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COMMERCIAL DERIVATIVE AIRCRAFT AND TURBINE ENGINE

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Abstract

A Commercial Derivative Aircraft (CDA) is a commercial off-the-shelf produced aircraft with an FAA Type Certificate (TC). The aircraft may be modified for use as a Military aircraft. Military modifications may be fully or partially FAA approved to civil statutes for the purpose of retaining airworthiness certification.

The key concept of this paper is that the future of military transport aviation will be based on procurement of commercial derivative aircraft & turbine engine. The purpose of this paper is to examine various methods of civil and military airworthiness systems integration.

Military specifications are concerned mainly with performance (payload, range, endurance), while civil standards mainly focus on flight safety. This paper discusses certification procedures and airworthiness requirements applied to CDA.

Differences between civil and military approach to aircraft flying qualities, structure, avionics, and turbine engine certification and development of harmonized procedures for certification of CDA are examined. Also explored are areas of weakness with the current certification processes.

Wright aircraft was the first powered commercial derivative aircraft to be purchased by the military. It was also the first performance based military contract for a power aircraft with a requirement to exceed 40 MPH (the Wright aircraft flew at 42 MPH).

Introduction

Utilizing civil type certification for CDA is not new. It has been in use for many years on an ad hoc basis. However, efforts by the military to procure commercial aircraft and re-qualify the aircraft using the organic military process typically fail. The primary objective for using the civil certification process is initially to maintain the airworthiness and design integrity inherent in the baseline type-certificated aircraft.

In an effort to standardize military airworthiness criteria MIL-HDBK-516 [*Airworthiness Certification Criteria*] was created in October 1st 2002. Civil and military airworthiness processes both rely upon managing and mitigating risk. Civil type certification relies upon minimum flight safety standards. Military airworthiness manages risk through performance criteria.

Because the two systems are designed for different purposes, the two systems and their processes are not entirely compatible. However, examination of technical design standards and flight safety requirements reveal that the criteria used to define civil and military "*airworthiness*" have more in common than not.

When the military mission parallels the mission the civil aircraft is designed to perform, using civil type certification standards to modify and convert the aircraft for military use can be the most cost effective and efficient solution. Cargo transport and a multitude of special mission aircraft fall into this category when the military & mission aircraft can be operated and maintained in a manner consistent with the original civil design criteria.

The modern military depends on international partnerships, and both the import and export of aviation products. Those international military aviation partnerships will be very similar to the civil model for bilateral aviation agreements that exist today. While the role of civil and military aviation will always be different, CDA is the first step towards increased cooperation and future harmonization of regulatory processes.

Background

Military airworthiness authorities rely on civil regulatory material for military type certification and design change certification programs, such as airworthiness design standards; FAA 14 CFR, EASA CS, etc., and associated advisory material; FAA Advisory Circular (AC), EASA Acceptable Means of Compliance (AMC), etc.

Civil processes provide an excellent basis for military aircraft programs. However, civil target levels may be different for military aircraft, equipment or missions. There are significant military / civil gaps in the following areas:

- Civil aircraft **handling qualities** or **flying qualities** (controllable, maneuverable and trimmable) requirements do not adequately address military tactical roles / missions / tasks requirements in the intended operating environment.
- Civil airworthiness standards have **no equivalent** for weapon systems.
- Military & mission aircraft often operate in a **harsher environment**, more severe than equivalent civil aircraft.
- Military & mission aircraft may operate in a **hostile environment** requiring the use of self-defense technologies.
- Military wartime operations include **extremely hazardous** missions under conditions of operational necessity.
- Military roles / missions / tasks are unique and have **no civil equivalent**.
- Military performance requirements demand **technology advances**, which may not sufficiently mature to be civil certified.

Flight Safety & Airworthiness

Aviation safety consists of three factors:

- **Human:** the active part of flight operations.
- **Machine:** aircraft systems and structure.
- **Environment:** the external factors that influence flight, including meteorological conditions, traffic situations and communication.

