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Type Certification of Military Commercial Derivative Aircraft & Turbine Engine

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- Approximately 80% of the civil and military design and safety standards are similar.
- 10% of the criteria are different:
 - 5% are **robust** military requirements
 - 5% are **conservative** civil requirements
- An additional 10% represent military design criteria for weapons and other military systems which have no civil application or regulatory counterpart.
- The key concept of this presentation is that the future of Military Transport Aviation (aircraft, helicopter, UAV) will be based on procurement of commercial derivative aircraft & turbine engine.

- Utilizing civil type certification practices for Military Commercial Derivative Aircraft is not new; it has been performed for many years on an “ad hoc” basis.
 - No single source for formal guidance on how airworthiness should be granted or maintained (development/sustainment/operation).
 - Many of the military specifications and standards which contained airworthiness requirements have been cancelled by acquisition reforms.
- Efforts by the military to procure commercial aircraft and requalify them using the organic military processes typically fail.
- The military processes affords too many opportunities to redesign the baseline aircraft, and the end product is no longer the affordable off-the-shelf solution that was expected.



Post No. 3619

Order No. 3619

Regulation No.

Place these numbers in title and refer to them in correspondence.
Forward title to Issuing Office, Signal Corps, U. S. Army, Washington, D. C.,
indicating where the order may be required to reach.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER
WASHINGTON February 10, 1908.

Wright Brothers,
Dayton, Ohio.

Gentlemen:

Under proposal No. 200, opened in this office on February 1, 1908, (41) *one directed by the Chief Signal Officer of the Army to place order with you for the articles listed below, subject to the instructions on the back hereof.*

Goods must be securely packed for shipment and delivered within 200 days from receipt of order. ~~Yourselves~~ to Fort Myer, Va.

If transportation charges are to be borne by the United States, Government bill of lading must be received by you before shipment is made. If you ship without Government bill of lading, you will be held for transportation charges. Advise if there is delay in furnishing bill of lading. Inspection will be made at Fort Myer, Va.

Mark packages: Order 3619.

Address and ship: Signal Officer,
Fort Myer,
Virginia.

ITEM:

One (1) heavier-than-air flying machine, in accordance with Signal Corps Specification No. 486, dated December 22, 1907, at \$25,000.00-----\$25,000.00

NOTE:

Bond is required in the sum of ten percent of the consideration, and upon receipt of same your certified check for \$2,500.00 will be returned to you.

Approved: *W. H. Walker*
Chief, Signal Corps, U. S. A.,
Issuing Office.

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Issuing Office.

- Wright aircraft was the first powered commercial derivative aircraft to be purchased by the military with a requirement to exceed 40 MPH.
- The Wright aircraft flew at 42 MPH.

What Is a Military Commercial Derivative Aircraft (MCDA)

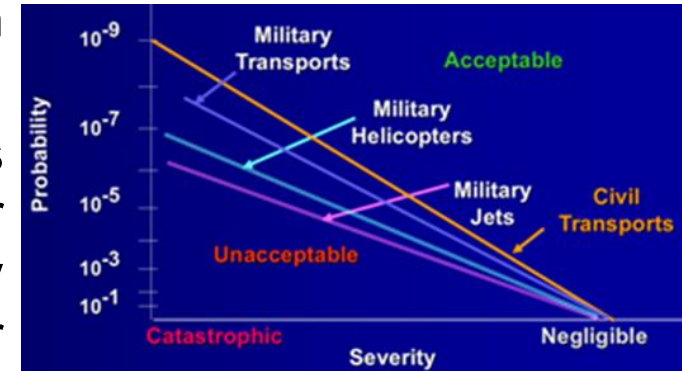
- MCDA is a commercially produced aircraft with an FAA Type Certificate (TC) and produced under Production Certificate (PC) - *“commercial off-the-shelf”* product.
- The aircraft may be modified to a varying extent for use as a military aircraft if manufactured under a Production Certificate.
- The FAA baseline certification is the starting point for substantiation of military modifications.
- Military modifications may be fully, or partially FAA approved to civil statutes for the purpose of retaining airworthiness certification.

