection of data. Should the actual usage of the rotorcraft differ from the usage spectrum that was used to derive the regime recognition parameters, then the quality of the collected data will be reduced (e.g., in-theatre role).

3.17.8 Associated Publications and Standards

1. The source references identified in Figure 3-17-3 are associated with the design, installation, maintenance and in-service usage of HUMS.

Regulator or Organization	Number	Title
DND/CAF	A-GA-135-001/AA-001	Flight Safety for The Canadian Forces, CVR/FDR Equipment
	C-05-005-001/AG-001	TAM Part 5, Chapter 5, Electronic Record Keeping
	C-05-005-001/AG-002	ADSM Part 3, Chapter 6, CVR/FDRs
FAA	AC 29 MG 9	Rotorcraft One-Engine-Inoperative (OEI) Power Assurance
	AC 29 MG 15	Airworthiness Approval of Rotorcraft Health Usage Monitoring System
RAAF	AAP 7001.054	Health and Usage Monitoring System
RTCA	DO-178B	Software Considerations in Airborne Systems and Equipment Certification
	DO-200	RTCA DO-200, "Preparation, Verification and Distribution of User Selectable Navigation Data Bases"
	DO-254	Design Assurance Guidance for Airborne Electronic Hardware
SAE	ARP 4754	Certification Considerations for Highly-Integrated or Complex Aircraft Systems
	AS 5391	Health And Usage Monitoring System Accelerometer Interface Specification

Figure 3-17-3 (Sheet 1 of 2) Associated Publications and Standards Related to HUMS

Regulator or Organization	Number	Title
UK CAA	CAP 693	Acceptable Means of Compliance Helicopter Health Monitoring System CAA AAD 001-05-99
UK MoD	DEF STAN 00-970	Volume 2, Chapter 727 to 727/5 – HUMS

Figure 3-17-3 (Sheet 2 of 2) Associated Publications and Standards Related to HUMS

PART 3
AIRCRAFT SYSTEMS DESIGN AND CERTIFICATION

CHAPTER 18 — AEROSPACE RIGID TUBING

3.18.1 Introduction

1. This chapter identifies the airworthiness design standards and associated guidance accepted by the Technical Airworthiness Authority (TAA) for aircraft rigid tubing.

2. Aluminium alloy, titanium alloy and corrosion resistant steel alloy rigid tubing are commonly used in aeronautical products for fuel, oil, oxidizers, coolant, breathing air, instrument, hydraulic, vent, electrical conduits and ventilating ducts.

3.18.2 Airworthiness Design Standards

1. Design standards listed in the following tables are acceptable for application to DND/CAF aircraft.

	Military Airworthiness Design Standards
1.	**MIL-T-8504B,** Military Specification, Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
2.	**MIL-T-8808B,** Military Specification, Tubing, Steel, Corrosion-Resistant (18-8 Stabilized), Aircraft Hydraulic Quality

Figure 3-18-1 Military Airworthiness Design Standards Related to Aerospace Rigid Tubing

	Civil Airworthiness Design Standards
1.	**AMS-WW-T-700,** Tube, Aluminium Alloy, Drawn, Seamless, General Specification
2.	**AMS-WW-T-700/1,** Tube, Aluminium Alloy, Drawn, Seamless, 1100
3.	**AMS-WW-T-700/3,** Tube, Aluminium Alloy, Drawn, Seamless, 2024
4.	**AMS-WW-T-700/2,** Tube, Aluminium Alloy, Drawn, Seamless, 3003
5.	**AMS-WW-T-700/4,** Tube, Aluminium Alloy, Drawn, Seamless, 5052
6.	**AMS-WW-T-700/5,** Tube, Aluminium Alloy, Drawn, Seamless, 5086
7.	**AMS-WW-T-700/6,** Tube, Aluminium Alloy, Drawn, Seamless, 6061
8.	**AMS-WW-T-700/7,** Tube, Aluminium Alloy, Drawn, Seamless, 7075
9.	**AMS 2243,** Tube, Steel, Corrosion and Heat-Resistant, Tolerances
10.	**AMS 2244,** Tube, Titanium and Titanium Alloy, Tolerances
11.	**AMS 4942D,** Tube, Titanium, Seamless, Annealed, 40,000 psi (275 MPa) Yield Strength
12.	**AMS 4946,** Tube, Titanium Alloy, Seamless, Hydraulic 3Al – 2.5V, Texture Controlled Cold Worked, Stress Relieved
13.	**AMS 5540N,** Tube, Steel, Corrosion and Heat Resistant, Seamless 18Cr – 11Ni – 0.40Ti (SAE 30321), Solution Heat Treated
14.	**AMS 5560L,** Tube, Steel, Corrosion Resistant, Seamless, 19Cr – 10Ni (SAE 30304) Solution Heat Treated
15.	**AMS 5571G,** Steel, Corrosion and Heat Resistant, Seamless Tube, 18Cr – 10.5Ni – 0.70Cb (SAE 30347), Solution Heat Treated

Figure 3-18-2 (Sheet 1 of 2) Civil Airworthiness Design Standards Related to Aerospace Rigid Tubing

Civil Airworthiness Design Standards	
16.	**AMS -T-6845,** Tube, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition
17.	**AS33611,** Tube – Bend Radii

Figure 3-18-2 (Sheet 2 of 2) Civil Airworthiness Design Standards Related to Aerospace Rigid Tubing

3.18.3 Guidance Information – General

1. AMS-T-6845 specifies requirements for thin-walled (inside diameter greater than four times the wall thickness and outside diameter 1/4 inch and larger) corrosion-resistant steel tubing in approximately the 1/8 hard condition, of special quality, suitable for use in high-pressure hydraulic systems.

2. AMS-WW-T-700 covers the general requirements for aluminium and aluminium alloy tube, drawn, seamless. Specific requirements for these products in a particular alloy are covered by the applicable detail specification.

3. AMS 5540N covers a corrosion and heat resistant steel in the form of seamless tubing. This tubing has been used typically for parts requiring both corrosion and heat resistance (especially when such parts are welded during fabrication) and also for parts requiring oxidation resistance up to 1500ºF/816ºC, although it is useful at that temperature only when stresses are low; nevertheless, usage is not limited to such applications.

4. AMS 5560L covers corrosion-resistant steel in the form of seamless tubing. This tubing has been used typically for parts, such as fluid-conducting lines, not subject to high pressure and requiring good corrosion resistance, but usage is not limited to such applications. Welding, brazing, or other exposure to temperatures over 800ºF/427ºC during fabrication may impair corrosion resistance.

5. AMS 5571G covers corrosion and heat resistant steel in the form of seamless tubing. This tubing is used typically for parts requiring both corrosion and heat resistance especially when such parts are welded during fabrication. It is also suitable for parts that require oxidation resistance up to 1500ºF/816ºC, although it is useful at that temperature only when stresses are low; nevertheless, usage is not limited to such applications.

3.18.4 Associated Publications and Standards

1. The source references identified in Figure 3-18-3 are associated with the design, installation, maintenance and in-service usage of aerospace rigid tubing.

Regulator or Organization	Number	Title
DND/CAF	C-05-010-015/TP-000	Engineering Manual Series Aircraft and Missile Repair Structural Hardware
	C-12-010-013/TP-000	Pipeline Identification
	C-12-010-026/TP-000	Pipeline and Aperture Blanking Procedure
	C-12-010-040/TR-011	Rigid Fluid Tubing Repair and Replacement
SAE	AMS-WW-T-700	Tube, Aluminium Alloy, Drawn, Seamless, General Specification for
	AMS-WW-T-700/1	Tube, Aluminium Alloy, Drawn, Seamless, 1100
	AMS-WW-T-700/2	Tube, Aluminium Alloy, Drawn, Seamless, 3003
	AMS-WW-T-700/3	Tube, Aluminium Alloy, Drawn, Seamless, 2024
	AMS-WW-T-700/4	Tube, Aluminium Alloy, Drawn, Seamless, 5052
	AMS-WW-T-700/5	Tube, Aluminium Alloy, Drawn, Seamless, 5086
	AMS-WW-T-700/6	Tube, Aluminium Alloy, Drawn, Seamless, 6061
	AMS-WW-T-700/7	Tube, Aluminium Alloy, Drawn, Seamless, 7075

Figure 3-18-3 (Sheet 1 of 2) Associated Publications and Standards Related to Aerospace Rigid Tubing

Regulator or Organization	Number	Title
SAE (Cont)	AMS 2243	Tolerances, Corrosion and Heat-Resistant Steel Tubing
	AMS 2244	Tolerances, Titanium and Titanium Alloy Tubing
	AMS 4942D	Titanium Tubing, Seamless, Annealed, 40,000 psi (275 MPa) Yield Strength-UNS R50400
	AMS 4946	Titanium Alloy Tubing, Seamless, Hydraulic 3Al – 2.5V, Texture Controlled Cold Worked, Stress Relieved-UNS S30400
	AMS 5540N	Steel, Corrosion and Heat Resistant, Seamless Tubing, 18Cr - 11Ni – 0.40Ti (SAE 30321), Solution Heat Treated
	AMS 5560L	Steel, Corrosion Resistant, Seamless Tubing 19Cr – 10Ni (SAE 30304) Solution Heat Treated UNS S30400
	AMS 5571G	Steel, Corrosion and Heat Resistant, Seamless Tubing, 18Cr - 10.5Ni – 0.70Cb (SAE 30347), Solution Heat Treated
	AMS-T-6845	Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition
	AS33611	Tube Bend Radii
U.S. DoD	MIL-T-8504B	Military Specification, Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
	MIL-T-8808B	Military Specification, Tubing, Steel, Corrosion-Resistant (18-8 Stabilized), Aircraft Hydraulic Quality

Figure 3-18-3 (Sheet 2 of 2) Associated Publications and Standards Related to Aerospace Rigid Tubing

PART 4
UNCREWED AIRCRAFT SYSTEMS (UAS) – DESIGN AND CERTIFICATION (TO BE PROMULGATED)

CHAPTER 1 — UAS – CERTIFICATION REQUIREMENTS (TO BE PROMULGATED)

PART 4
UNCREWED AIRCRAFT SYSTEMS (UAS) – DESIGN AND CERTIFICATION (TO BE PROMULGATED)

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PART 4
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MISCELLANEOUS EQUIPMENT APPROVAL / CERTIFICATION (TO BE PROMULGATED)

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PART 5
MISCELLANEOUS EQUIPMENT APPROVAL / CERTIFICATION (TO BE PROMULGATED)

CHAPTER 2 — MISSION SYSTEMS (TO BE PROMULGATED)

PART 5
MISCELLANEOUS EQUIPMENT APPROVAL / CERTIFICATION (TO BE PROMULGATED)

CHAPTER 3 — AEROMEDICAL EQUIPMENT (TO BE PROMULGATED)

PART 5
MISCELLANEOUS EQUIPMENT APPROVAL / CERTIFICATION (TO BE PROMULGATED)

CHAPTER 4 — ELECTRONIC FLIGHT BAG (TO BE PROMULGATED)

PART 5
MISCELLANEOUS EQUIPMENT APPROVAL / CERTIFICATION (TO BE PROMULGATED)

CHAPTER 5 — PORTABLE ELECTRONIC DEVICES (TO BE PROMULGATED)