Safety factors can be seen as three links of a chain. The failure of a single link is sufficient for an accident to occur. Pilot error can put an aircraft in jeopardy, and in most cases, the pilot cannot compensate for a serious aircraft failure. A method used to delineate "*significant hazard*" is a risk reduction technique known as "*As Low as Reasonably Practicable (ALARP)".* A risk is ALARP when it has been demonstrated that the cost of any further risk reduction is grossly disproportionate to the benefit obtained from that risk reduction. The civil flight safety concept is based on FAA / EASA Advisory Circular AC 25.1309-1A / Acceptable Means of Compliance AMC 25.1309 [*System Design and Analysis*]:

- A single failure should not prevent continued safe flight and landing regardless of its probability.
- A subsequent failure during the same flight, whether detected or latent, and a combination thereof, should also be assumed, unless the joint probability (with the first failure) is shown to be extremely improbable.

The Level of Safety (LOS) is generally based on an acceptable accident rate. LOS in civil aviation was established as a maximum of 1.0E-9 for each failure condition with a catastrophic effect. MIL-STD-882E [*System Safety*] identifies and classifies military systems hazards and is approved for use by all military departments and defense agencies within the United States Department of Defense (DoD).

Level of safety for military & mission aircraft is based on a risk assessment process. The associated probability of occurrences for military & mission aircraft is higher than the equivalent civil aircraft due to the nature of their purpose. A factor of 10 is often used when comparing a military & mission aircraft with an equivalent civil aircraft. When this military standard is required, the Severity Category: **Catastrophic** / Probability Level: **Improbable**, probability of occurrence is less than 1.0E-6.

Airworthiness represents a fulfillment of the necessary requirements for safe flying, within the allowable operational limits:

- A safe condition is the freedom from conditions that can cause death, injury or damage to equipment.

- Achievement of the necessary requirements means that the aircraft, or any of its parts, are designed and built to fly in safe conditions.
- Allowable limits means that the aircraft is designed for operation within a certain flight envelope, including speed, load factors, altitude and operational conditions such as visual flight rules (VFR), night flight, instrument flight rules (IFR) and icing.

Airworthiness is defined in the UK Military Aviation Authority (MAA) MAA02 [*Military Aviation Authority Master Glossary*] as: "*The ability of an aircraft or other airborne equipment or system to be operated in flight and on the ground without significant hazard to aircrew, ground crew, passengers or to third parties…throughout its lifecycle*".

Flight safety is often viewed as synonymous with airworthiness (see Table 1). However, airworthiness is concerned mainly with the approved configuration of the aircraft at the time of certification and is primarily focused on the ability of the aircraft to perform safe flight and landing. Flight safety is one element of the entire certification basis and is based on reliability evaluation techniques and lessons learned from aircraft incidents and accidents.

Flight Safety	Airworthiness
Flight safety is the systematic process involving justification of functional integrity, and identification and resolution of potential hazards. This process is analytically driven, toward safe product and irrespective of any airworthiness regulations. It is often required by regulations FAA 14 CFR / EASA CS Part 25.1309 [*Equipment, Systems, and Installations*]. Functional integrity is justified upon certification. However, the resolution of hazards is never fully satisfied. The flight safety field continually monitors the design and operational safety risks through a continuous process of hazard identification and trend monitoring throughout the system life-cycle. Depending on contract, the safety analysis usually ends upon issuance of the final safety assessment. The safety issues remain relevant during the entire life-cycle of the product and require continuous and careful engineering, usually via some sort of safety management system (SMS).	Demonstration of conformance for an airframe or airborne system to a set of specific regulations for a specific type and category of aircraft as determined by the airworthiness authority. Airworthiness is regulation driven to show compliance with accepted standards. Airworthiness is satisfied as soon as it is objectively proven that the regulations and requirements for a specific aircraft type and category are met. The process is typically concluded with the authority issuing a TC, or in the case of a modification, a STC. The process terminates upon the authority issuing the TC or STC. Airworthiness is considered to be compromised if configuration differs from that specified in the TC / STC.

Table 1: Flight Safety & Airworthiness

Harmonization of Civil & Military Regulations

In general, there are two parts to the military qualification procedures:

- Military airworthiness qualification is an activity concerning the verification of compliance with applicable airworthiness requirements.
- Military performance qualification concerns compliance with contractual performance and functional requirements.