- Military specifications are concerned mainly with **performance** (endurance, range, thrust) while civil standards mainly focus on **flight safety**.
- Civil processes provide an excellent basis for military programs. However, civil target levels may be different for the military:
 - Military roles/missions/tasks are **unique** and have no civil equivalent.
 - Civil **handling quality** (controllable, maneuverable and trimmable) do not adequately address military tactical requirements in the intended operating environment.
 - Military often operate in a **harsh environment**, more severe than equivalent civil.
 - Military wartime operations include extremely **hazardous missions** under conditions of operational necessity.
 - Military performance requirements demand **technology advances**, which may be implemented before they are sufficiently mature to be certified for civilian use.

Background (Cont.)

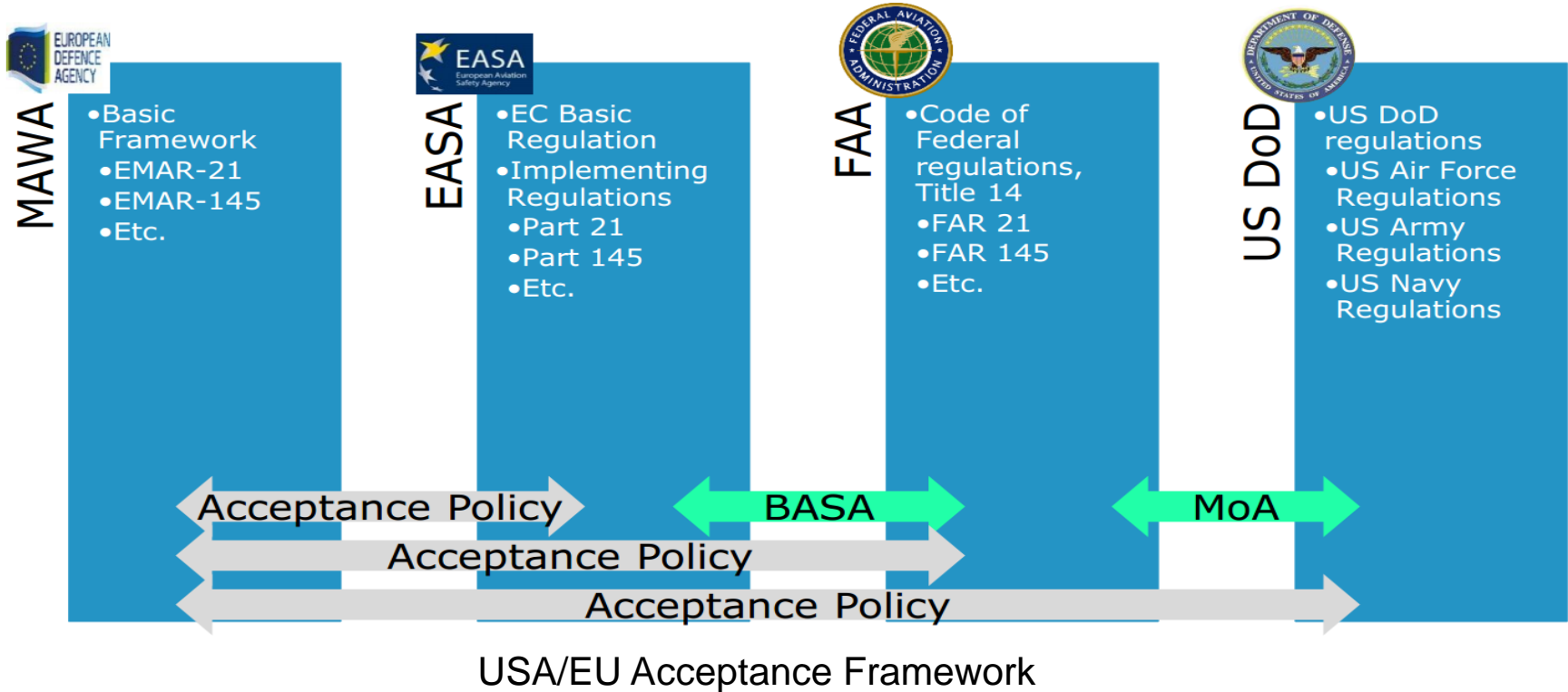
- Two main difficulties related to MCDA certification are:
 - Use of civil aircraft for special military missions: military transportation, low level operation, air-to-air refueling, maritime patrol, search and rescue (SAR).
 - Rules for navigation & communication on civil routes and under civil aviation control.
- However, development and maintaining FAA certification of MCDA is beneficial when compared to military certification.
- The US Armed Services and numerous air forces around the world, are directed, when appropriate and viable, to procure derivatives of commercial aircraft and turbine engine due to cost saving. This leads to the adherence to civil airworthiness standards, when the intended use is consistent with civil operation.