LIST OF ABBREVIATIONS

1 Cdn Air Div	1 Canadian Air Division
14 CFR	United States Title 14 Code of Federal Regulations
AA	Airworthiness Authority
AAD	Advanced Anomaly Detection
AAP	Australian Air Publication
AAR	Air-to-Air Refueling
AC	Advisory Circular (FAA and TCCA)
ACARS	Aircraft Communication Addressing and Reporting Systems
ACAS	Airborne Collision Avoidance System
ACE	Advanced Crew Ensemble
ACNS	Airborne Communications, Navigation and Surveillance
ADC	Air Data Computer
ADF	Australian Defence Force
ADF	Automatic Direction Finder
ADM(Mat)	Assistant Deputy Minister (Materiel)
ADM(IM)	Assistant Deputy Minister (Information Management)
ADO	Acceptable Design Organization
ADRM	Airworthiness Design Requirements Manual (Australian Defence Force)
ADS	Aeronautical Design Standard (U.S. Army)
ADS	Air Data System
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance–Broadcast
ADSM	Airworthiness Design Standards Manual
AECTP	Allied Environmental Conditions and Test Publication (NATO)
AEEC	Airlines Electronic Engineering Committee (ARINC)
AEH	Airborne Electronic Hardware
AEO	Aircraft Engineering Officer
AEPM	Aerospace Equipment Program Management
AETE	Aerospace Engineering Test Establishment
AFIC	Air Force Interoperability Council
AFM	Approved Flight Manual
AFN	ATS Facilities Notification
AFSC DH	Air Force Systems Command Design Handbook (U.S. DoD)
AGATE	Advanced General Aviation Transport Experiments (FAA-led)
AHRS	Attitude Heading and Reference System
AIA	Airworthiness Investigative Authority (DND)
AIA	Aerospace Industries Association
AID	Automatic Inflation Device
AIM	Airworthiness Investigative Manual
AIP	Aeronautical Information Publication
AIR	Aerospace Information Reports (SAE)
AIR	Airborne Image Recorder (ICAO)
AIR STD	Air Standard (NATO)
AISS	Aeronautical Information System Security
ALOS	Acceptable Level of Safety
ALSE	Aviation Life Support Equipment

LIST OF ABBREVIATIONS (Cont)

AM	Additive Manufacturing
AMC	Acceptable Means of Compliance
AMS	Aerospace Material Specification (SAE)
AMS	Acute Mountain Sickness
AMSS	Aeronautical Mobile Satellite Services
AMSS	Aviation Mission Support Systems
ANC	Air Force – Navy – Commerce Bulletin (DoD)
ANR	Active Noise Reduction
ANS	American National Standard
ANSI	American National Standards Institute
ANVIS	Aviator's Night Vision Imaging System
AOI	Aircraft Operating Instructions
APR	Antenna Placement Report
APU	Auxiliary Power Unit
ARC	Aviation Rulemaking Committee (FAA)
ARINC	Aeronautical Radio Incorporated
ARD	Aerospace Resource Documents (SAE)
ARMP	Allied Reliability and Maintainability Publication (NATO)
ARP	Aerospace Recommended Practice (SAE)
AS	Aerospace Standards (SAE)
ASAP	Aviation Safety Action Program
ASCC	Air Standards Coordination Committee
ASE	Aircraft Support Equipment
ASIC	Application Specific Integrated Circuits
ASIP	Air Force Aircraft Structural Integrity Program (U.S.)
ASIMP	Aircraft Structural Integrity Management Plan/Program
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non-Destructive Testing
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
ATESS	Aerospace and Telecommunications Engineering Support Squadron
ATO	Authorization/Authority to Operate (cybersecurity)
ATS	Air Traffic Services
AWG	American Wire Gauge
AWM	Airworthiness Manual (TCCA)
AWS	American Welding Society
BIT	Built-in Test
BS	British Standard
BV	Basic Vehicle
CAA	Civil Aviation Authority
CAF	Canadian Armed Forces
CAN-TSO	Canadian Technical Standard Order (TCCA)
CAP	Civil Aviation Publication (UK CAA)
CAR	Canadian Aviation Regulations (TCCA)
CbA	Certification by Analysis
CBA	Circuit Board Assembly

CBAAC	Commercial and Business Aviation Advisory Circular (TCCA)
CCA	Common Cause Analysis
CD	Chemical Defence
CDA	Canadian Domestic Airspace
CDRE	Crash Damage Recovery Equipment
CDRL	Contract Data Requirement List
CDS	Chief of Defence Staff
CDTI	Cockpit Display of Traffic Information
CDU	Control Display Unit
CEMS	Clothing and Equipment Millennium Standard
CFTO	Canadian Forces Technical Order
CGSB	Canadian General Standards Board
CIA	Change Impact Analysis
CIR	Cockpit Image Recorder
CM	Configuration Management
CMA	Cyber Mission Assurance
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CONOPS	Concept of Operations
COTS	Commercial off-the-Shelf
CofG	Centre of Gravity
CP	Certification Plan
CPDLC	Controller Pilot Data Link Communications
CPU	Central Processing Unit
CRS	Corrosion Resistant Steel
CRT	Cathode-ray tube
CS	Certification Specifications (EASA)
CSA	Canadian Standards Association
CS&E	Cabin Systems and Equipment
CSL	Computer Security Lab (RMC)
CVR	Cockpit Voice Recorder
DA	Design Authority
DAD	Deployable Aerodynamic Decelerator
DAFIF	Digital Aeronautical Flight Information File
DAH	Designated Airspace Handbook (Canada)
DAL	Design Assurance Level
DAOD	Defence Administrative Orders and Directives (DND)
DAR	Directorate Air Requirements
DASA	Defence Aviation Safety Authority (ADF)
DD	Dangerous Detected (Failure Condition Mode)
DEF STAN	Defence Standard (UK MoD)
DFS	Director Flight Safety (DND)
DFSM	DND Frequency Spectrum Management
DICP	Division Instrument Check Pilot (DND)
DFLIP	Digital Flight Information Publications
DGAEPM	Director General Aerospace Equipment Program Management
DGIMO	Director General Information Management Operations
DLR	Data Link Recorder
DLS	Data Link Services
DME	Distance Measuring Equipment
DND	Department of National Defence (Canada)
DNS	Doppler Navigation System

LIST OF ABBREVIATIONS (Cont)

DoD	U.S. Department of Defense
DRDC	Defence Research and Development Canada
DTAES	Director Technical Airworthiness and Engineering Support (DND)
DWAN	Defence Wide Area Network
E3	Electromagnetic Environmental Effects
E3CAB	E3 Control Advisory Board
E3ATP	E3 Acceptance Test Plans
E3CP	E3 Control Program
E3CPP	E3 Control Program Plan
E3TR	E3 Test Report
EAA	Enhanced Altitude Accuracy
EASA	European Union Aviation Safety Agency
EBS	Emergency Breathing Systems
ECS	Environmental Control System
ED	EUROCAE Document
EDA	European Defence Agency
EAA	Enhanced Altitude Accuracy
EFB	Electronic Flight Bag
EFIS	Electronic Flight Instrument System
EGPWS	Enhanced Ground/Proximity Warning System
EIA	Electronic Industries Alliance
ELA	Electrical Load Analysis
ELOS	Equivalent Level of Safety
ELT	Emergency Locator Transmitter
EMACC	European Military Airworthiness Certification Criteria (EDA)
EMC	Electromagnetic Compatibility
EMCON	Emission Control
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMV	Electromagnetic Vulnerability
EGPWS	Enhanced Ground/Proximity Warning System
ENSIP	Engine Structural Integrity Program
EPM	Electrical Power Management
ES	Ejection System
ESA	European Space Agency
ESDU	Engineering Science Data Unit
ET	Eddy Current Testing
ET&E	Engineering Test and Evaluation
ETSO	European Technical Standard Orders
EUBA	Emergency Underwater Breathing Aid
EUROCAE	European Organisation for Civil Aviation Equipment
EWIS	Electrical Wiring Interconnection System
FAA	Federal Aviation Administration (U.S.)
FAR	False Alarm Rate
FAR	Federal Aviation Regulations (U.S.)
FCC	Federal Communications Commission (U.S.)
FDR	Flight Data Recorder
FDR	Failure Detection Rate
FE	Flight Engineer
FHA	Functional Hazard Assessment
FMCS	Flight Management Computer System

LIST OF ABBREVIATIONS (Cont)

FMEA	Failure Mode Effect Analysis
FMECA	Failure Modes Effect Criticality Analysis
FMS	Flight Management System
FOD	Foreign Object Damage
FOV	Field of Vision
FL	Flight Level
FLIP	Flight Information Publication
FM Immunity	Frequency Modulation Immunity Support
FPGA	Field Programmable Gate Array
Fps	Feet per second
FR	Flame Resistant
FRPC	Flight Recorder Playback Center
FRT	Fixed Radius Transition
FTA	Fault Tree Analysis
G	Gravity
GAT	General Air Traffic
GCS	Ground Control Station
GEO	Geosynchronous Orbit
GLONASS	Global Orbiting Navigation Satellite System (Russian Federation)
GM	Guidance Material (EASA)
GNSS	Global Navigation Satellite System
GPH	Government Publication Handbook (DND)
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HACR	Harmonized Assessment of Cybersecurity Risk
HEED	Helicopter Emergency Egress Device
HEELS	Helicopter Emergency Egress Lighting System
HEO	High-Earth Orbit
HEUBA	Helicopter Emergency Underwater Breathing Apparatus
HF	Human Factors
HFDL	High Frequency Data Link
HFE	Human Factors Engineering
HIC	Head Injury Criteria
HIFR	Hover-in-Flight-Refuelling
HIFR	Helicopter In-Flight Refuelling
HIRF	High Intensity Radiated Field
HMD	Head Mounted Display
HTAWS	Helicopter Terrain Awareness and Warning System
HUD	Head Up Display
HUMS	Health and Usage Monitoring System
IAC	Investigative Airworthiness Clearance
IAP	Instrument Approach Procedure
IAS	Indicated Air Speed
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organisation
ICS	Inter-Communication System
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETM	Interactive Electronic Technical Manual
IFC	Instrument Flight Conditions

LIST OF ABBREVIATIONS (Cont)

IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMA	Integrated Modular Avionics
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
IP	Internet Protocol
IPE	Individual Protective Equipment
IRS	Inertial Reference System
IRU	Inertial Reference Units
ISA	International Standard Atmosphere
ISO	International Organization for Standardization
IUEI	Intentional Unauthorized Electronic Interaction
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement (JAA)
JHMCS	Joint Helmet Mounted Cueing System
JSSG	Joint Service Specification Guide (U.S. DoD)
LCD	Liquid Crystal Display
LCEP	Life Cycle Environmental Profile
LEO	Low-Earth Orbit
LEP	Laser Eye Protection
LOA	Letter of Authorization
LODA	Letter of Design Approval (FAA TSO)
LOX	Liquid Oxygen
LP	Life Preserver
LPSV	Life Preservers/Survival Vests
LRU	Line Replaceable Unit
MAA	Military Aviation Authority
MA&S	Materiel Acquisition and Support
MAS	Military Agency for Standardization (NATO)
MASPS	Minimum Aviation System Performance Standards
MAWA	Military Airworthiness Authorities (EDA)
MCAAV	Mission Criticality Analysis and Asset Valuation
MDM	Mission Dependency Model
MEL	Minimum Equipment List
MEO	Medium-Earth Orbit
METS™	Modular Egress Training Simulator
MFD	Multifunction Display
MG	Miscellaneous Guidance (FAA)
MIL-DTL	Military Detailed Specification (U.S. DoD)
MIL-HDBK	Military Handbook (U.S. DoD)
MIL-PRF	Military Performance Specification (U.S. DoD)
MIL-SPEC	Military Specification (U.S. DoD)
MIL-STD	Military Standard (U.S. DoD)
MMDH	Metallic Materials Data Handbook
MMEL	Master Minimum Equipment List
MMP	Maintenance Monitor Panel
MMPDS	Metallic Materials Properties Development and Standardization
MND	Minister of National Defence
MNPS	Minimum Navigation Performance Specifications (Canada)
MoD	Ministry of Defence (UK)
MOPS	Minimum Operational Performance Standards