Two difficulties related to CDA certification are unique roles such as military transportation, airborne cargo deployment, low level operation, air-to-air refueling, and rules for civil / military navigation & communication in Air Traffic Management (ATM).

Over time, these two situations are occurring more frequently and special documentation is being issued by civil aviation authorities to address them. For example, in the USA, FAA Advisory Circular AC 20-169 [*Guidance for Certification of Military and Special Mission Modifications and Equipment for Commercial Derivative Aircraft (CDA)*] has been generated to provide guidance.

Airworthiness Certification Tools

The U.S. DoD acquisition procedures are reflected in Air Force Policy Directives AFPD 62-6, NAVAIR Instruction 13100.15, Army Regulation 70-62, and MIL-HDBK-516. The roles and responsibilities of the FAA Military Certification Office (MCO) are defined in FAA Order 8110.101A [*Type Certification Procedures for Military Commercial Derivative Aircraft*].

Table 2 illustrates the FAA involvement spectrum in various programs. The first column is regarding CDA that fall under AFPD 62-4 [*Standards of Airworthiness for **Passenger Carrying** Commercial Derivative Aircraft*]. The second column is regarding Commercial Derivative Aircraft that fall under AFPD 62-5 [*Standards of Airworthiness for Commercial Derivative **"Hybrid"** Aircraft*].

C-32, C-37, C-40	E-3, E-4, E-8, KC-10	B-1, B-2
Air Force responsible for continued airworthiness certification.	Air Force responsible for qualification of non- FAA equipment.	Air Force responsible for all qualification and airworthiness activities.
Heavy FAA Involvement → No FAA Involvement		

Table 2: FAA Involvement Spectrum

FAA Order 8110.101A

FAA Order 8110.101A was published and available on the FAA regulatory and guidance library under "*Orders and Notices*":

- Defines role of the **"*FAA Military*"** certification and procedures for all type certification approval for military & mission conversion / modification of commercial derivative aircraft.
- Provides special guidance and procedures for **Conformity** and **Compliance** findings for military special mission equipment and unique military functions.
- Contains procedures, guidance, and policy-essential for **Military Program Offices** (MPOs) and contractors pursuing commercial derivative programs.
- Provides instructions on how to manage the **Airworthiness Seams** between FAA approved type design and military configuration for "*hybrid*" aircraft.
- Establishes guidance and policy for **Levels of Approvals** which support later military approved modifications.

FAA Certification of CDA from FAA Order 8110.101A is supplementing by FAA Order 8110.4C [*Type Certification*] with key issues regarding CDA airworthiness role and responsibilities.

Airworthiness Seams

The dividing line between FAA certification and MIL-HDBK-516 approval is determined at the point where FAA certification no longer satisfies military airworthiness criteria for components, systems or installations on the military & mission aircraft configuration. For example air refueling system operating, proof and burst pressures 120 PSIG, 240 PSIG and 360 PSIG (MIL-A-19736A), compared with civil aircraft fuel system 60 PSIG, 120 PSIG and 180 PSIG respectively.

The military handbook is the all-inclusive airworthiness guide for acceptance of military & mission aircraft, airworthiness qualification and validation. Verification criteria must be developed and defined for installations, systems, or components for which FAA certification are not applicable.

FAA certification is a disciplined airworthiness process. The key to success for well-defined Tailored Airworthiness Certification Criteria (TACC) is airworthiness integration and understanding the similarities and differences between military and civil certification.

There is some degree of similarity between the structure of MIL-HDBK-516 and FAA 14 CFR. However, the military handbook is not detailed as FAA 14 CFR. It is intended to be used in conjunction with the DoD Joint Service Specification Guide (JSSG) Standardization Program document, and the FAA 14 CFR, as a check list, to define the airworthiness certification basis.

Levels of Civil & Military Certification Approvals

The FAA may certify certain non-essential or non-critical electrical / avionics Government Furnished Equipment / Special Mission Equipment (GFE / SME) when all of the below criteria are fulfilled:

- Access to the necessary data is not limited.
- The applicant has demonstrated that the GFE / SME function does not interfere, during normal operation or failure conditions, with critical or essential functions of equipment that are necessary for safe flight and landing of the aircraft.
- The military airworthiness authority issues a statement that the GFE / SME complies with the designed specifications, and
- Unless otherwise specified, the GFE / SME must be certified to meet all other FAA 14 CFR requirements.

