Docket No. SA-542

Exhibit No.: 7-D

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

FAA Supporting Material
(18 Pages)

FAA Exhibit:

Aircraft and Engine Certification

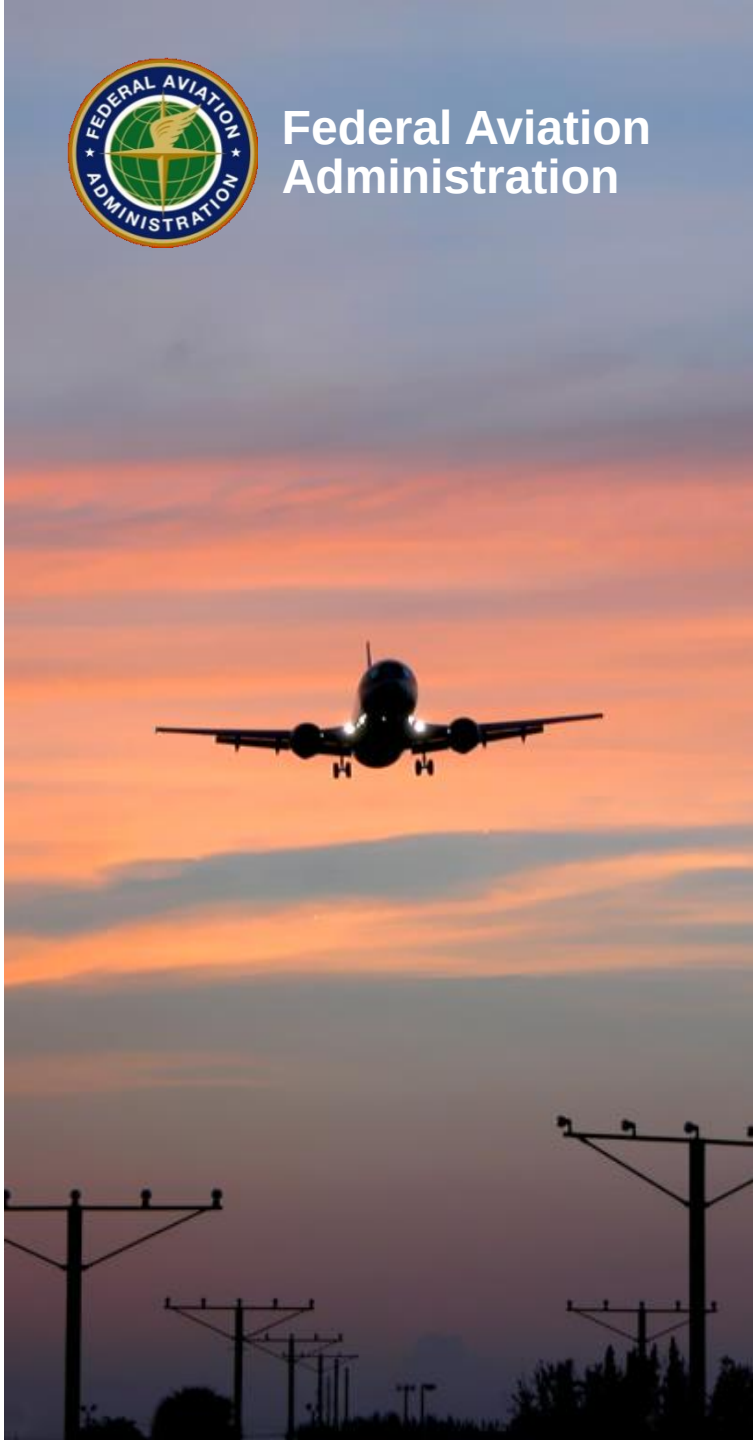
and

Continued Operational Safety

Presented to: **NTSB Public Hearing – SWA 1380**

By: **FAA Aircraft Certification Service**

Date: **November 14, 2018**



FAA Aircraft Certification (AIR)