LIST OF ABBREVIATIONS (Cont)

MOT	Minister of Transport (Canada)
MOTS	Military-Off-the-Shelf
MRTT	Multi Role Tanker Transport
MSS	Material Specification and Standard
MT	Magnetic Particle Testing
NAARMO	North American Approvals Registry and Monitoring Organization (U.S.)
NAS	National Aerospace Standard (AIA)
NATO	North Atlantic Treaty Organization
NAVAIR	U.S. Navy Standard
NavDB	Navigation Database
NAVSTAR	U.S. Global Positioning System
NBC	Nuclear, biological, chemical
NCA	Northern Control Area
NCAMP	National Center for Advanced Materials Performance
ND	Navigation Display
NDA	Northern Domestic Airspace
NDB	Non-Directional Beacon
NDE	Non-Destructive Evaluation
NDI	Non-Development Item
NDT	Non-Destructive Testing
NDTAF	Non-Destructive Testing Area Facilities
NEMP	Nuclear Electromagnetic Pulse
NFPA	National Fire Protection Association
NGA	National Geospatial-Intelligence Agency (U.S.)
NM	Nautical Miles
NMAA	National Military Airworthiness Authorities (EDA member states)
NSO	NATO Standardization Office
NSSN	National Standards Systems Network
NTIAC	Non-destructive Testing Information Analysis Center
NVG	Night Vision Goggles
NVIS	Night Vision Imaging Systems
OAA	Operational Airworthiness Authority (DND)
OAC	Operational Airworthiness Clearance
OAT	Operational Air Traffic
OBOGS	On-Board Oxygen Generating System
OCA	Original Certification Authority
OEI	One Engine Inoperative
OEM	Original Equipment Manufacturer
OPI	Office of Primary Interest
OPR	Open Problem Report
OSP	Occupant Safety Policy (DND)
OT&E	Operational Test and Evaluation
PBCS	Performance Based Communication and Surveillance
PBN	Performance Based Navigation
PCDS	Personnel-Carrying Device Systems
PE	Programmable Element
PED	Portable Electronic Device
PFD	Primary Flight Display
PHA	Preliminary Hazard Assessment
PHL	Preliminary Hazard List
PLB	Personal Locator Beacon
PLD	Programmable Logic Device
PM	Preventative Measures
PMO	Project Management Officer

LIST OF ABBREVIATIONS (Cont)

POAM	Plan of Actions and Milestones
POL	Petroleum, Oil and Lubricant
PPS	Precise Positioning Service
PRV	Pressure Reducing Valve
PSAC	Plan for Software Aspects of Certification
PSecAC	Plan for Security Aspects of Certification
PSI	Pounds per Square Inch (unit of pressure)
PSRA	Preliminary Security Risk Assessment
PSSA	Preliminary System Safety Assessment
PT	Liquid Penetrant Testing
PVC	Polyvinyl Chloride
QETE	Quality Engineering Test Establishment
QSTAG	Quadripartite Standardization Agreement
RA	Resolution Advisory
RAAF	Royal Australian Air Force
RadAlt	Radar Altimeter
RADHAZ	Radiation Hazards
R&D	Research and Development
R&M	Reliability and Maintainability
RCAF	Royal Canadian Air Force
RCMAP	Risk-based Cyber Mission Assurance Process
RCN	Royal Canadian Navy
RCP	Required Communication Performance
RIPS	Recorder Independent Power Supply
RSP	Required Surveillance Performance
RDIMS	Records, Documents and Information Management System
RF	Radio Frequency
RMC	Royal Military College
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP APCH	RNP Approach
RNP AR	Required Navigation Performance Authorization Required
RNPC	Required Navigation Performance Capability
RPAS	Remotely Piloted Aircraft System
RT	Radiographic Testing
RTCA Inc.	RTCA Incorporated (formerly Radio Technical Commission for Aeronautics)
RVSM	Reduced Vertical Separation Minimum
RWR	Radar Warning Receiver
S3	Stores Safety and Suitability for Service
SAE	Society of Automotive Engineers
SAL	Security Assurance Level
SAR	Search and Rescue
SARP	Standards and Recommended Practices
SATVOICE	Satellite Voice
SB	Service Bulletin
SC	Special Condition
SC	Special Committee (RTCA/FAA)
SCCRAM	Short Course in Cybersecurity Risk Assessment Methodology

LIST OF ABBREVIATIONS (Cont)

SDA	Southern Domestic Airspace
SERE	Survival, Evasion, Resistance and Escape
SELCAL	Selective Calling
SI	Système International (IEC)
SID	Standard Instrument Departure
SLAB	Sealed Lead Acid Battery
SME	Subject-Matter Expert
SOFT	Safety of Flight Test
SOI	Statement of Operating Intent
SOLAS	Safety Of Life At Sea (USCG)
SoSHA	System-of-Systems Hazard Analysis
SOW	Statement of Work
SRA	Security Risk Assessment
SRHA	Safety Requirements Hazard Analysis
SRTM	Security Requirements Traceability Matrix
SSA	System Safety Assessment (or Analysis)
SSAR	Survival, Search and Rescue
SSD	Security Scope Definition
SSEC	Static Source Error Correction
SSecWG	System Security Working Group
SSEMP	System Security Engineering Management Plan
SSHA	Subsystem Hazard Analysis
STANAG	Standardization Agreement (NATO)
STAR	Standard Terminal Arrival
STC	Supplemental Type Certificate
STING	Sustained Tolerance at Increased G
SV	Survival Vest
TAA	Technical Airworthiness Authority
TAC	Technical Airworthiness Clearance
TACAN	Tactical Air Navigation
TAM	Technical Airworthiness Manual
TAO	Temporary Authority to Operate
TAS	Traffic Advisory System
TAWS	Terrain Awareness and Warning Systems
TBO	Time Between Overhaul
TC	Type Certificate
TCAS	Traffic Alert and Collision Avoidance System
TCCA	Transport Canada Civil Aviation
TCDS	Type Certificate Data Sheet
TCH	Type Certificate Holder
TDE	Type Design Examination
TEMPEST	Telecommunications Electronics Material Protected from Emanating Spurious Transmissions
TOAC	Time of Arrival Control
T-PED	Transmitting Portable Electronic Device
TSO	Technical Standard Order (FAA)
TSOA	Technical Standard Order Authorization (FAA)
TPP	Thermal Protection Performance
UA	Uncrewed Aircraft
UAB	Underwater Acoustic Beacon
UAS	Uncrewed Aircraft System
UAV	Unmanned Air Vehicle (DEF STAN 00-970)
UCLP	Universal Carrier Life Preserver
UCS	UAS Control Station

LIST OF ABBREVIATIONS (Cont)

UHF	Ultra High Frequency
UK	United Kingdom
ULB	Underwater Locater Beacon
ULD	Underwater Locating Device
UOR	Urgent Operational Requirement
U.S.	United States
USAF	U.S. Air Force
USAR	UAV Systems Airworthiness Requirements
USAR-RW	USAR Rotary Wing
USCG	United States Coast Guard
USN	US Navy
UT	Ultrasonic Testing
VAC	Volts Alternating Current
VCMS	Vehicle Control and Management System
VDC	Volts Direct Current
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VSM	Vertical Separation Minimum
VTOL	Vertical Takeoff and Landing
WSM	Weapon System Manager

GLOSSARY

EDITORIAL NOTE

In an effort to standardize the terminology adopted by the DND Technical Airworthiness Authority and accepted by the Defence Terminology Bank, this Glossary includes some of the definitions provided in the Technical Airworthiness Manual (TAM). However, consideration was given to the fact that the TAM contains strictly TAA-released rules and standards, while the ADSM delves into the standards and codes of TAA-recognized airworthiness authorities. As a result, certain TAM terms have been modified in this Glossary to facilitate the interpretation of those authorities' airworthiness standards and codes. Those terms have been clearly flagged for awareness and marked "[Derived from the TAM]".

Click on a link

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

A

Acceptable Design Organization (ADO)

An organization deemed acceptable by the TAA to perform airworthiness management roles and technical airworthiness functions in the development of the design of aeronautical products, including subsequent design changes to the approved type design. An ADO may also be approved to provide engineering support to aeronautical products.

Acceptable Level of Safety (ALOS)

The minimum safety goals established by the Regulator, generally defined in terms of the probability of an aircraft accident occurring. The ALOS for an aircraft is defined as the design safety goals and requirements for the aircraft type design. These design goals are defined in the certification requirements, standards and criteria specified in a certification basis. Since the certification basis for a specific type design may be unique, the detailed ALOS for that type may also be unique. The Regulator's approval of the certification basis declares that the Level of Safety specified in the certification requirements is 'Acceptable'. Any subsequent changes to the certification basis may cause changes to the ALOS levels.

Acceptable Means of Compliance (AMC)

The minimum safety goals established by the Regulator, generally defined in terms of the probability of an aircraft accident occurring. The ALOS for an aircraft is defined as the design safety goals and requirements for the aircraft Type Design. These design goals are defined in the certification requirements, standards and criteria specified in a Certification Basis. Since the Certification Basis for a specific Type Design may be unique, the detailed ALOS for that type may also be unique. The Regulator's approval of the Certification Basis declares that the Level of Safety specified in the certification requirements is 'Acceptable'. Any subsequent changes to the Certification Basis may cause changes to the ALOS levels.

Advisory Material

Documentation that augments an airworthiness authority's airworthiness code and offers interpretation of an airworthiness standard to assist in its understanding and implementation. This documentation provides guidance on methods and procedures that are in accepted by the respective issuing airworthiness authority. Advisory material, including the described methods and procedures, is not mandatory and organizations may choose to follow other means of demonstrating compliance. Advisory material may be included, by reference, in the certification basis of the aeronautical product to indicate the applicant's intention to comply with a specific design or process standards. Once advisory material has been included in the certification basis and accepted by the TAA, compliance becomes mandatory [Derived from the TAM, see EDITORIAL NOTE].

Aeronautical Product

Any aircraft, aircraft engine, aircraft propeller, aircraft appliance or the component parts of any of those things including computer systems and software.

Aeronautics Act

The authoritative document for both civil and military aviation safety in Canada. As a statute of Canada, the Act is a law that places upon the Minister of Transport (MOT), the Minister of National Defence (MND) and the Chief of Defence Staff (CDS) under the direction of the MND, the responsibility for the development and regulation of aeronautics and the supervision of all matters related to aeronautics.

Attitude and Heading Reference System (AHRS)

A system that provides attitude and heading information to flight crew. Although not specifically a navigation system in and of itself, the information provided by the AHRS is required to support many navigation functions found on most modern aircraft.

Airborne Collision Avoidance System (ACAS)

Also known as Traffic Alert and Collision Avoidance System (TCAS), an ACAS is an installed system whose function is to interrogate nearby aircraft transponders, listen to their broadcast messages, and use internal complex algorithms to identify and display potential collision threats.

Airborne Electronic Hardware

Complex and simple custom micro-coded components including application specific integrated circuits (ASIC), programmable logic devices (PLD), field programmable gate arrays (FPGA), or similar electronic components used in the design of aircraft systems and equipment.

Air Data System (ADS)

Systems used to collect and process air data characteristics from various sensors to compute critical air data parameters (e.g., altitude, airspeed, height deviation, and temperature) for use by the pilot and other systems in the aircraft (source: FAA AC 91-85B).

Aircraft

Any machine capable of deriving support in the atmosphere from reactions of the air.

Aircraft Cybersecurity

See **Airworthiness Security**.