If it is not desirable, practical, or possible, to fully certificate GFE / SME equipment as part of the type design, therefore, other possible options are:

- **Full Approval:** military & mission aircraft which meet the same applicable airworthiness regulations of a civil aircraft including: type design data, compliance substantiation, airplane flight manual supplements, maintenance and continued airworthiness documentation.
- **Installation Approval:** CDA authorized for military operations with appropriate limitations / restrictions for civil operations.
- **Provision Only (partial approval):** Provision only approval allow modifications or define limits for military installations. An aircraft may be certified and operated with provisions

for GFE / SME. The provisions should be fully defined and must comply with all applicable FAA 14 CFR requirements.

- **Safe Carriage (partial approval):** an aircraft may be certified with GFE / SME installed, but non-operational (wire bundles are capped and stowed, "*inoperative*" placards are installed, etc.). The FAA 14 CFR requirements applicable to the aircraft type design must be met with the installed GFE / SME in the non-operational state. FAA 14 CFR Part 21.3 [*Reporting of Failures, Malfunctions, and Defects*] requires design approval holder to report to the FAA about certain failures, malfunctions, and defects on type certificated products, which include CDA. The MCO must be notified by Certificate Management Aircraft Certification Office (CMACO) about the FAA 14 CFR Part 21.3 with reports on potential to affect the CDA. Where MCO is the CMACO, design approval holders must report directly to the MCO.

Commercial Derivative Aircraft Flying Qualities

Handling qualities or flying qualities is an attempt to subjectively measure the capability of an airplane and its human operator to complete a specific task within defined performance limits and within reasonable physical, mental and skill bounds for the pilot or crew. There are both a task completion element and a workload element in these subjective measures.

The military developed much of the literature and did most of the early research on such pilot-vehicle interactions. One of the most commonly used rating schemes is the Cooper-Harper rated scale published in NASA Technical Reports Server (NTRS) TN D-5153 [*The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities*].

Advisory Circular AC 25-7C [*Flight Test Guide for Certification of Transport Category Airplanes*], Appendix 6 [*Correction of Air Minimum Control Speed to Standard Conditions*], details the FAA Handling Qualities Rating Method (HQRM) which bears considerable resemblance to the Cooper-Harper scheme and shows the correlation between the two. It includes also two elements; atmospheric conditions, and probability of occurrence.

Tailoring rules are as follows:

- Identify each criterion as applicable, partially applicable or non-applicable, considering aircraft class, flight phase category and level.
- Identify the applicable or non-applicable portion of a criterion partially applies.
- Fully applicable criteria may not be deleted or modified.
- Develop additional criteria as appropriate. Standards and methods of compliance may be tailored, considering complexity, capabilities and intended use.

It is expect that each contract in the U.S. will spell out what elements or subsystems of the CDA should be covered by MIL-STD-1797A / MIL-F-8785C [*Flying Qualities of Piloted Aircraft*] requirements.

Commercial Derivative Aircraft Structure

A military & mission aircraft differs from a civil commercial transport aircraft, in the type of loading it is subjected to and in the environmental conditions. Both aspects are much more demanding for a military & mission aircraft.

Unlike the new generations of civil aircraft, where the usage of composite materials is becoming extensive for principal structural elements, the military & mission derivative aircraft are still mainly metallic. This is because the baseline models are usually not the newest ones. It is also common that the military & mission aircraft is derived from "*second market*" civil operation.