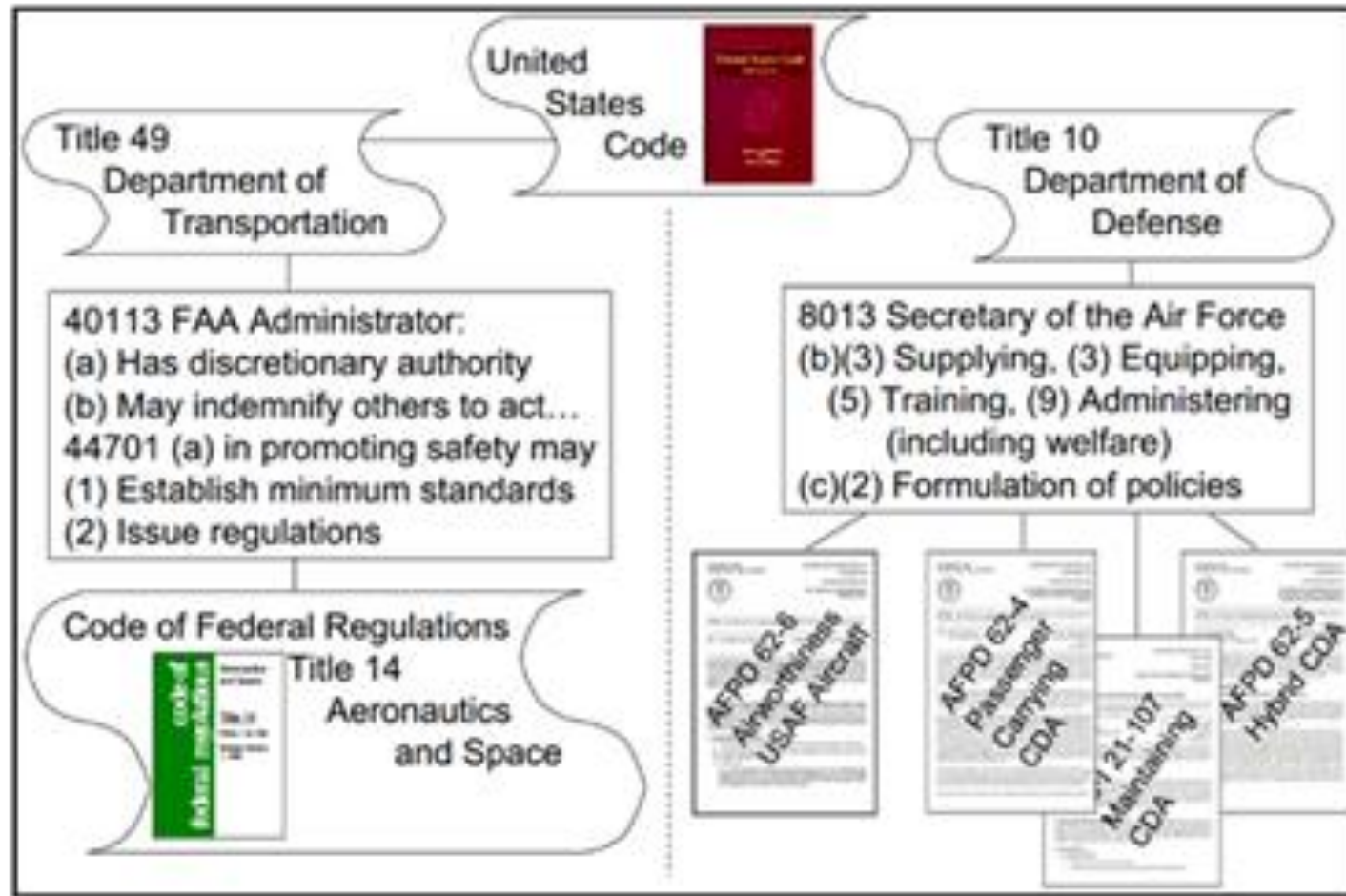
- The Level of Safety (LOS) is based on an acceptable accident rate.
- The associated probability of occurrences for military aircraft is considered higher than the equivalent civil aircraft (**usually by a factor of 10**) due to the nature of their operation.
- Commercial equipment exhibits a significantly lower Mean-Time-Between-Failure (MTBF) in military service. Therefore, risk and As Low As Reasonably Practicable (ALARP) evaluation is required for each case, to identify where systems meet tolerability criteria, and where further action is required to achieve this.
- Therefore, integration methods of civil and military airworthiness systems and **harmonization** of certification procedures applied to Type Certificate (TC) or Supplemental Type Certificate (STC) of MCDA, are required.