AIR Responsibilities

Certification of aviation products – ***Cert***

Continued Operational Safety – ***COS***

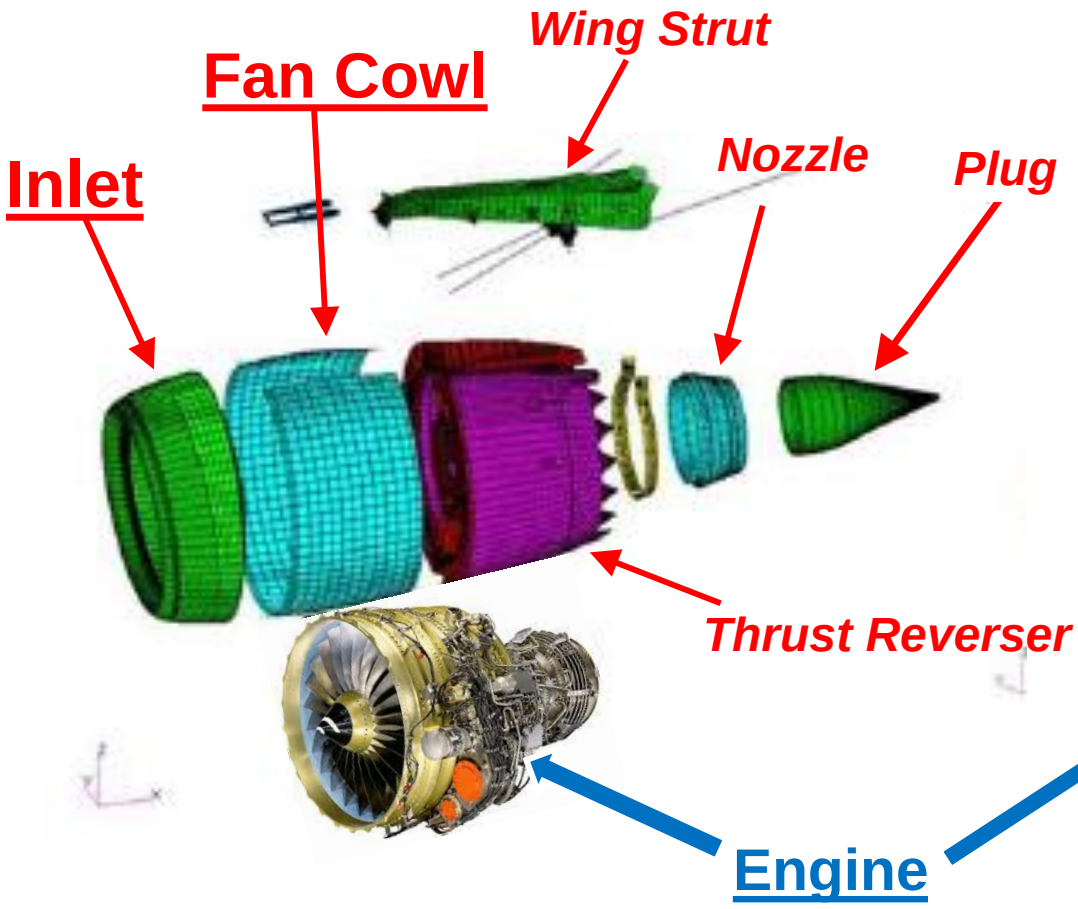
Airworthiness Standards - ***Standards***

Aviation Products – Aircraft, Engines or Propellers

Manufacturer	Product	Airworthiness Standards (Title 14 of CFRs)
Boeing	737-700	**Part 25** – Transport Category Airplanes
CFM International	CFM56-7B	**Part 33** – Aircraft Engines

Division of Components by Regulation:

Part 25 (*Nacelle*) and Part 33 (*Engine*)



CFM56-7B Certification Background

- Designed by *CFM International SA* (CFM)
- CFM is a partnership company between ***Safran*** of France and ***GE*** of the U.S.
  - 737 engine inlet & fan cowl are *airframe* compon[illegible] *Technologies Aerospace Services* **(UTAS)** as subcontractor to Boeing.
- CFM56-7B jointly certified by FAA and DGAC* of France in December 1996. *(DGAC certification now performed by the European Aviation Safety Agency)*
- While there is a unique dual certification management plan in place for CFM, it does not affect the requirements.
  - ✓ Engine met all engine certification requirements for both agencies
  - ✓ No significant difference in requirements

****Director General Civil Aviation***

Applicable FAA Engine Regulations - FBO

***Fan blade containment is addressed in two airworthiness standards*:**

Part 33 Subpart B, Design and Construction

-- **§ 33.19 Durability**… "The design of the compressor and turbine rotor cases must provide for the containment of the damage from rotor blade failure. Energy levels and trajectories of fragments resulting from rotor blade failure that lie outside the compressor and turbine rotor cases must be defined."