There are three important differences between a military & mission aircraft and its civil counterpart:

- **Physical Configuration:** The structural modifications introduced in a civil aircraft converted into a military & mission aircraft are strongly dependent on the intended usage, which is the driver of the specific equipment (antennas, lights, sensors, mission kits, etc.) that has to be installed.
- **Usage:** Commercial aircraft are operated many more hours per day (actually, a commercial aircraft might have ten times as many lifetime flying hours as a military & mission aircraft of similar age). Furthermore, and in contrast to

the predictable profiles of the civil commercial flights, mainly constrained by the international air traffic rules, the military & mission aircraft are designed to operate in changing scenarios with highly demanding missions. Typical profile for civil aircraft generally corresponding to climb up to optimum cruise level, cruise at optimum speed, descent and landing. Military & mission aircraft usually includes several climbs and descents, loiters, and / or special maneuvers such as air refueling. The cruise altitude, generally optimum for transport flights, may vary for military & mission aircraft from a few thousand feet to the aircraft ceiling, being both conditions equally probable. In a similar way, for a given flight profile in terms of altitude or duration, the number and / or kind of maneuvers made by the aircraft may differ significantly depending on the intended usage.

- **In-service Management of the Structural Integrity:** Actually, the starting point is the same, as commercial derivative aircraft usually retain the core of the civil certification basis, so the damage tolerance philosophy based on FAA 14 CFR and / or EASA CS Part 25.571 [*Damage tolerance and fatigue evaluation of structure*] or FAA 14 CFR Part 26 [*Continued Airworthiness and Safety Improvements for Transport Category Airplanes*] regulations, are applicable to both. These regulations clearly state the need of establishing an appropriate maintenance program to prevent the failure of any structural element which would cause a catastrophic failure of the aircraft during the life of the aircraft. In practice, the so-called Usage Based Maintenance (UBM) is used in the vast majority of the aircraft which are currently flying. The UBM is based in the determination of an inspection program which ensures the detection of any damage before it reaches a critical size. The inspection program is determined based on the assumption of a determined usage of the fleet, and therefore, if the actual usage of a given aircraft departs of the predefined hypotheses, the maintenance program has to be adapted to ensure the continued airworthiness. In the case of the civil transport aircraft, the manufacturers usually analyze periodically the actual usage of the platforms by means of fleet surveys to ensure that the maintenance program is adequate. If this analysis concludes that the fleet is being used in a different way as considered to determine the maintenance program, this is updated accordingly. In the case of the military & mission commercial derivative aircraft, the range of possible missions is increased and the determination of an envelope inspection program which ensures the continued airworthiness of the whole fleet becomes a not-affordable exercise. To cope with this difficulty, these aircraft are fitted with Health and Usage Monitoring Systems (HUMS), which allow an Individual Aircraft Tracking (IAT) of each unit of the fleet. In the most sophisticated forms of these systems, they incorporate also an Operational Loads Monitoring (OLM) subsystem. The HUMS / OLM form essential part of the structural integrity management of the fleet, allowing detection of deviations of the actual usage from the certified usage; this enables the implementation of corrective actions to the maintenance program if required.

Commercial Derivative Avionics

Avionics are the electrical systems used on aircraft. Avionic systems include communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to aircraft to perform individual functions. These can be as simple as a searchlight for a maritime aircraft or as complicated as the tactical system for an airborne early warning platform.

Avionics plays a heavy role in the modernization of the next generation of the air transportation system in six areas:

- **Routes and Procedures** - improved navigation and routing.
- **Trajectories** - adding data communications to create preferred routes dynamically.
- **Delegated separation** - enhanced situational awareness in the air and on the ground.
- **Low Visibility / Ceiling Approach / Departure** - allowing operations with weather constraints with less ground infrastructure.

- **Surface Operations** - to increase safety in approach and departure.
- **Air Traffic Management (ATM) Efficiencies** - improving the ATM process.

The cockpit of an aircraft is a typical location for avionic equipment, including control, monitoring, communication, navigation, weather, and anti-collision system.

Production CDA combines Civil & Military Flight Management System (FMS) and integrates control of the military radios and navigational equipment. "*Second market*" CDA incorporates civil / military switch to allow the flight crew to select either to fly in civil mode using the original civil aircraft equipment's data or in military mode, by switching all data lines necessary to provide the flight plan and guidance data from the Military FMS.

The military FMS is not FAA TSO. The military FMS system is composed of:

- Military FMS Control Display Units (CDUs).
- Commercial Avionics Full-Duplex Switched Ethernet (AFDX).
- Data Transfer Unit (DTU).