Key Objectives

- Investigation of the role of FAA 14 CFR, the US Air Force Policy Directives AFPD 62-6, NAVAIR Instruction 13100.15, Army Regulation 70-62 and Department of Defense (DoD) MIL-HDBK-516C [*Airworthiness Certification Criteria*].
- Overview of the scope of the Memorandum of Agreement (MOA)/interagency support agreement, between the US Department of Transportation (DOT), FAA and the DoD/Armed Services, and clarification of the FAA Military Certification Office (MCO) responsibilities.
- Discussion of the Bilateral Aviation Safety Agreements (BASA) for Government Furnished Equipment (GFE) & Military Special Mission Equipment (MSME).
- Overview of the European Defense Agency (EDA)/European Military Airworthiness Authorities (MAWA) Forum.





[Type Certification Procedures for Military Commercial]

- Establishes FAA policy and guidance to support MCDA certification for the US Armed Services.
- Unique material for MCDA certification by FAA delegated organizations and designees.
- Instructions on how to apply for FAA military projects.
- Provides special guidance and procedures for **Conformity** and **Compliance** for military equipment.
- Establishes guidance and policy for **Levels of Approvals** which support military modifications.
- Provides instructions on how to manage **Airworthiness Seams** between FAA approved type design and military configuration.

*Advisory Circular AC 20-169 [*Guidance for Certification of Military Special Mission Modifications and Equipment for Commercial Derivative Aircraft (CDA)*]

Civil & Military Airworthiness Approval Seams



MIL-HDBK-516C claims that an FAA certification basis suffices for military criteria.

An FAA Type Certification Data Sheet (TCDS) provides the certification basis for the airplane.

- AFPD 62-6 requires Tailored Airworthiness Criteria.
- Army Regulation 70-62 requires an Airworthiness Qualification Plan (AQP).
- NAVAIR Instruction 13100.15 requires a Source Selection Plan (SSP).