Part 33 Subpart F, Block Tests, Turbine Aircraft Engines

-- **§ 33.94 Blade Containment and Rotor Unbalance Tests** – states "…it must be demonstrated by tests that the engine is capable of containing damage without catching fire and without failure of its mounting attachments…after… Failure of the most critical compressor or fan blade while operating at maximum permissible rpm. The blade failure must occur at the outermost retention groove."

-- **This test is often referred to as the *"fan blade out"* or *"FBO test".***

These requirements have been in place since 1984.

CFM56-7B Certification Results for FBO

- **Two official *FBO Demonstration Tests* were run for certification**
  - Engine -002 Build 2, run in April 1996
  - Engine -002 Build 4, run in December 1996

- **Engine -002 *Build 2* Test demonstrated primary containment, mount integrity and fire requirement.**
  - Significant instrumentation to record required data for certification
  - Fan blade retention mechanism failed after the primary blade release
  - Multiple additional fan blades were then released

- **Engine -002 *Build 4* Test demonstrated successful redesign of the fan blade retention mechanism.**
  - Specific test to demonstrate fan blade retention for certification

Data Sharing
between Part 25 *and* Part 33 Manufacturers

- The minimum data that is required to be shared by Part 33 regulations are the *maximum loads*, and the *energy and trajectory* of the debris that exits the engine.
- This information is shared through the *Engine Installation Instructions* required by **14 CFR § 33.5.**
- Additional information is shared by the engine manufacturer to facilitate the design and installation for the airframe manufacturer.

FAA's *Continued Operational Safety* (COS) Process

Investigation	-- Root cause and contributing factors is determined -- NTSB, FAA, Original Equipment Manufacturers (OEMs) and Operators contribute
Risk Assessment	Preliminary -- Is there a potential safety issue? -- Is urgent action necessary? Is there time to continue investigation? -- Conducted by senior safety professionals. Formal -- Evaluated against pre-determined acceptable guidelines -- Forms the basis for FAA's determination of an unsafe condition -- Reaction time is assessed -- Reviewed by FAA and OEM safety review panels
Corrective Action	OEM's and Operators -- Develop corrective action in conjunction with operators -- Propose corrective action time line. -- Publish service documents and coordinate training FAA -- Mandate corrective actions as necessary by airworthiness directive (AD) -- Decision made at a corrective action review board (CARB) -- AD type is dependent on risk and reaction time assessments -- AD Types: ***Emergency***, ***Immediate***, or ***Public Notice***