Aircraft Design Standards

A generic term that refers to Industry and government-recognized standards used in the design and development of a range of products to introduce consistency in the operation, manufacture, maintenance and materiel support of equipment, and the delivery of related services. Aircraft design standards are a sub-set of the larger body of design standards that specifically apply to the design of aeronautical products. Aircraft design standards are typically published by a military or civilian standards organization for use in the design of aircraft (e.g., the U.S. MIL-STD, or the RTCA Inc. standards).

Aircraft Support Equipment (ASE)

Also known as "Aircraft Operational Support Equipment" or "Aircraft Maintenance Support Equipment", the Aircraft Support Equipment (ASE) term is used to categorize all off-board logical based assets used, which directly or indirectly interface, influence, process, program or contribute to aircraft systems, the aircraft, or the operation thereof, for military aviation purposes. Examples include, but are not limited to, maintenance and operation-controlled hardware, software, data, information exchange paths, and electronic data transfer devices. ASE is generally logical based and has a processor and electronic storage component designed to specifically support aircraft functions, or test/verify the function of complex avionics.

Aircraft Structural Integrity Program (ASIP)

The Aircraft Structural Integrity Program (ASIP) is defined in MIL-STD-1530 and is composed of a series of tasks that cover design, certification, testing, in-service support and disposal of aircraft structures to ensure their safety, performance, durability, and supportability throughout their service lives, with the least possible economic burden (source: DAFI 63-140).

Airworthiness

A standard of safety demonstrating that an aeronautical product is fit and safe for flight in its intended role, in conformance with its approved type design and manufacturing and maintenance standards, when operating within its design limits.

Airworthiness Approval

A certification by an Authorized Individual that a Type Design, or Design Change to an Approved Type Design, is in compliance with the Certification Basis. Airworthiness Approval is a Technical Airworthiness Function.

Airworthiness Authority (AA)

A generic term for any of the following: aviation regulatory agency (or authority), aviation safety authority, National Aviation (or Airworthiness) Authority (NAA), Civil Aviation (or Airworthiness) Authority (CAA), or Military Aviation (or Airworthiness) Authority (MAA). The DND/CAF AA is the person designated in writing by the Minister of National Defence (MND) through the Chief of Defence Staff (CDS) to have overall supervision and management of the DND/CAF Airworthiness Program, and acts as Chair of the Airworthiness Advisory Board (AAB). That person is the Chief of the Air Force Staff (C Air Force). The AA's responsibilities include the development, promotion, supervision and management of the Airworthiness Program for the DND/CAF, the nomination of competent individuals to fill the roles of Operational and Investigative Airworthiness Authorities and, in consultation with ADM(Mat), the nomination of a competent individual to fill the role of Technical Airworthiness Authority.

Airworthiness Clearance

A certification issued by the AA that the requirements of the airworthiness program have been met and that, from an airworthiness perspective, a specific Aeronautical Product is ready to enter into operational service.

Airworthiness Code

A comprehensive set of airworthiness standards that define those attributes of aircraft systems or equipment required for safe flight. These requirements are used to develop a Certification Basis that defines the attributes of an aircraft Type Design that underpin safe flight and, thus, an Acceptable Level of Safety for the operation of the aircraft. Airworthiness codes are issued by civil and military Airworthiness Authorities for a range of aircraft categories, e.g., transport, rotorcraft and Uncrewed Aircraft Systems (UAS). Examples of Airworthiness Codes include the European Union Aviation Safety Agency (EASA) Certification Specifications (CSs), Transport Canada's Canadian Airworthiness Manual (AWM), the U.S. Title 14 Code of Federal Regulations (14 CFR), the U.S. Department of Defense MIL-HDBK-516 and the European Defence Agency's European Military Airworthiness Certification Criteria (EMACC).

Airworthiness Design Standard

Used in the ADSM as a general label when referring to airworthiness standard, design standard, certification standard and certification criteria.

Airworthiness Investigative Authority (AIA)

The person responsible for the regulation of the airworthiness aspects of the Flight Safety Program for the DND/CAF. The DND Chief of Defence Staff, under the direction of the Minister of National Defence, has delegated the Director Flight Safety (DFS) to fill the position of AIA. The AIA is also responsible for the investigation of airworthiness-related occurrences and for the monitoring of the Technical and Operational Airworthiness Programs to identify deficiencies.

Airworthiness Program

A combination of aviation activities including the design, manufacture, maintenance, material support, facilities, personnel and operations which contribute to a safe and acceptable level of aeronautical product operation.

Airworthiness Rule

The term used by the TAA, in the Technical Airworthiness Program, in place of the term ‘Airworthiness Regulation’. Under the Canadian federal government’s legal system, the term ‘regulation’ is reserved for regulations that have Order-in-Council approval. Unlike Transport Canada Civil Aviation regulations, the DND airworthiness requirements do not go through the Order-in-Council approval process. Instead, they are issued as rules under the authority vested in the Minister of National Defence and the Chief of the Defence Staff.

Airworthiness Security

The protection of the airworthiness of an aircraft from an Intentional Unauthorized Electronic Interaction (IUEI): harm due to human action (intentional or unintentional) using access, use, disclosure, disruption, modification, or destruction of data and/or data interfaces. This also includes the consequences of malware and forged data, and of access of other systems to aircraft systems (source: RTCA DO-326A/ED-202A).

Airworthiness Standard (Standard of Airworthiness)

The criteria and/or processes used in assessing or demonstrating compliance with an airworthiness rule. They are used to define the certification basis for a new aircraft type design and for a major design change to an existing design. This term is consistently used by major Civil Airworthiness Authorities (CAAs) to refer to the standards that they have issued to govern the certification of aircraft designs [Derived from the TAM, see EDITORIAL NOTE].

Airworthy

The state of an Aeronautical Product when it has been assessed or determined to conform to the Approved Type Design and declared Fit and Safe for Flight.

Ammunition

Device charged with explosives, propellants, pyrotechnics, initiating composition or nuclear, biological or chemical material, for use in military operations, including a non-charged or inert replica of such a device.

Ammunition Safety and Suitability Board (ASSB)

The oversight mechanism for all matters relating to the S3 of Ammunition and Explosives (A&E) under the direction or control of the Minister of National Defence. Its function is to validate A&E Safety and Suitability for Service (S3) assessments independent of the pressures of operations, production and procurement, prior to introducing them into service.

Appliance

Any instrument, mechanism, equipment, apparatus or accessory that is used, or intended to be used, in operating or controlling an aircraft in flight; installed in or attached to, or intended to be installed in or attached to, the aircraft; and not part of the airframe, engine or propeller of that aircraft.

Applicant

The regulated entity (organization's representative individual) that is applying to the Technical Airworthiness Authority for an airworthiness certificate, accreditation or other form of airworthiness approval. For a DND Type Certificate, the Applicant is the organization (or representative individual) applying for the Type Certificate (typically a Project Management Office [PMO]), or, in the case of an in-service design change, for Airworthiness Approval (typically the TCH organization).

Approved Flight Manual (AFM)

The Flight Manual, once Airworthiness Approval has been granted by the TAA and the OAA. See also **Flight Manual**.

Approved Maintenance Program

A maintenance program detailed within a suite of maintenance manuals for an Aeronautical Product, which specifies the maintenance requirements necessary for the Aeronautical Product and associated systems, equipment, component parts and software to be kept Fit and Safe for Flight.

Armament and Stores Integration

The determination of specific store(s)/aircraft compatibility and the formal publication of all technical and operational instructions necessary for the preparation, loading, maintenance and employment of a store on a specified aircraft.

Area Navigation (RNAV)

Formerly known as "random navigation" (hence the acronym RNAV), it is a type of performance-based navigation that enables aircraft to fly on any desired flight path within the coverage of ground or space-based navigation aids and/or the capability limits of the self-contained aircraft navigation systems (e.g., Inertial Reference System).

ARINC

ARINC (Aeronautical Radio Incorporated) is a private company that works closely with the FAA and the FCC to establish standards for aviation communication and navigation.

Asset

The logical and physical resources of the aircraft which contribute to the airworthiness of the aircraft, including functions, systems, items, data, interfaces, processes and information (source: RTCA DO-326A/ED-202A).

Assurance

The planned and systematic actions necessary to provide adequate confidence that a product or process satisfies given requirements (source: RTCA DO-326A/ED-202A).

Authorization to Operate (ATO)

In the context of aircraft cybersecurity, an Authorization to Operate (also known as Authority to Operate) represents the official management decision given by a senior organizational official to authorize operation of an aerospace system, and to explicitly accept the risk to organizational operations (including mission, functions, image, or reputation), organizational assets, individuals, other organizations, and the nation based on the implementation of an agreed-upon set of security controls (derived from NIST CNSSI 4009-2015).

Authorized Individual (AI or TAA AI)

A person empowered, though an authorization, or Assignment of Authority (AoA) process, to perform an airworthiness function on behalf of the TAA.

Automatic Dependent Surveillance (ADS)

A means by which aircraft, aerodrome vehicles and other objects can automatically transmit and/or receive data such as identification, position and additional data, as appropriate, in a broadcast mode via a data link (source: TCCA AC 100, 001).

Automatic Dependent Surveillance – Broadcast (ADS-B)

An advanced surveillance technology that combines an aircraft's positioning source, aircraft avionics, and a ground infrastructure to create an accurate surveillance interface between aircraft and air traffic control. ADS-B is a performance-based surveillance technology that is more precise than radar (source: FAA).

Automatic Direction Finder (ADF)

An air navigation system, which works based on the simple radio navigation concept that a ground-based radio transmitter (a Non-Directional Beacon [NDB]) sends an omnidirectional signal to be received by an aircraft directional antenna. The result is a cockpit instrument (the ADF), which displays the aircraft bearing relative to the NDB station, allowing a pilot to "home" to a station, or track a course from a station.

Aviation Life Support Equipment (ALSE)

All crewmember- and passenger-related life support systems and survival equipment primarily intended for the preservation of life, the prevention of injury, or the environmental protection of the crewmember and passenger during flight, emergency egress, survival and rescue.

Aviation Mission Support Systems (AMSS)/Aircraft Support Equipment (ASE)

Logical based aircraft material and aeronautical products used in connection with military aircraft or the operation thereof. The term is used to categorize all off-board logical based assets used, which directly or indirectly interface, influence, process, program or contribute to aircraft systems, aircraft, or the operation thereof, for military aviation purposes. Examples include, but are not limited to, maintenance and operations-controlled hardware, software, data, information exchange paths, and electronic data transfer devices. AMSS are generally logical based and have a processor and electronic storage component designed to specifically support aircraft functions, or test/verify the function of complex avionics.

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Baseline Vehicle (BV)/Baseline Aircraft

The already certified or qualified aircraft that is being submitted as part of a proposal, which will then be modified to produce the aircraft required by DND (source: TAA Advisory 2017-01).

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Certification

See **Type Certification**.

Certification Basis

A set of certification requirements and associated standards against which compliance must be demonstrated in order to obtain airworthiness approval for a new type design or a design change. The certification requirements and standards that form the certification basis are extracted from the Airworthiness Codes and are tailored to suit the aeronautical product type. The Certification Basis may also include special conditions, exemptions and deviations approved by the TAA, as well as environmental requirements.

Certification by Analysis (CbA)

The development of an analysis-based means of compliance for aircraft certification. Although continuously evolving, the goal of this field is to develop and mature current and future flight and engine modeling technology to shorten product testing programs, thus reducing their associated costs while maintaining equivalent levels of safety.

Certification Criteria

Certification criteria are used to construct the certification basis for military aircraft designs. The meaning and use of this term is generally equivalent to the way the term ‘airworthiness standard’ is used in the civil codes. The term ‘Certification Criteria’ is used extensively in both of the two major military airworthiness codes, the U.S. DoD MIL-HDBK 516 and the European Military Airworthiness Certification Criteria (EMACC) Handbook.