The military FMS provides an interface to send flight planning and guidance data to the Cockpit Display System (CDS) and Flight Director / Autopilot (FD / AP) system.

The CDUs, the data transfer unit and the Ethernet switch are connected via an Avionics Systems Local Area Networks (LANs) for the purposes of data loading of operational flight program software and flight plan files and hardware redundancy.

The Military FMS interfaces to and receive navigation data from the following sources:

- New Dual Embedded GPS / INS (EGI).
- Existing Air Data Inertial Reference Unit (ADIRU) / Digital Air Data System (DADS).
- New civil GPS with FAA TSO-145 [*Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)*] capability.

The selection between civil or military mode is to be executed on ground or in flight. In civil FMS mode; takeoff and landing, thrust management, vertical guidance, and CAT-IIIa auto-land are provided via dual FMS and / or autopilot flight director system (AFDS). In military FMS mode, the Military FMS provides guidance for departure, climb, cruise, and ingress to the active military flight pattern / procedures. Usually the Military FMS does not interface with the aircraft Maintenance Control and Display Panel (MCDP), Engine-Indicating and Crew-Alerting System (EICAS), and Electronic Engine Controller (EEC).

Civil specification and standards consist of ARINC 424 [*Navigation System Data Base*], ARINC 429 [*Digital Information Transfer System (DITS)*], ARINC 615A [*Software Data Loader Using Ethernet Interface*], ARINC 708 [*Airborne Weather Radar*], ARINC 818-1 [*Avionics Digital Video Bus (ADVB) High Data Rate*], RTCA DO-160 [*Environmental Conditions and Test Procedures for Airborne Equipment*], DO-254 [*Design Assurance Guidance for Airborne Electronic Hardware*], DO-178B [*Software Considerations in Airborne Systems and Equipment Certification*], RTCA ARP 4754A [*Certification Consideration for Highly-Integrated or Complex Aircraft Systems*], and ARP 4761 [*Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*].

Military specifications and standards consist of MIL-STD-1553B [*Military Standard Digital Time Division Command / Response Multiplex Data Bus*], MIL-STD-810 [*Test Method Standard for Environmental Engineering Consideration and Laboratory Tests*], MIL-STD-461 [*Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment*], MIL-STD-464 [*Electromagnetic Environmental Effects Requirements for Systems*], MIL-STD-1472 [*Human Engineering Design Criteria for Military Systems, Subsystems, Equipment and Facilities*], and MIL-HDBK-217 [*Reliability Prediction of Electronic Equipment*].

FAA Order 8110.101A provides extensive guidance relative to avionics, whether production or secondary market converted CDA. MIL-STD-810, DO-160, MIL-STD-498, DO-178B, etc. can all be utilized, based on the agreements / acceptance outlined in the civil certitude matrix between the U.S. DoD procuring entity and the FAA. Chapters 6, 7, 8, and 9 in Order 8110.101A provides guidance on packaging functionality of systems (avionics included) relative to unique military functions, use of full civil approval, limited civil approval, and safe carriage equipment approval.

There is great flexibility allowed between the DoD and FAA in airworthiness approval of CDA. Examples:

- For the KC-10A "*Extender*", the completed aircraft, including refueling boom, wing hose pods, all avionics (including military functionality) was civil type certificated as the KC-10A left the Douglas production line.
- For the Boeing KC-46A "*Pegasus*" it will leave the Boeing production line as a civil certified 767-2C "*Provisioned Freighter*", and be stuffed with the remaining systems / equipment at a completion center. How the stuffing's are approved, whether FAA or reserved to the U.S. Air Force, would be reflected in the agreed civil certitude matrix.