- The Source Selection Plan (SSP) is a key document which specifies how the source selection activities for the acquisition will be organized, initiated, and conducted.
- There is some degree of similarity between the structure of MIL-HDBK-516C [*Airworthiness Certification Criteria*] and the FAA 14 CFR. However, 516C does not have the same level of detail as the 14 CFR. It is intended to be used in conjunction with the 14 CFR referenced in its Appendix, as a check list to define the airworthiness certification basis.

- **Full Approval:** Military aircraft which meet the same applicable airworthiness regulations of civil aircraft.
- **Installation Approval:** Military aircraft authorized for operations with appropriate civil limitations.
- **Safe Carriage:** Military aircraft certified with military equipment installed but inoperative.
- **Provisions Only:** Military aircraft certified and operated with provisions only for military equipment.



T-6, T-1A, C-12, C-9, C-20,
VC-25, C-32, C-37, C-40

- FAA certified type design is maintained throughout service life.
- FAA provides airworthiness, test, engineering, and production staff to certify aircraft design.
- Air Force responsible for continued airworthiness certification.

E-3, E-4, E-8, KC-10, AL-1

- Basic aircraft is FAA type certified.
- Modifications may be more extensive than the FAA is willing to certify.
- Air Force is responsible for qualification of all non-FAA certified modes and airworthiness certification.

F-117, F-15, F-16,
F/A-22, B-1, B-2

- No FAA certification involvement.
- Air Force responsible for all airworthiness verification and certification activities.

Heavy FAA Involvement



No FAA Involvement

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, separately from the FAA certification.

Example: Boeing KC-46A “Pegasus” installed with military P&W PW4062A turbofan engine, which has about 500 lbs more thrust and accepts a different generator package. The commercial version is P&W 4000-94 62,000 lbs-thrust family.



2. Military qualification MIL-E-8593 [*Engines, Aircraft, Turboshaft and Turboprop, General Specification for*] or MIL-E-5007 [*Engines, Aircraft, Turbojet and Turbofan, General Specification For*] and FAA 14 CFR Parts 33 & 34 certification are performed concurrently with many common tests conducted using pre-agreed **harmonized** requirements.

Example: An AgustaWestland AW159 “*Lynx Wildcat*” installed with Light Helicopter Turbine Engine Co. (LHTEC), a joint venture between Rolls-Royce and Honeywell, military T800 turboshaft engines. The commercial version is the CTS800.

SAE Paper 891050 [*An Approach to Simultaneous Military Qualification and FAA Certification of Aircraft Turbine Engines*], LHTEC, 1989



Civil vs. Military Turbine Engine Requirements

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

- The **certification regulations** and design rules FAR/EASA 23, 25, 27, 29
- 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*], Part 35 [*Airworthiness standards: Propellers*], and EASA CS-E, CS-P,
- The DoD Joint Service Specification Guides JSSG 2007A [*Engines, Aircraft, Turbine*] specifications for **manned aircraft**, and
- The US Air Force AFGS-87271A [*Engines, unmanned air vehicle, airbreathing gas turbine, expendable*] specification for **UAV engines**.
- UK Ministry of Defense (MoD) DEF-STAN 00-971 [*Defense Standard: General Specification for Aircraft Gas Turbine Engines*] (29-MAY-1987).

The requirements of the military specifications are arranged to correspond to the subject matter of the FAA/EASA specifications. This arrangement provides an indication of the similarities and differences among the specifications.

Since the FAA/EASA specifications are 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/EASA.

However, **most of the military requirements are also required by the FAA/EASA, although the methods of verification may be different** (endurance, vibration, operation, over temperature, over speed, rotor locking test, blade containment and rotor unbalance tests, engine-propeller systems tests, etc.)

Civil vs. Military Turbine Engine Requirements (Cont.)