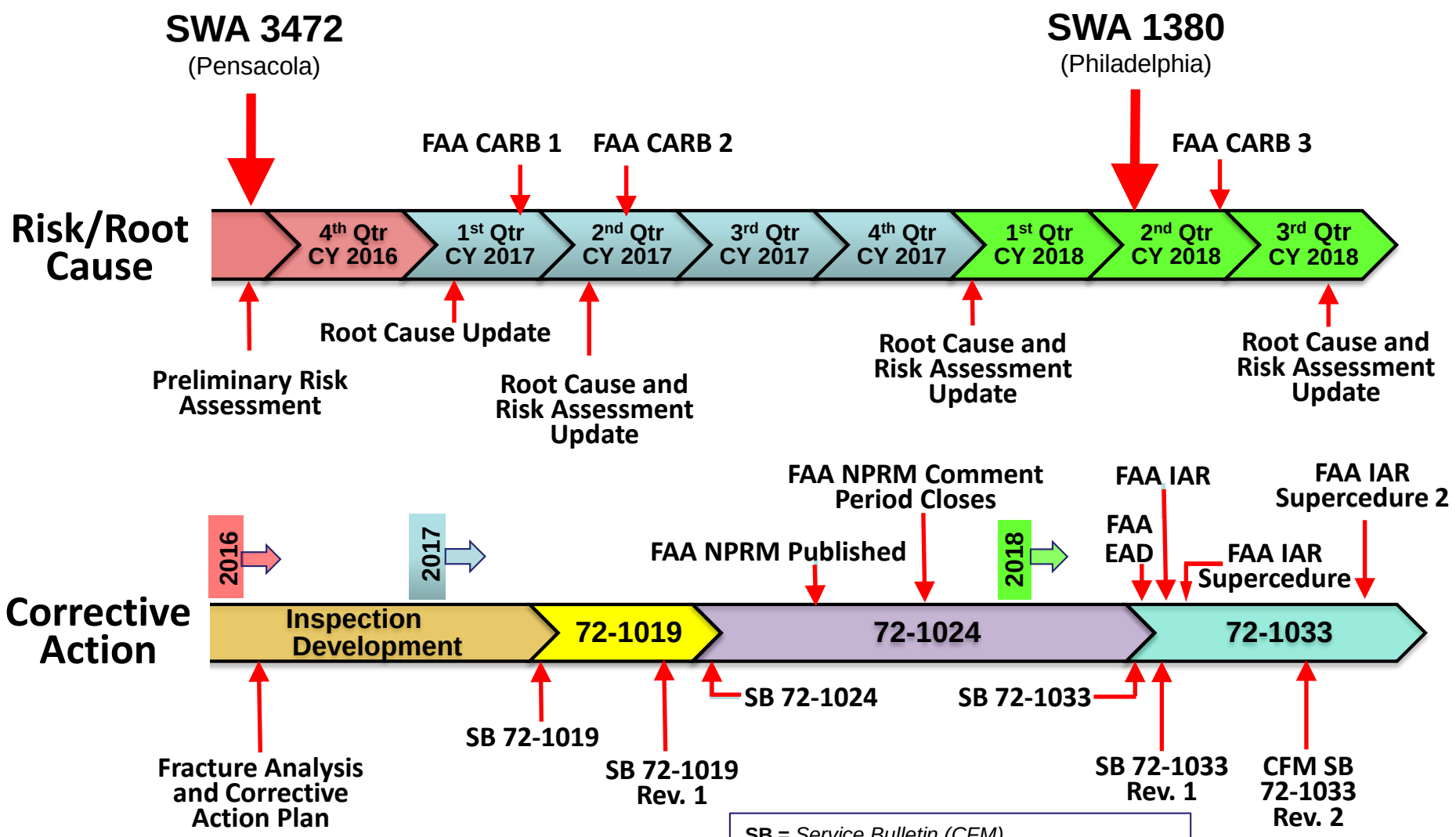
FAA Airworthiness Directive (AD) Process

- Process is governed by the *Administrative Procedures Act* and also FAA Order 8040.1C – *"Airworthiness Directives"*
- FAA seeks public comment as much as practicable

Types of actions the FAA may take

Type of FAA Action	Criteria for Issuance	Compliance Time *(approximate)*
Emergency AD	*High risk, very short compliance times, effective upon receipt.*	*Before further flight to about 30 days*
Immediate Adopted Rule (IAR) AD	*Medium risk, compliance time not long enough to allow notice.*	*Approx. 30 to 90 days*
Final Rule following a NPRM	*Low risk but above threshold of unsafe condition. Compliance time allows for public comment.*	*More than ~90 days*
No AD Action	*Risk is below threshold -- not an unsafe condition.*	*N/A*

Timeline: CFM56 Fan Blade Failure



SB = *Service Bulletin (CFM)*
CARB = *FAA Corrective Action Review Board*
IAR = *Immediate Adopted Rule*
NPRM = *Notice of Proposed Rulemaking*
EAD = *Emergency Airworthiness Directive*