Commercial Derivative Turbine Engine

Civil markets frequently exist for aircraft engines originally developed and qualified for use by the U.S. military. There are methods that can be used to take advantage of this situation by simultaneously satisfying the requirements for FAA engine certification, with minimal impact on the primary military engine qualification program. Commercial derivative engines in a military configuration, role and environment can create specific and sometimes unique problems that require ongoing diligence and generate significant demand for engineering resources, for example:

- Specific configuration mostly to support the upgrade of the Integrated Drive Generator (IDG) required for the CDA mission equipment.
- Reliability for Extended Range Operation (ERO). It is necessary to identify hazards and assess risks where exercises or deployments require higher than commercial ERO.
- Commercial operators rarely perform missed approaches and go-arounds during revenue service. Such maneuvers are limited to simulator time. However, missed approaches & go-arounds occur on most military flights. Therefore, changes in the role of the military commercial derivative engine may require new engine cycles. The new engine cycles definition consists of frequency and severity of the missed approaches and go-arounds, and should be reviewed at the initial mission analysis activity. This is required to adequately track damage to Life Limited Parts (LLPs).
- The extended periods for which the engines may rest in a saline and humid environment creates accelerated corrosion issues. This requires generating Structure Repair Manuals (SRMs) supplement procedures.

There are two approaches for new engines:

1. The military accepts a commercial off-the-shelf FAA certified engine for their basic requirements. The military then addresses additional desired requirements such as armament gas ingestion, enhanced corrosion resistance, EMI / EMC, are taken care separately from the FAA certification. For example, Boeing KC-46A "*Pegasus*" installed with commercial P&W 4000-94 turbofan engine, 62,000 lbs.-thrust family.
2. Both a military qualification and FAA certification are performed concurrently with many common tests conducted using pre-agreed "*harmonized*" requirements established to satisfy both the FAA Part 33 and the military engine system specifications. For example, an AgustaWestland AW159 "*Lynx Wildcat*" installed with a military version of the CTS800. The Light Helicopter Turbine Engine Company's T800 is a turboshaft engine for rotary wing applications. It is produced by the Light Helicopter Turbine Engine Co. (LHTEC), a joint venture between Rolls-Royce and Honeywell. The commercial and export version is the CTS800. The engine was primarily developed for the U.S. Army's cancelled RAH-66 "*Comanche*" armed reconnaissance helicopter, but has found use in other applications. An SAE Paper 891050 [*An Approach to Simultaneous Military Qualification and FAA Certification of Aircraft Turbine Engines*], prepared by LHTEC in 1989, describes the concurrent T800 military / FAA CTS800 certification approach. It was apparent that a practical program could be designed for simultaneous military qualification and FAA engine certification and to fulfill both military and civil requirements.

There are different engine specifications potentially applicable to various types of engines:

- The **commercial engine** specification of the FAA 14 CFR Part 33 [*Airworthiness standards: Aircraft engines*] & Part 34 [*Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes*],
- The DoD Joint Service Specification Guides JSSG-2007C [*Engines, Aircraft, Turbine*] specification for **manned aircraft**,
- The U.S. Air Force AFGS-87271A [*Engines, Unmanned Air Vehicle, Air Breathing Gas Turbine, Expendable*] specification for **UAV engines**, and
- UK Ministry of Defense (MOD) DEF-STAN 00-971 [*Defense Standard: General Specification for Aircraft Gas Turbine Engines*].

Civil airworthiness requirements tailored for military UAV systems can also be found in NATO STANAG 4671 [*Standardization Agreement: Unmanned Aerial Vehicle (UAV) Systems Airworthiness Requirements*].

The requirements of the military specifications are arranged to correspond to the subject matter of the FAA specification. This arrangement provides an indication of the similarities and differences among the specifications. Since the FAA specification is much more highly aggregated than the military specifications, it is not possible to ascertain the specific military requirements that are also required by the FAA. Most of the military requirements are also required by the FAA, although the methods of verification may be different.

Benefits

CDA programs can greatly benefit from FAA airworthiness certifications:

- **Commercial Parts Pool Participation:** Perhaps one of the most significant benefits of CDA and commercial certification similarity is the commercial parts pool. A common pool of parts reduces the level of spare parts inventory that each member must maintain. Further guidance can be found in FAA Advisory Circular AC 20-169 which states that new, modified, or replacement parts must be approved under the TC, STC, or FAA letter of TSO design approval. It is critical that configuration control and proper tracking be maintained on all parts in the pool. For example, CDA used parts can be accepted back into the commercial parts pool, only if configuration control is maintained and all applicable requirements outlined in FAA 14 CFR Part 21 [*Certification Procedures for Products*].
- **Access to Commercial Data:** Primarily technical data used for modification (hardware, software, and design & test data) is readily available.
- **Use of Existing Processes:** Some processes have proven to be very successful over time. Examples of such processes include FAA Service Bulletin (SB) and Airworthiness Directive (AD), as well as many other maintenance or safety related processes proven in the aviation industry.
- **Sale of Demilitarized CDA:** The secondary market for previously owned military & mission aircraft is dependent upon many factors such as aircraft type, age, fleet size, availability of similar aircraft. If the sale or transfer of CDA is considered as part of a budgeting strategy, the commercial value of the aircraft must be fully understood.
- **Configuration Management:** FAA regulatory and advisory guidance regarding aircraft configuration management, control, and tracking are extremely comprehensive. Details regarding evaluation and verification of aircraft configuration are outlined in FAA Order 8900.1 [*Flight Standards Information Management System (FSIMS)*] as well as several sections of FAA 14 CFR.
- **Quality and Safety:** The sharing of practices between similar organizations can lead to substantial cost savings and improved efficiency. One of the major roles of the FAA is to promote safety through regulation. FAA quality assurance is often used as the benchmark for military quality improvement effort. Along with many years of experience, the FAA can bring substantial benefits.
- **Cost:** Avoids paying the cost of development and test programs of a new aircraft. Life cycle and maintenance costs are shared with the commercial fleet. This includes using FAA 14

CFR Part 145 certified repair stations as well as supply systems for spare parts.

- **FAA Certification:** This method allows maintaining ongoing FAA certification, which is significantly less expensive.
- **Large Commercial Fleet:** This allows Original Equipment Manufacturers (OEMs) to maintain adequate engineering staff to support the products and to develop upgrades.

Drawbacks

However, some drawbacks should be considered:

- **ISO 9000:** The FAA does not acknowledge ISO 9000 standards. Compliance with FAA standards is far more costly and time consuming than ISO 9000. The FAA develops and maintains its own standards and does not acknowledge ISO 9000 standards. CDA contractors find that compliance with FAA standards is far more costly and time consuming than compliance with ISO 9000.
- **Special Government Requirements:** CDA programs may face difficulties complying with special government requirements. Small businesses are unable to cope with special, unique requirements. For example: specialty metals and Unique Item Identification (UID) of all parts. These requirements may incur additional costs. Some small businesses are unable to cope with specialty metal requirements and therefore, are unable to participate in certain CDA programs. Each of these requirements may have a negative effect on CDA system support because specialty metal parts must be tracked separately.
- **FAA Delays:** The FAA is sometimes very slow to act, often disregarding production or test schedules. Extensive FAA delays forced the government to take responsibility in order to maintain schedule commitments.
- **Airworthiness System Complexity:** The current airworthiness system lacks sufficient clarity, simplicity, and transparency. Roles and responsibilities are diffused and diluted. The collection of so many disparate regulators, each responsible for different aspects of airworthiness, and each having different levels of authority, is an arrangement that is neither effective, nor understood by the majority of practitioners in the Arm Services.

Summary & Conclusions

A lot of commercialization of military acquisition of derivative transport aircraft has occurred. Close cooperation between the DoD and the FAA results in cost saving and the DoD ability to field new, fully supportive weapon systems, that meet the operator mission requirements. However much more remains to reform the acquisition system to take maximum advantage of the economics:

- Civil and military airworthiness are clearly separated from the regulatory point of view, although they share many common objectives.
- The complexity of some military systems requires the participation of civil authorities, based upon technical and economical optimization criteria.
- The current situation implies high costs to military programs that have a potential to be reduced by involving civil authorities and adopting civil processes.
- The military authorities have recognized that the civil model can be adapted to military air systems.
- In the U.S., formal collaboration agreements already exist between the civil and military authorities.
- The aviation industry can play a significant role as a catalyst for the process.
- There is increasing need for streamlining and optimizing CDA airworthiness processes, practices, procedures and standards.
- There are potential benefits to harmonization between civil and military procedures.
- There is potential expansion of synergies between the civil and military airworthiness organizations and implementation of established civil design standards accepted by the military authorities.
- Establishment of a formal National Military Aviation / Airworthiness Authority for each country is desirable.