FAA 14 CFR Part 33	DoD JSSG 2007A	Air Force AFGS 87271A
33.17 Fire prevention	3.1.8.2 Fire prevention	N/A
33.21 Engine cooling	3.2.2.13 Surface temperature and heat rejection 3.2.2.13.1 Controls and external component limiting temp	3.6.3 Engine surface temperature and heat rejection 3.6.4 Engine component limiting temperature
33.66 Bleed air system	3.1.1.7 Bleed air interface 3.1.1.7.1 Customer bleed air contamination	N/A
33.69 Ignitions System	3.7.5 Ignition system	3.5.4.1 Ignition system
33.71 Lubrication system	3.7.8 Lubrication system	3.5.7 Lubrication system

Civil vs. Military MIL-HDBK-516C Requirements

Subject	Criterion	References
7.2.4.1.7 Ignition system	Verify that the engine ignition system provides a safe and effective ignition source for the main combustor and augments.	<ul style="list-style-type: none"> • JSSG 2007A: A.3.2.2.3.5, A.4.2.2.3.5 Auto-Relight; and A.3.7.5, A.4.7.5 Ignition Systems • FAA 14 CFR: 33.69, 33.89
7.2.4.1.11 Lubrication system operation	Verify that the engine lubrication system safely operates under all engine operating conditions.	<ul style="list-style-type: none"> • JSSG 2007A: A.3.7.8, A.4.7.8 Lubrication System; A.3.1.8.1, A.4.1.8.1 Flammable Fluid Systems - fire resistance and fireproof testing • SAE AS1055 [<i>Fire Testing of...</i>] • FAA 14 CFR: 33.5, 33.71, 33.87, 33.89
7.2.4.1.15 Engine bleed air system	Verify that engine bleed air system operation, including malfunctions, does not adversely affect safety of flight.	JSSG-2007A: A.3.1.1.7, A.4.1.1.7 No FAA 14 CFR References!!!



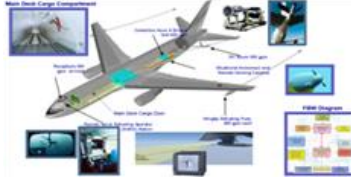
Civil vs. Military Requirements Engine Bleed Air System

FAA 14 CFR Part 33		DoD JSSG 2007A	
33.66 Bleed air sys	The engine must supply bleed air without adverse effect on the engine, excluding reduced thrust or power output, at all conditions up to the discharge flow conditions established as a limitation under 33.7(c)(11) [Engine ratings and operating limitations] . If bleed air used for engine anti-icing can be controlled, provision must be made for a means to indicate the functioning of the engine ice protection system.	3.1.1.7 Bleed air interface	The engine shall provide customer bleed air extraction for aircraft use. The capabilities and maximum flow of each bleed port, including the acceleration or start bleed air ports, shall be as shown in ...(a)...Bleed duct external surface temperatures shall meet the requirements of 3.1.8.2 [Fire prevention] . If a fire shield is required, it shall be identified in...The bleed port internal pickup points shall be located at positions which have low susceptibility to FOD, and ingestion of sand, dust, ice, moisture, and any other foreign materials contained in the air. Provisions shall be made to prevent high-pressure bleed air from entering lower pressure bleed ports. A failure in the air vehicle bleed system shall result in ...(b)...engine operation. If compressor venting is necessary, the temperature, pressure and airflow inflow and outflow conditions for which venting provisions must be made shall be specified in...(c)...The ducting attachment detail shall be shown on the engine interface and installation drawings.