FAA Actions on *CFM56 Engine* *(2016-2018)*

Event / Milestone	Date
SWA Flt 3472, Pensacola, FL	August 2016
NTSB and FAA Investigation Launched	August 2016
Preliminary Risk	September 2016
Monitor Fleet Campaign	November 2016 – September 2018
Formal Risk	December 2016
CARB Meetings	March 2017 – August 2018
NPRM	August 2017
NPRM Comments Close	October 2017
Accepted Revised Corrective Actions	January 2018
SWA Flt 1380, Philadelphia, PA	April 2018
Preliminary Risk	April 2018
Emergency AD	April 2018
Immediate Adopted Rule AD	May 2018 / September 2018
NPRM Withdrawal	September 2018

Applicable *Airframe* Regulations for FBO events

- *Retention of the engine inlet* and other major nacelle components is required if separation of the component following a foreseeable single failure could jeopardize safe operation of the airplane. A fan blade failure is considered a foreseeable failure.
- *Safety analysis* is required to assess potential effects of major component separation.
- If safety analysis shows component separation could jeopardize safe operation, *structural assessment* must show the component will not separate or otherwise jeopardize safety.
- In addition to general safety analysis requirements, the FAA required the engine mount system, pylon, wing, and fuselage to withstand the loads associated with an FBO event with specified factors of safety.

Additional *Airframe* Regulations for FBO events

(continued)

- **Part 25 Subpart C, Structure**

-- Special Condition 25-ANM-132 -- addresses engine stoppage *(in lieu of §25.361; This Special Condition later became §25.362)*

--§25.571(e) ***Damage-tolerance evaluation***. The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of … (2) Uncontained fan blade impact; (3) Uncontained engine failure; or (4) Uncontained high energy rotating machinery failure. The damaged structure must be able to withstand the static loads (considered as ultimate loads) which are reasonably expected to occur on the flight. Dynamic effects on these static loads need not be considered. Corrective action to be taken by the pilot following the incident, such as limiting maneuvers, avoiding turbulence, and reducing speed, must be considered. If significant changes in structural stiffness or geometry, or both, follow from a structural failure or partial failure, the effect on damage tolerance must be further investigated.

-- §**25.629(d)** ***Failures, malfunctions, and adverse conditions***. The failures, malfunctions, and adverse conditions which must be considered in showing compliance with this section are… (4) Failure of any single element of the structure supporting any engine... (9) Any damage, failure, or malfunction considered under, §§ 25.631, 25.671, 25.672, and 25.1309 …. (10) Any other combination of failures, malfunctions, or adverse conditions not shown to be extremely improbable.

Additional *Airframe* Regulations for FBO events

(continued)

- **Part 25 Subpart E, Powerplant**
  - **§ 25.901** – "For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the airplane except that the failure of structural elements need not be considered if the probability of such failures is extremely remote."
  - **§ 25.903** – "There must be means for stopping the rotation of any engine individually in flight, except that, for turbine engine installations, the means for stopping the rotation of any engine need be provided only where continued rotation could jeopardize the safety of the airplane…"

FAA Approach to Certification *and* Continued Operational Safety (COS)

Familiarization Briefings

Regulatory Requirements & Standards

Certification Basis

Issue Papers, Special Conditions, Advisory Circulars

Methods of Compliance

Airplane level compliance findings

Detailed level compliance findings

Flight Test

Issue Type Certificate

Issue Production Certificate

Deliveries Begin

Continued Operational Safety Maintained

Unsafe Condition Eliminated

Operators comply with AD

Airworthiness Directive (AD) Issued

Corrective Action Development

FAA Safety Determination

Risk-based Safety Assessment

FAA Review of § 21.3 Report

CFR § 21.3 Required Report

In-Service Event

Operations Begin

Certification

Continued Operational Safety

FAA Actions on *737NG Inlet* *(2016-2018)*

Event / Milestone	Date
SWA Flt 3472, Pensacola, FL	August 2016
NTSB and FAA Investigation Launched	August 2016
Examination of Parts, and Review of Failure Sequence	September 2016
Airplane Preliminary Risk	September 2016
Continue Inlet Investigative Actions	September 2016 - May 2017
FAA Safety Decision – *No airplane safety issue*	May 2017
SWA Flt 1380, Philadelphia, PA	April 2018
Airplane Preliminary Risk	April 2018
FAA Safety Decision – *Airplane safety issue*	May 2018
Root Cause Investigation	Ongoing