Certification Plan

A document describing the intended certification process leading to TAA airworthiness approval of an Approved Type Design. It is produced by the applicant and submitted for TAA approval. The Certification Plan outlines the proposed Certification Program from the development of the proposed Certification Basis to the issuance of the DND Type Certificate.

Certification Standard

Criteria used in determining if the safety objectives expressed in the Certification Requirements have been achieved. Normally, the Certification Standards may be found in one of the following:

a. embedded directly in the certification requirements provided in Airworthiness Codes;

b. in the Acceptable Means of Compliance (AMC);

c. in advisory material published by the Airworthiness Authority.

Used in the ADSM with the same meaning as the terms ‘airworthiness standard’ and ‘certification criteria’. See also **Design Standard**.

Certification Program

The processes, documents and activities that define the methodology followed by the Applicant and Regulator to certify a new Type Design or a design change. The program has the following four phases:

a. Development and approval of the Certification Plan and Certification Basis;

b. Establishing the Means of Compliance and the Regulator’s level-of-involvement;

c. Completing the Compliance Program by reviewing compliance artefacts and making findings of compliance; and

d. Issuing the Type Certificate or granting Airworthiness Approval.

Certification Requirements

The airworthiness requirements published by a regulator that are related to the certification of a type design. Requirements are typically published in an Airworthiness Code that defines those technical or functional attributes required of an aircraft type design to be airworthy. See also **Type Certification Requirements**.

Change Impact Analysis (CIA)

The analysis required for every modification to aircraft interfaces which may permit access by unauthorized persons or equipment either during operations or maintenance. Additional aircraft interfaces could be physical, wireless, or logical. The CIA is intended to verify that the aircraft and its systems, networks and other assets are protected from IUEI, procedures exist to ensure the continuing airworthiness of the aircraft, malicious or inadvertent change to aircraft systems and networks required for safe flight and operations are prevented and previously approved security measures are maintained (derived from DO-326A).

Civil Aviation Authority (CAA)

A country's civil authority that oversees the approval and regulation of civil aviation. Depending on how it is structured within every state, the Airworthiness Authority function may be established as a sub-component of the larger Civil Aviation Authority. The CAA may also be referred to as the National Aviation (or Airworthiness) Authority (NAA).

Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM)

A group of technologies that support reduced aircraft separation and improve Air Traffic Control (ATC) efficiencies. CNS/ATM is a system based on digital technologies, satellite systems and enhanced automation to achieve a seamless global air traffic control and separation.

Commercial Off-the-Shelf (COTS)

Equipment hardware and software that is not qualified to aircraft standards. An example of COTS equipment hardware and software is a personal computer (PC) and its operational software (source: FAA AC 29-2C MG 15).

An acquisition term referring to commercially available ready to use (hardware or software) products that require no customization in order to meet performance requirements (source: U.S. Patent and Trademark Office).

Compliance

A certification or confirmation that a given Type Design, Design Change, or airworthiness process meets a Technical Airworthiness Requirement and/or the Certification Basis requirement.

Compliance Artefact

The work product of a compliance program that is associated with demonstrating compliance to the Certification Requirements. Examples include:

a. Design data packages (e.g., drawings, test plans/reports, analysis reports, inspection reports);

b. Functional Hazard Assessment, System Safety Assessment; and

c. Any other work products or documents that are used to make a Finding of Compliance.

Compliance Matrix

The central record in the conduct of a compliance program. The Compliance Matrix contains the details of the Certification Requirements and Standards, the Means and Methods of Compliance, the Compliance Artefacts and identifies the Finding of Compliance results. When each cell of the Compliance Matrix is completed with the relevant entry, it forms the Compliance Record, which is part of the aircraft Type Record.

Compliance Program

The processes, documents and activities that define the methodology followed by the Applicant and Regulator to demonstrate compliance with the Certification Basis for a new Type Design or design change.

Compliance Record

A completed Compliance Matrix. The Compliance Record is a component of the aircraft Type Record.

Configuration

The functional and physical characteristics of hardware, firmware and software, or a combination thereof, as set forth in technical documentation and achieved in an Aeronautical Product.

Configuration Management (CM)

The discipline that applies technical and administrative direction and surveillance on the configuration(s) and changes to the configuration(s) of Aeronautical Products throughout their life cycles. The CM process consists of the following essential elements: configuration identification, configuration control, configuration status accounting, and configuration audits.

Contaminated Runway

A runway is contaminated when a significant portion of the runway surface area (whether in isolated areas or not) within the length and width being used is covered by one or more of the following substances: compacted snow, dry snow, frost, ice, slush, standing water, wet ice or wet snow (source: TCCA AC 300-019).

Continued Airworthiness

Those Airworthiness Requirements, processes and activities necessary to implement Design Changes to the Type Design and verify that the conditions under which a Type Certificate has been granted continue to be fulfilled.

Continuing Airworthiness

Those Airworthiness Requirements, processes and activities necessary to ensure that Aeronautical Products continue to meet the appropriate airworthiness rules and standards throughout their operating life. Continuing airworthiness is an integral part of the day-to-day management and monitoring of an Approved Type Design and the associated Aeronautical Products after a Type Certificate has been issued. Compliance with Airworthiness Standards during the in-service period ensures that the initial inherent safety of the Approved Type Design and the actual Aeronautical Products are maintained throughout the product life cycle.

Crash Damage Recovery Equipment (CDRE)

Equipment that provides a means to recover data from a damaged flight recorder.

Credit

Used in relation to HUMS, this term means to give approval to a HUMS application that adds to, replaces, or intervenes in industry accepted maintenance practices or flight operations (source: FAA AC-29-2C MG 15).

Cyber Mission Assurance (CMA)

The ability of an organization, service, infrastructure, platform, weapon system or equipment to operated in a cyber-contested operational environment and accomplish its mission. Cyber mission assurance requires a mission-focused continuous risk management process that supports decision-making aimed at improving resilience and increasing the probability of mission success (source: DRDC report DRDC-RDDC-20190R118, August 2019).

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Design/Development Assurance

All those planned and systematic actions used to substantiate, to an adequate level of confidence, that development errors have been identified and corrected such that the system satisfies the applicable certification basis (source: SAE ARP 4761).

Design Authority (DA)

An organizational role associated with the Original Equipment Manufacturer (OEM) of an Aeronautical Product. The DA will have the in-depth competency and comprehensive technical data related to the Approved Type Design; it is normally the only organization capable of performing a full assessment of the design and thus providing or recommending Airworthiness Approval for any subsequent Design Changes.

Design Change

The act of making a change to the Approved Type Design of an Aeronautical Product. Design Changes include modifications, alterations, changes to the Approved Maintenance Program and changes to the approved role, mission and/or task.

Design Standard

A standard published by a civilian or military standards body for use in the design of aircraft, such as, for example, U.S. MIL-STD, or RTCA standard. These are normally ‘chosen’ by the design organization to achieve the design functional objectives, as well as the intended airworthiness objectives. See also **Certification Standard**.

Design Values

Material strength properties that have been established based on the requirements of TAA-recognized airworthiness codes, or by other means deemed acceptable to the TAA. Generally, these values are statistically determined based on sufficient data that, when used for aircraft design, the probability of structural failure due to material variability is minimized.

Detailed Specification (MIL-DTL)

A U.S. specification that states how design requirements, such as materials, are to be used, how a requirement is to be achieved, or how an item is to be fabricated or constructed. A specification that contains both performance and detail requirements is still considered a detail specification.

Deviation

A written authorization to depart from an Airworthiness Requirement or an Airworthiness Standard, or a specified portion of the requirement or standard. The Airworthiness Requirement or Standard is still applicable; however, the deviation allows for a change to a specific part or feature of the requirement or standard. A deviation can be permanent or temporary, as defined in the deviation approval documents.

Director Ammunition and Explosives Management and Engineering (DAEME)

A directorate with the DND ADM(Mat) division of the Director General Land Equipment Program Management responsible for the lifecycle management of all ammunition, explosives and ordinance, and chair of the Ammunition Safety and Suitability Board (ASSB).

DND/CAF Airworthiness Policy

A policy document outlining the DND/CAF Airworthiness Program requirements, airworthiness regulatory responsibilities and key program definitions. It is issued by the Chief of Defence Staff (CDS) and the Deputy Minister (DM) as a Defence Administrative Order and Directive (DAOD).

DND/CAF Airworthiness Program

The DND/CAF military airworthiness policy document that regulates all aspects of the Canadian military aviation activities, facilities and services to ensure and maintain the Airworthiness of Aeronautical Products and provide for the safe operation of those products. The document is issued and maintained under the authority of the Chief of Defence Staff as a Canadian Forces Technical Order, under the NDID number A-GA-005-000/AG-001.

DND Type Certificate

A Type Certificate issued by the DND/CAF Technical Airworthiness Authority. See **Type Certificate**.

Doppler Navigation System (DNS)

A self-contained dead reckoning system that requires no external inputs or references from ground stations. The DNS can provide an accurate measurement of the aircraft's drift and ground speed.

Due Regard

While there is no standard definition of "due regard", the term appears in The Chicago Convention (or the Convention on Civil Aviation, to which Canada is a signatory, and which establishes rules of airspace, aircraft registration and safety, and details the rights of the signatories in relation to air travel) in the context of operational situations that do not lend themselves to ICAO standards and flight procedures, such as politically sensitive missions, military contingencies or classified missions. According to the Chicago Convention, "States undertake, when issuing regulations for their state aircraft [e.g., military, customs or police aircraft], that they will have due regard for the safety of navigation of civil aircraft." For example, crews operating with "due regard" may not be obliged to communicate with air traffic control (ATC), which makes their intentions unknown to ATCs. As a result, this prerogative compels the authorized state aircraft commander to:

a. Separate their aircraft from all other air traffic; and

b. Operate under at least one of the following conditions:

   1. In visual meteorological conditions (VMC);

   2. Within radar surveillance and radio communications of a surface radar facility;

   3. Be equipped with airborne radar that is sufficient to provide separation between their aircraft and any other aircraft they may be controlling and other aircraft; or

   4. Operate within Class G airspace.

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European Military Airworthiness Certification Criteria (EMACC)

European Defence Agency document that establishes the airworthiness certification criteria to be used in the determination of airworthiness of all manned and unmanned, fixed and rotary wing aircraft systems. It is a foundational document to be used by the relevant military airworthiness authority or authorities or other entity to define the aircraft's airworthiness certification basis (source: EMACC Ed. 3.1, 25 Sep 2018).

Electromagnetic Environmental Effects (E3)

The impact of the electromagnetic environment upon the operational capability and safety of aircraft, systems, and equipment. It encompasses all electromagnetic disciplines, including electromagnetic compatibility (EMC); electromagnetic interference (EMI); electromagnetic vulnerability (EMV); electromagnetic pulse (EMP); electronic protection; hazards of electromagnetic radiation to personnel, ordnance, and volatile materials; and natural phenomena effects of lightning and precipitation static.

Electromagnetic Environment (EME)

The power and time distribution, in appropriate frequency ranges, of the electromagnetic levels that may be encountered by an equipment, subsystem or system when performing its intended function(s). The EME is normally expressed in terms of field strength or power density. Part of the EME is the High Intensity Radiated Fields (HIRF) environment.

Electromagnetic Compatibility (EMC)

EMC is the ability of electronic/electrical equipment, subsystems and systems to operate in their intended operational environments without suffering or causing unacceptable degradation due to electromagnetic interference.

Electromagnetic Interference (EMI)

The conducted or radiated electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment(s).