- **FAA Certification & Inspection**
- **Commercial Parts Pool Participation**
- **Access to Commercial Data**
- **Use of Existing Processes**
- **Sale of Demilitarized MCDA**
- **Configuration Management**
- **Quality and Safety**
- **Large Commercial Fleet**
- **Cost Saving**

- **Special Government Requirements**
- **FAA Delays**
- **Airworthiness System Complexity**
- **FAA does not acknowledge ISO 9000 standards used by many organizations to meet customers requirements for quality**

<p>S-2E "Tracker" Maritime Patrol Aircraft (MPA)</p>		<ul style="list-style-type: none"> US NAVY ASW piston aircraft re-engining with Garrett TPE331-15AW Military Commercial Derivative Turboprop Engine. Commercial engine TPE331-14A was marinized to enhanced corrosion resistance per MIL-STD-889 [<i>Dissimilar Metals</i>]. Propeller development in accordance with 14 CFR Part 33 + Advisory Circular AC 33-2 [<i>General Type Certification Guidelines for Turbine Engines</i>] + military endurance qualification test per MIL-E-8593 [<i>Engines, Aircraft, Turboshaft and Turboprop, General Specification for</i>] procedures.
<p>Boeing AEW&C, E-7A "Wedgetail" / P-8 "Poseidon"</p>		<ul style="list-style-type: none"> CFM56-7B27 Military Commercial Derivative Turbofan Engine (based on commercial CFM56-7B family) to support the upgrade from the 90kVA to 180 kVA Integrated Drive Generator (IDG). A new electronic engine control (EEC) software for elevated idles and higher approach shaft speed to accommodate higher mechanical IDG drag. 50% of Accessory Gear Box (AGB) Driver Train Gears and Bearing designs changed. New lubrication nozzles. Track missed approaches and go-arounds as full engine cycles generating additional Life Limited Parts (LLPs). Military Extended Range Operation (ERO) compliance with civil ERO with respect to engine and IDG reliability.
<p>MQ-9 "Reaper" ("Predator B")</p>		<ul style="list-style-type: none"> Garrett TPE331-10GD Military Commercial Derivative Turboprop Engine. Based on commercial TPE331 family approved with fire protection system (detection and extinguishing). Accommodates increasing electrical load requirements up to 45 kVA with integrated high capacity starter-generator. Improved power management and increased loiter time from Digital Electronic Engine Control (DEEC).

<p>IAI “Eitan” Heron TP</p>		<p>Heron TP (turboprop) is designed as a multi-payload, multi-mission platform. Heron TP is powered by a single commercial 1,200HP Pratt & Whitney Canada PT6A-67A Turbo-Prop engine (fire detection only), powering a four blade propeller. The use of such powerful turbo-prop engine enables the aircraft to climb and operate at altitude above 40,000 ft avoiding any airspace conflict with commercial aircraft traffic.</p>
<p>Bombardier Global 5000 Airborne Reconnaissance Multi-sensor Imagery System (ARMIS)</p>		<ul style="list-style-type: none"> • Type Certificate (TC) by Transport Canada and conversion by IAI to military commercial derivative Maritime Patrol Aircraft (MPA). • Certified by the CAA of Israel (CAAI) for "Safe Carriage" per guidance provided in FAA Order 8110-101 Chapter 2 [<i>The FAA Military Certification Office [MCO]</i>] and as "Non-Required/Non-Essential" per guidance provided in Chapter 8 [<i>Methods of Approving Military Equipment</i>] along with Advisory Circular AC 20-169 Appendix B [<i>Discussion of required/essential versus non-required/non-essential electrical equipment</i>]. • Modifications are evaluated per 14 CFR Part 21.101 and Advisory Circular AC 21.101-1A [<i>Establishment of the Certification Basis for Changed Aeronautical Products</i>]. • The Global 5000 is powered by two commercial Rolls-Royce Deutschland BR710A2-20 turbofan engines.
<p>B767-300ER Multi-Mission Tanker-Transport (MMTT)</p>		<p>The B767-300ER MMTT “second market” aircraft is equipped with two commercial CF6-80C2B6F turbofan engines or equivalent. The “green aircraft” certification is based on 14 CFR Part 25. The MMTT certification will be based on 14 CFR Part 25, 14 CFR Part 21.101, Advisory Circular AC 21.101-1A, FAA Order 8110-101, Advisory Circular AC 20-169, and MIL-HDBK-516C procedures.</p>