Electronic Flight Bags (EFBs)

An electronic device (iPad, tablet, laptop computer) that contains exclusively unclassified information such as Flight Information Publications (Flips), NOTAMS, weather information, flight planning information, checklists, maps/charts, unclassified publications, and other similar information (source: RCAF Flight Operations Manual).

Elastomer

A high polymer that can be or has been modified to a state exhibiting little plastic flow and quick or nearly complete recovery from an extending force." Such material, before modification, is frequently referred to as crude rubber. Common aerospace elastomeric materials are aircraft tires, aerospace flexible hose assemblies, fuel cells and "O-ring" seals (source: American Society for Testing and Materials [ASTM]).

Emergency Electrical Circuits

Essential (critical) electrical; circuits that may cause the inability of the aircraft to maintain controlled flight and effect a safe landing in case of failure (source: SAE ARP 4404).

End-to-End

In the context of HUMS, the term is used to define the qualification and certification boundaries of the HUMS application and any effect on the rotorcraft. As the term implies, the boundaries are the starting point that corresponds with the airborne data acquisition to the result that is meaningful in relation to the defined end use of the information (source: FAA AC 29-2c MG 15).

Energetic Material

Refers to the explosives and pyrotechnic material contained in military weapons/stores-associated equipment (e.g., torpedoes, bombs, sonobuoys, flares, etc.).

Engine Structural Integrity Program (ENSIP)

An organized and disciplined approach to the structural design, analysis, qualification, production, and life management of gas turbine engines (source: MIL-HDBK-1783B, 15 February 2002). The goal of ENSIP is to ensure engine structural safety, durability, reduced life cycle costs, and increased service readiness.

Engineering Process Manual (EPM)

The name given to the Airworthiness Process Manual within a TAA-Acceptable Design Organization (ADO) or a TAA-Acceptable Technical Organization (ATO).

Environmental Qualification

The process used to show compliance to environmental airworthiness standards identified in an aircraft certification basis. In this context, the ADSM term “qualification” is aligned with the term used by other recognized airworthiness authorities in the context of environmental qualification.

Equivalent Level of Safety (ELOS)

A level of safety that is approximately equal to that defined in a Certification Requirement or a Certification Standard. The demonstration of ELOS may employ qualitative or quantitative means that differ from those specified in the standard. ELOS is normally used during a compliance program, when literal compliance with a Certification Requirement cannot be shown, and compensating factors in the design can be shown to provide a level of safety equivalent to that established by the Certification Standards. An ELOS may document a Method of Compliance that is different from what is stated in the standard, but is judged as acceptable by the TAA.

Essential Electrical Circuits

Electrical circuits that are necessary to accomplish the mission of the aircraft under the most adverse environmental conditions for which the aircraft was designed (source: SAE ARP 4404).

Exemption

A written authorization that allows for a specific Airworthiness Requirement or Standard not to be applied. It is used in situations where full relief from an Airworthiness Requirement or Standard is required. The boundaries of the exemption, with respect to future Design Changes, are defined in the exemption approval documents.

Explosive

Anything that is made, manufactured or used to produce an explosion or a detonation, or pyrotechnic effect, and includes anything prescribed to be an explosive by the regulations, but does not include gases, organic peroxides or anything prescribed not to be an explosive by the regulations (source: *Explosives Act*, Section 2).

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Finding Authority

A person who has been authorized by the TAA, or a TAA AI, to make a Finding of Compliance.

Finding of Compliance

Finding of Compliance is a certification by an Authorized Individual that a specific element of a Type Design, or Design Change to an Approved Type Design, complies with the applicable requirements in the Certification Basis. Making a Finding of Compliance is a Technical Airworthiness Function.

Fit and Safe for Flight

The state of an aircraft when it is deemed to be in conformance with its Type Design. This requires all of maintenance to have been conducted in accordance with the Approved Maintenance Program, and all additional aircraft specific requirements (i.e., repairs, special inspections, modifications and flight permits) to have been completed in accordance with the approved instructions issued by the Type Certificate Holder for the Aeronautical Product.

Flight Management System (FMS)

An integrated suite of sensors, receivers and computers, coupled with one or more databases. The FMS automates a wide variety of in-flight tasks, reducing the workload on the flight crew by providing performance and navigation guidance to displays and automatic flight control systems. Inputs can be accepted from multiple sources, such as GNSS, INS, DME, and VOR. These inputs may be applied either one at a time, or in combination, to provide a navigation solution.

Flight Manual

A technical document, normally provided by the Original Equipment Manufacturer (OEM), which contains the Technical Airworthiness Data (TAWD). A typical Flight Manual would contain operating limitations, Normal/Abnormal/Emergency operating procedures, performance data and loading information. It is submitted to the TAA and the OAA for airworthiness approval as part of the Type Certification process.

Fuel Cell

Flexible container, usually of rubber, rubber and nylon, or all nylon construction, which can be removed from an aircraft. Fuel Cells are subdivided into two categories: those that are self-sealing, and those, namely bladder and nylon cells, which are not self-sealing.

Fuel System

The fuel system comprises the tanks, pumps, filters, quantity gauges refueling/defueling components and fuel feed up to, but excluding, the engine(s). Fuel consumption may cause the aircraft center of gravity (CofG) to shift laterally or longitudinally throughout a flight. Thus, there may be a fuel management system, as a subordinate function of the fuel system, which will maintain the aircraft CofG within acceptable limits.

Functional Hazard Assessment (FHA)

A systematic, comprehensive examination of functions to identify and classify Failure Conditions of those functions according to their severity (source: SAE ARP 4761).

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Gas Turbine

A type of engine which consists of an air compressor, a combustion section, and a turbine. Thrust is produced by increasing the velocity of the air flowing through the engine. Thrust can be transformed into mechanical power (source: *Termium Plus*®).

General Air Traffic (GAT)

All flights conducted in accordance with the ICAO rules and procedures. These may include military flights for which ICAO rules satisfy their operational requirements (source: EUROCONTROL).

Global Navigation Satellite System (GNSS)

A space-based satellite navigation system used to pinpoint the geographic location of a user's receiver anywhere in the world. There are a number of countries that operate GNSSs in accordance with the ICAO Annex 10 requirement in support of civil aviation operations. For example, the United States operate the NAVSTAR Global Positioning System (GPS) while the European Space Agency operates Galileo GNSS and the Russian Federation operates the GLONASS GNSS. There are other countries that have, or are in the process of implementing, ICAO-compliant GNSS systems.

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Health And Usage Monitoring Systems (HUMS)

Equipment, techniques, and/or procedures by which selected incipient failure or degradation and/or selected aspects of service history can be determined for Rotorcraft (source: FAA AC 29-2C MG 15). A HUMS is composed of:

a. Health Monitoring System: Equipment, techniques, and/or procedures by which selected incipient failure or degradation can be determined; and

b. Usage Monitoring System: Equipment, techniques, and/or procedures by which selected aspects of service history can be determined.

Handling Qualities

The qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks.

High Intensity Radiated Field (HIRF)

A radio-frequency energy of a strength sufficient to adversely affect the operation of aircraft electric and electronic systems. The electromagnetic HIRF environment results from the transmission of electromagnetic energy from radar, radio, television, and other ground-based, shipborne, or airborne radio frequency (RF) transmitters (derived from FAA Notice of Proposed Rulemaking).

Human Engineering

The application of knowledge about human capabilities and limitations to system or equipment design and development to achieve efficient, effective, and safe system performance at minimum cost and manpower, skill, and training demands. Human engineering assures that the system or equipment design, required human tasks, and work environment are compatible with the sensory, perceptual, mental, and physical attributes of the personnel who will operate, maintain, control and support it (source: MIL-HDBK-1908).

Human Factors (HF)

A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations; it includes, but is not limited to, principles and applications in the areas of human engineering, personnel selection, training, life support, job performance aids, and human performance evaluation (source: MIL-HDBK-1908).

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Inertial Navigation System (INS)

A navigation aid that uses a computer, motion sensors, rotation sensors and, occasionally, magnetic sensors to continuously calculate the acceleration, velocity, position and the orientation of a moving object without the need for external references.

Initial Airworthiness

TAM rules that address the following activities:

a. Type Certification of an Aeronautical Product;

b. Assignment of Authority in a Certification Program;

c. Aircraft registration and marking;

d. Manufacturing product conformance;

e. Granting Flight Authority; and

f. Technical Airworthiness Clearance (TAC).

Instructions for Continued Airworthiness (ICA)

Maintenance instructions developed during type certification that are necessary to keep an Aeronautical Product in a condition that is Fit and Safe for Flight.

Instrument Flight Rules (IFR)

Rules and regulations that govern flight under conditions in which flight by outside visual reference is not safe. IFR rules and regulations permit flight under IMC conditions in a properly equipped aircraft that depends upon flying (and navigating) by reference to instruments in the flight deck.

Instrument Meteorological Conditions (IMC)

Meteorological conditions that are less than the minima specified for VMC. It is important not to confuse IMC with (Instrument Flight Rules) IFR. IMC describes the actual weather conditions, while IFR describes the rules under which the aircraft is flying. Aircraft can, and often do, fly IFR in clear weather (i.e., VMC), for operational reasons, or when flying in a certain class of controlled airspace (e.g., Class A) where VFR is not permitted.

Instrument Landing System (ILS)

Ground-based instrument approach system that provides precision lateral and vertical guidance to an aircraft approaching and landing on a runway, using a combination of radio signals and, in many cases, high-intensity lighting arrays to enable a safe landing during IMC, such as low ceilings or reduced visibility due to fog, rain, or blowing snow.

Integrity

In the context of HUMS, this term designates an attribute of a system or a component that can be relied upon to function as required by the criticality determined by the Functional Hazard Assessment (FHA) (source: FAA AC 29-2C MG15).

Intentional Unauthorized Electronic Interference (IUEI)

A circumstance or event with the potential to affect the aircraft due to human action resulting from unauthorized access, use, disclosure, denial, disruption, modification, or destruction of information and/or aircraft system interfaces. Note that this includes malware and the effects of external systems on aircraft systems, but does not include physical attacks or electromagnetic jamming (source: DO-326A Glossary).

Investigative Airworthiness Clearance (IAC)

A certification issued by the Airworthiness Investigative Authority (AIA) to declare that the investigative requirements of the airworthiness program have been met and that, from an investigative airworthiness perspective, the Aeronautical Product is ready to enter operational service.

Issue Paper

Documentation used during a Certification Program to document a certification issue and request that the Applicant or TAA provide a response to address the issue. Issue Papers may be iterative, but they must be closed by the TAA before issuing the Type Certificate or granting Airworthiness Approval for a design change. Issue Papers are also used to document the requirement for a Special Condition.

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J

Joint Aviation Authorities (JAA)

A former associated body of the European Civil Aviation Conference (ECAC), established in 1970, and absorbed into the European Union Aviation Safety Agency (EASA), after its creation as a Europe-wide regulatory authority. The former 'JAA' became 'JAA T' (Transition), which consisted of a temporary Liaison Office (JAA LO) and a Training Office (JAA TO).

Joint Service Specification Guide (JSSG)

A U.S. document that establishes a common framework for developing program unique requirements documents for Air Systems, Air Vehicles, and major Subsystems. Each JSSG contains a compilation of candidate references, generically stated requirements, verification criteria, and associated rationale, guidance, and lessons learned for program team consideration.

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M

Maintenance

The technical and supporting administrative actions necessary to keep an Aeronautical Product, its associated systems, equipment, component parts and software in a specified condition. Maintenance includes the overhaul, repair, required inspection or modification of an Aeronautical Product and the removal of a component or its installation on an Aeronautical Product. It also includes part and component storage and reactivation, but does not include elementary work or servicing.

Maintenance Program

See **Approved Maintenance Program**.

Major Design Change

A Design Change that has, or may have, more than a negligible effect on the airworthiness of an Approved Type Design of an aeronautical product.

Master Minimum Equipment List (MMEL)

A TAA/OAA-approved document created specifically to regulate the dispatch of an aircraft type with inoperative equipment. The MMEL contains the conditions, limitations and procedures required for operating the aircraft with these items inoperative while maintaining the level of safety of the aircraft type dictated by the type of operation for which the aircraft was certified and the minimum standards specified in the Certification Basis. A MMEL is neither a mandatory airworthiness requirement, nor a condition of aircraft type certification.

Material Strength Properties

Material properties that define the strength-related characteristics of any given material (e.g., ultimate and yield values for compression, tension, bearing, shear, etc.).

Means of Compliance – Certification

The techniques that will be used to demonstrate the compliance of the type design against each certification requirement identified in the certification basis. The four primary means of compliance are: description, inspection, analysis and test. See also **Acceptable Means of Compliance (AMC)**.

Method of Compliance

Detailed information about the methodology that will be used to demonstrate compliance. Methods of compliance should include the specific conditions required to demonstrate compliance, critical assumptions, pass/fail criteria, specific levels of performance that must be attained and any other information required to describe the process used to demonstrate compliance with airworthiness criteria and standards. Method(s) of compliance will generate artifacts and objective evidence used in an airworthiness authority's determination of airworthiness.

Military Airworthiness Authority (MAA)

The military authority of a state normally responsible for the airworthiness of the military aircraft of that State. The Canadian MAA is headed by an AA supported by an Operational Airworthiness Authority (OAA), an Airworthiness Investigative Authority (AIA), and a Technical Airworthiness Authority (TAA). Other military regulators may use different terminology and have other organizational structures, for example: the UK Ministry of Defence (MoD) MAA is referred to as the Military Aviation Authority.

Military Handbook (MIL-HDBK)

A U.S. document that provides standard procedural, technical, engineering, or design information about materiel, processes, practices and methods.

Military Performance Specification (MIL-PRF)

A U.S. document that states requirements in terms of the required results with criteria for verifying compliance, but without stating the methods for achieving the required results. A performance specification defines the functional requirements for the item, the environment and interface characteristics.

Military Specification (MIL-SPEC)

A U.S. document that describes the essential technical requirements for military unique material or substantially modified commercial items.

Military Standard (MIL-STD)

A U.S. document that establishes uniform engineering and technical requirements for military-unique or substantially modified commercial processes, procedures, practices, and methods. There are five types of defense standards: interface standards, design criteria standards, manufacturing process standards, standard practices, and test method standards.

Minor Design Change

A design change that has a negligible effect on the Airworthiness of the Approved Type Design of an Aeronautical Product.

Mission Equipment

Equipment or systems installed on an aircraft whose function is not required (essential) to safely take off, fly or land the aircraft. This type of equipment or systems may be essential for the performance of a military mission, and their installation and operation must not have an adverse effect on the safe flight of the aircraft.

Modification

A change to the authorized configuration of the Approved Type Design of an Aeronautical Product. Typical examples are component changes, equipment additions, or software changes, and often involve a revision to the drawings and support documentation.

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Non-Destructive Testing (NDT)

The testing, inspection or examination of any material, component or assembly by means that do not affect the future serviceability of such material/component/assembly. Typical NDT methods include visual examination, liquid penetrant testing (PT), magnetic particle testing (MT), radiographic testing (RT), ultrasonic testing (UT) and eddy current testing (ET).

Non-Destructive Testing (NDT) Technique

The formal written instruction describing the procedure to follow, and the equipment required, to perform a specific NDT inspection. Ultrasonic, radiographic, eddy current, magnetic particle and liquid penetrant inspections are carried out in accordance with NDT Techniques. Within DND, contractors must carry out NDT inspections in accordance with approved DND NDT Techniques.

Non-Developmental Item (NDI)

A term used for products which do not require further development or require only minimal modification. Commercial Off-the-Shelf (COTS) and Government Off-the-Shelf (GOTS) are two subtypes of NDI.

Non Directional Beacon (NDB)

A ground-based radio transmitter (the NDB) emitting an omnidirectional signal that is received by an aircraft directional antenna. The result is a cockpit instrument (the Automatic Direction Finder [ADF]) that displays the aircraft bearing relative to a NDB station, allowing a pilot to "home" to a station or track a course from a station.

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O

Occupant Safety Assessment (OSA)

An evaluation against contemporary civilian and military standards related to occupant safety. The results are documented in an Occupant Safety Assessment Report (source: Occupant Safety Assessment Report).

Original Certification Authority (OCA)

The Airworthiness Authority (AA) who ensured the oversight for the original Certification Program and issued the Type Certificate for an aircraft type or the Airworthiness Approval for a Design Change.

Operational Air Traffic (OAT)

Military traffic that does not comply with ICAO rules and procedures (source: EUROCONTROL). When operating as OAT, DND/CAF aircraft are required to fly with 'Due Regard' for the safety of civil aviation.

Operational Airworthiness (OA)

A standard of safety for air operations and Aeronautical Products as they relate to flying operations. The term applies collectively to all operational aspects of airworthiness-related flying operations (including aerospace control, aircraft utilization, operator training and proficiency) in addition to Compliance with airworthiness policies, regulations, orders and standards.

Operational Airworthiness Authority (OAA)

The person responsible for the regulation of the airworthiness aspects of the Operational Airworthiness Program and the regulation of all flying operations for the DND/CAF. The Chief of Defence Staff, under the direction of the Minister of National Defence, has delegated the Commander of 1 Canadian Air Division (1 Cdn Air Div) to fill the role of OAA. The OAA’s responsibilities include the regulation and oversight of operational procedures, flight standards, operator training, qualification and licensing, aerospace control operations and operational airworthiness clearance of Aeronautical Products prior to operational service.

Operational Airworthiness Clearance (OAC)

A certification issued by the OAA to declare that the operational requirements of the airworthiness program have been met and that from an operational airworthiness perspective the Aeronautical Product is ready to enter operational service.

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P

Performance Based Navigation (PBN)

Area navigation based on performance requirements for aircraft operating along an Air Traffic Services route, on an instrument approach procedure or in a designated airspace. Performance requirements are expressed in navigation specifications in terms of accuracy, integrity, continuity and functionality needed for the proposed operation in the context of a particular airspace concept. PBN Navigation Specifications are divided into two areas: Area Navigation (RNAV) and Required Navigation Performance (RNP) (source: ICAO).

Portable Electronic Device (PED)

Any piece of lightweight, electrically powered equipment. These devices are typically consumer electronics devices functionally capable of communications, data processing and/or utility. The definition of PEDs is intended to encompass transmitting PEDs.

Preliminary System Safety Assessment (PSSA)

A systematic evaluation of a proposed system architecture and implementation based on the Functional Hazard Assessment and failure condition classification to determine safety requirements for all items (source: SAE ARP 4761).

Project Management Office (PMO)

A distinct and temporary organizational DND unit formed for the sole purpose of managing a major project for the acquisition of a product or service (source: TAA Advisory 2017-01).

Propulsion

A system consisting of a power-unit and all other equipment utilized to provide those functions necessary to sustain, monitor and control the power/thrust output of any one power-unit following installation on the airframe”. In the context of the ADSM, it can be used interchangeably with “powerplant” (source: *Termium Plus*®).

Powerplant

In the context of the ADSM, it comprises the installed engines and, when it is integral to the engines, the reduction gearbox. Its primary function is to generate thrust or shaft power and it may also perform secondary tasks, such as driving hydraulic pumps and electrical generators and providing bleed air for engine starts and/or the Environmental Control System (ECS). Generally, the powerplant also includes a number of support systems, usually provided by the aircraft, such as: bleed air; air intake and exhaust; oil cooling; engine compartment draining, venting and cooling; structural support of the engine; fire protection and suppression; and the fuel feed interface.

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Qualification

The process used by the DND acquisition project office to establish compliance of an aircraft system with the performance, functional and design requirements established in the contract with the design agency. Qualification and certification are processes that normally occur simultaneously, but are separately regulated and managed. Generally, type certification is considered a pre-requisite to qualification, and it focuses exclusively on aviation safety-related requirements, while qualification expands the scope to encompass all the aircraft system performance and mission capability requirements. Within DND, it is the TAA's role to regulate and oversee the type certification process, while qualification is entirely the responsibility of the project manager.

Qualified Ammunition Technical Authority (QATA)

A qualified specialist provided or authorized by the Director Ammunition and Explosive Management and Engineering (DAEME) to conduct S3 assessments of stores that contain ammunition and explosives, to document and present findings to the ASSB, as well as to present the ASSB decision documentation and S3 analysis, conclusions, and recommendations to armament and stores integration Subject Matter Experts (SMEs) and Offices of Primary Interest (OPIs) of Weapon System Managers (WSM) or Project Management Offices (PMOs).

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R

Radar Altimeter (RadAlt)

A flight instrument that provides the distance between the antenna and the ground directly below it. Radar altimeters are an essential part of CAT II ILS and ground proximity warning systems (GPWS), warning the pilot if the aircraft is flying too low or descending too quickly.

Radiation Hazards (RADHAZ)

Hazards caused by transmitter or antenna installation that generates electromagnetic radiation in the vicinity of ordnance, personnel, or fueling operations in excess of established safe levels or increases the existing levels to a hazardous level; or a personnel, fueling, or ordnance installation located in an area that is illuminated by electromagnetic radiation at a level that is hazardous to the planned operations or occupancy (source: U.S. DoD Dictionary of Military and Associated Terms);

or

Those health hazards to personnel caused by an unexpected exposure to radio and/or radar bands of the electromagnetic spectrum at levels higher than safety levels (source: NATO Terminology Database).

Reciprocating Engine

An engine in which the to-and-fro motion of a piston is changed into circular motion by a crankshaft (source: *Termium Plus*®).

Reduced Vertical Separation Minimum (RSVM)

The reduction, from 2,000 feet to 1,000 feet, of the standard vertical separation required between aircraft flying between flight level 290 (29,000 ft) and flight level 410 (41,000 ft). Note: also referred to as Reduced Vertical Separation Minima.

Registration

The formal recording of individual aircraft on an aircraft register and the assignment of a tail number.

Regulate

A means to control airworthiness-related activities by rule.

Regulator

An individual or organization responsible for the development and enforcement of rules and standards for the design, manufacture, maintenance, materiel support and operation of aeronautical products.

Request for Proposal (RFP)

A form of bid solicitation used where the selection of a supplier cannot be made solely on the basis of the lowest price. An RFP is used to procure the most cost-effective solution based upon evaluation criteria identified in the RFP (source: DND Supply Manual).

Required Navigation Performance (RNP)

A type of performance-based navigation that allows an aircraft to fly a specific path between two 3D-defined points in space. RNAV and RNP systems are fundamentally similar. The key difference is that RNP adds the requirement for the aircraft navigation system to monitor its achieved navigation performance and alert the flight crew when the required performance is not met.

Required Navigation Performance Capability (RNPC) (airspace)

A controlled airspace within the Canadian Domestic Airspace (CDA). RNPC airspace accommodates area navigation (RNAV) operations and is contained within the Southern Domestic Airspace (SDA) and Northern Control Area (NCA) (source: NavCan *Aeronautical Information Publication* [AIP]).

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S

Safe Carriage and Release

The term used by the TAA to identify those aspects of the stores clearance process that are subject to the certification process.

Safe Separation

The physical separation of a store from the releasing aircraft, without exceeding the design limits of the store or the aircraft or anything carried thereon, and without damage to, contact with, or unacceptable adverse effects on the aircraft, suspension equipment, or other store(s) both released and unreleased (source: MIL-HDBK-1763).

Security Effectiveness

The ability of the security measure to mitigate misuse of the Assets by the unauthorized elements of the external population, while permitting and preserving use of the Assets by the authorized elements of the external population (source: RTCA DO-326A/ED-202A).

Security Environment

The external security context in which an Asset performs its function. For an aircraft, or system of an aircraft, the aircraft/system security environment is characterized by the set of security assumptions outside the control of the aircraft/system developer that are used in the safety assessment of the aircraft/system (source: RTCA DO-326A/ED-202A).

Security Risk Assessment (SRA)

In the context of cybersecurity, this refers to an iterative process in which IUEI threat scenarios are determined, associated security measures are identified and characterized, and the resulting level of system security risk to the platform's safety, and mission(s) in relation to IUEI are calculated.

Servicing

All activities related to the cleaning, lubricating and fluid replenishment for an Aeronautical Product that do not require the disassembly of the product.

Special Condition

Conditions imposed by a Regulator when an Airworthiness Code does not have suitable Certification Requirements for a new or novel design to be certified. In this situation, the Regulator can add a new requirement to the Certification Basis by approving and issuing a special condition.

Stability and Control

In the context of air vehicle performance and handling, these terms refer to the response of an aerial vehicle to perturbations in flight conditions from some dynamic equilibrium (stability) and to control inputs (control), respectively.

STANAG

A normative document that records an agreement among several or all NATO member states – ratified at the authorized national level – to implement a standard, in whole or in part, with or without reservation (source: NATO).

Statement of Operating Intent (SOI)

A document that identifies the intended roles, missions, tasks and in-service usage of the proposed aeronautical product in sufficient detail to permit an engineering analysis and an assessment to determine and apply the appropriate Airworthiness Standards.

Statement of Work (SOW)

A narrative description of the work required that stipulates the deliverables or services required to fulfill the contract. It defines the task to be accomplished or services to be delivered in clear, concise and meaningful terms (source: Buyandsell.gc.ca).

Store

Any device intended for internal or external carriage and mounted or placed on aircraft suspension or release equipment, regardless of whether or not the device is intended to be separated in flight from the aircraft. Stores include, without being limited to, the following devices:

a. missiles;

b. rockets and rocket launchers;

c. bombs and mines;

d. torpedoes and torpedo simulators;

e. pyrotechnic flares and markers;

f. Electronic Counter Measures (ECM) flare and chaff cartridges and related carts and squibs;

g. fuel tanks and deployable refuelling hoses;

h. pods (i.e., photographic, ECM, dispenser, rescue, targeting, etc.);

i. maritime search stores, such as sonobuoys;

j. towed targets;

k. air-launched drones;

l. air-droppable cargo and containers;

m. mounted guns, cannons and machine guns, including applicable ammunition; and

n. parachutes, parachutists and parachute-retarded stores and loads.

[Derived from the TAM, see EDITORIAL NOTE.]

Stores Carriage

The conveying of a store by an aircraft under all flight and ground conditions including taxi, take-off, and landing. The store may be located either external or internal to the aircraft. Carriage should include time in flight up to the point of complete separation of the store from the aircraft (source: MIL-HDBK-1763).

Stores Clearance

The determination of specific store(s)/aircraft compatibility and the formal publication of all technical and operational instructions necessary for preparation, loading, maintenance and employment of a store on a specified aircraft.

Stores Safety and Suitability for Service (S3)

The requirement for ammunition and explosives to be acceptably free from hazards and to have inherent characteristics that meet specified requirements during their agreed life cycle. Operational effectiveness is not factored into the definition of S3.

System Safety

The application of engineering and management principles, criteria, and techniques to achieve acceptable risk within the constraints of operational effectiveness and suitability, time, and cost throughout all phases of the system life-cycle (source: MIL-STD-882E).

System Safety Assessment (SSA)

A systematic, comprehensive evaluation of the implemented system to show that the relevant requirements are met (source: SAE ARP 4761).

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Tactical Air Navigation (TACAN)

A UHF omnidirectional navigation aid that provides continuous azimuth information in degrees from the station, slant range distance information up to 200 NM from the station.

TAM Rule

See **Technical Airworthiness Rule**.

TAM Standard

See **Technical Airworthiness Standard**.

Technical Airworthiness (TA)

A standard of safety for an Aeronautical Product as it relates to product design, manufacture, maintenance and material support. The term applies collectively to those technical airworthiness aspects of the product's Conformity with its Approved Type Design, manufacture, maintenance standards and operated within its design limits.

Technical Airworthiness Authority (TAA)

The person responsible for the regulation of the technical airworthiness aspects of the design, manufacture, maintenance and materiel support of Aeronautical Products and the determination of the airworthiness acceptability of those products prior to operational service. The Chief of the Air Force Staff, designated by the CDS as the Airworthiness Authority for the DND/CAF Airworthiness Program, has delegated the Director General – Aerospace Equipment Program Management (DGAEPM) as the TAA for the DND/CAF. In turn, the TAA assigns this responsibility to the Director – Technical Airworthiness and Engineering Support (DTAES), whose regulatory staff performs the day-to-day management of the Technical Airworthiness Program.

Technical Airworthiness Clearance (TAC)

A certification by the TAA or an Authorized Individual that the technical requirements of the airworthiness program have been met and that, from a technical airworthiness perspective, a specific Aeronautical Product is ready to enter operational service.

Technical Airworthiness Program

One of the three airworthiness programs developed and managed under the umbrella of the DND/CAF Airworthiness Program to ensure a safe operation of the Canadian military Aeronautical Products. The Technical Airworthiness Program regulates the technical aspects of military aviation safety and provides for an Acceptable Level of Safety for Aeronautical Products in compliance with the applicable design, manufacturing, maintenance and materiel support rules and standards. See also **Investigative Airworthiness Clearance (IAC)** and **Operational Airworthiness Program**.

Technical Airworthiness Rule

A form of Technical Airworthiness Requirements, published in the TAM as rules. The TAA regulates by issuing Technical Airworthiness Rules and Standards.

Technical Airworthiness Standard

A standard of Technical Airworthiness published in the TAM directly linked to a specific TAM rule. The TAA regulates by issuing Technical Airworthiness Rules and Standards.

Technical Record

A set of documents that describes the state of Airworthiness of a particular Aeronautical Product and must be maintained throughout the life cycle of the Aeronautical Product. The documents in a technical record generally fall into one of the following sub-categories:

a. In-service product certification documentation, including Maintenance Release records, aircraft release records, Flight Authority records and Certificates of Conformance; and

b. Product status documentation, including operating records, maintenance records, configuration status data, airworthiness directive records and product-related deviations/waivers.

Terrain Awareness Warning System (TAWS)

Also known as Enhanced Ground Proximity Warning System (EGPWS), a TAWS is an installed system whose function is to provide flight crew increased awareness of obstacle and terrain via visual and aural alerts. The intent of a TAWS is to reduce the likelihood of collision with terrains or obstacles.

Testability

A design characteristic, which describes the ability to determine an item's status and to isolate faults within an item in an accurate and timely manner. Testability directly affects maintainability.

Type Certificate

A document issued by the Technical Airworthiness Authority to confirm that it has certified a particular Type Design. The Type Certificate includes, or provides references to, the Type Design data, the Type Certificate Data Sheet (TCDS), the Certification Basis and any other conditions or limitations prescribed by the Airworthiness Authority. Within the DND/CAF Airworthiness Program, these documents are called 'DND Type Certificates'. DND Type Certificates issued before 1998 were called 'Canadian Military Aircraft Type Certificate (CMATC)'.

Type Certificate Holder (TCH)

An organizational role established within the Technical Airworthiness Program. The TCH organization is accountable to the TAA for ensuring that, when placed on the DND Aircraft Register, an Aeronautical Product meets all continuing airworthiness requirements stipulated within the TAM. This normally involves the management of the in-service engineering support, maintenance support, materiel support and disposal of aeronautical products. The TCH is normally the only organization with sufficient visibility and control over all aspects of an aeronautical product's design, manufacture, maintenance and materiel support to provide or recommend a Technical Airworthiness Clearance (TAC) for a design change to an approved type design. The TCH for an Aeronautical Product would normally require accreditation by the TAA as an Acceptable Technical Organization (ATO).

Type Certification

A process by which it is demonstrated that the design of a new or modified aircraft type design complies with the applicable airworthiness requirements. This process includes the steps and activities required to complete a Certification Program and issue a Type Certificate. The process has four stages as follows:

a. Certification Plan and Certifications Basis;

b. Establishing Methods of Compliance and Regulator level of involvement;

c. Demonstrating and Recording Compliance; and

d. Type Certificate Issuance.

Type Certification Requirements

The Airworthiness Requirements published by the Regulator that are related to the Certification of a Type Design.

Type Design

A description of all characteristics of an Aeronautical Product, including its design description data, limitations, and Instructions for Continued Airworthiness (ICA).

Type Design Approval

The release of a certificate by, or on behalf of an airworthiness authority, to signify approval of a type design.

Type Design Examination (TDE)

A process that is used to establish the amount of credit that will be given to previous certification work of other organizations. TDE normally consists of a TAA staff review of the design and certification data that show compliance with the Certification Basis of the original aircraft. This credit may be applied, in whole or in part, towards obtaining Airworthiness Approval. The TDE process does not grant any Airworthiness Approvals.

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Uncrewed Aircraft (UA)

An aircraft that is designed to operate with no human pilot on board and which does not carry personnel. Moreover, a UA is:

a. capable of sustained flight by aerodynamic means;

b. remotely piloted, or automatically flies a pre-programmed flight profile;

c. reusable; and

d. not classified as a guided weapon or similar one-shot device designed for the delivery of munitions.

Uncrewed Aircraft System (UAS)

An Uncrewed Aircraft System is comprised of individual UA System elements, consisting of the Uncrewed Aircraft (UA), the UA Control Station (UCS) and any other UA System elements necessary to enable flight, such as a command and control data link, communication system and take-off and landing element. There may be multiple UA, UCS, or take-off and landing elements within a UAS.

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VHF Omnidirectional Range / Distance Measuring Equipment (VOR/DME)

A combined radio navigation station for aircraft, which consists of two units placed together: a VHF Omnidirectional Range (VOR) receiver and Distance Measuring Equipment (DME) transceiver. The VOR identifies which radial the aircraft is located on, while the DME indicates the slant distance to the ground-based station. Together, they provide the two measurements needed to produce a navigational "fix". It should be noted that aircraft can be equipped with one or more VORs, DME only, or a combination of both.

Visual Flight Rules (VFR)

A set of regulations that govern the conditions under which a pilot can operate an aircraft visually (i.e., by observing the terrain) without relying on instruments.

Visual Meteorological Conditions (VMC)

Meteorological conditions expressed in terms of visibility, distance from cloud and ceiling equal to or better than the ones specified in operational regulations. When VMCs are not present, then Instrument Meteorological Conditions (IMC) are deemed to exist. IMC and VMC are mutually exclusive.

Vulnerability

A flaw or weakness in system security procedures, design, implementation, or internal controls that could be exercised (unintentionally triggered or intentionally exploited) and result in a security breach or a violation of the system's security policy (source: RTCA DO-326A/ED-202A).

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W

Waiver (Program-related)

A written authorization from the applicable authority releasing a program or project from meeting a specified requirement under specific condition(s). Authorized waivers apply to specific cases and do not constitute changes to the approved baseline [Derived from the TAM, see EDITORIAL NOTE].

Weapon System Manager (WSM)

A person who has the overall responsibility for the management of a particular weapon system following its handover from the project management office (source: Defence Terminology Bank).

Weather Radar

A system which actively senses potentially problematic weather conditions with the intent of helping crews make appropriate decisions.

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