## Gorham Conference - 2017

# FAA Update on Additive Manufacturing

## AFS-300 Flight Standards Perspective on AM in Maintenance & Repair

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Federal Aviation Administration

# Outline

- Flight Standards AFS-300– Who we are
- Current State of AM
- AM Headlines
- AM Potential Applications
- AM Challenges and Concerns
- Airworthiness Regulatory Requirement
- Recent FAA Activities involving AM
- Summary

# Flight Standards AFS-300

**Aircraft Maintenance Division is responsible for;**

- Maintenance Regulations, Policy, Guidance, & Training:
  - Certification, Inspection & Surveillance of air carriers, air taxi, commuter airlines & commercial operators maintenance & continued airworthiness programs
  - Certification of Mechanics, Repairman, & Parachute Riggers
  - Certification & Surveillance of Repair Station policy & AMT Schools
- Maintenance Focal, Interface, Representative:
  - AFS-AIR
  - Suspected Unapproved Parts (SUPS)
  - NTSB/FAA Safety Recommendations
  - Research Program

# Current State of AM

- **Commonly known as “3D-Printing”**
- **US government & major US aerospace companies continue to promote research & use of AM**
- **AM is rapidly evolving & is being introduced into new aircraft deigns, repairs, & alterations**
  - **Most major OEM’s have announced that their new products will have AM parts (metallic)**
  - **Thermoplastic AM parts have been utilized for years by multiple aircraft manufacturers**
- **Anticipate a rapid increase in the use of AM in manufacturing and maintenance**

# Additive Manufacturing Headlines

**December 2015** – "China Eastern Airlines adopts 3D printing to significantly reduce costs of cabin components" (www.3ders.org)

**Established their own AM laboratory**

**3D Printing Onsite**

- **Reduced lead time for parts**
- **Reduce cost (examples)**
  - **Toilet seat 90% less that OEM**
  - **iPad holder 95% less that OEM**
  - **Misc. Interior brackets 97% less that OEM**

**Developed CAR25 - fully nonmetallic 3D printable material for cabin parts that is flame retardant**

# Additive Manufacturing Headlines

**February 2016 –** "Air New Zealand to 3D print its own aircraft interior parts" (*DC VELOCITY Magazine*)

**Airline will 3D print seatback trays to order instead of keeping them in stock.**

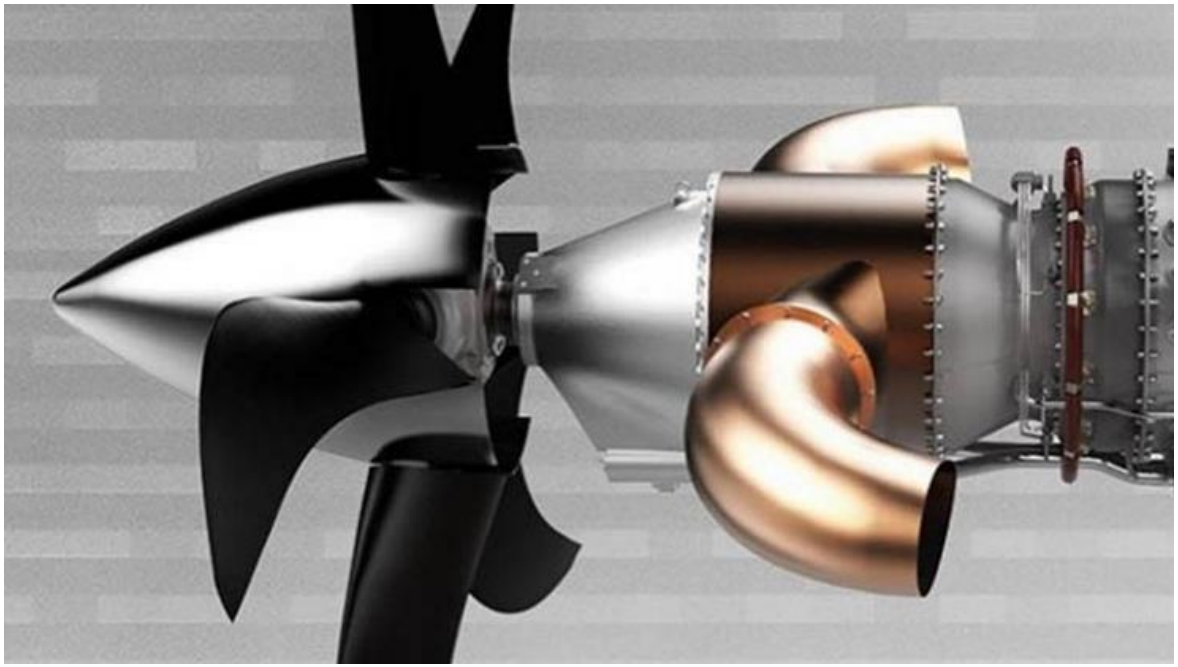
# Additive Manufacturing Headlines

**November 2016 –** "Renishaw uses 3D printing to help restore Hawker Typhoon aircraft" (Additive Manufacturing Today)

- Used original 1938 drawings
- Renishaw's engineers modeled each bracket from scratch using a computer-aided design (CAD)
- Prototyped in plastic polycarbonate
- Final cockpit brackets recreated in an aluminum alloy like the originals

# Additive Manufacturing Headlines

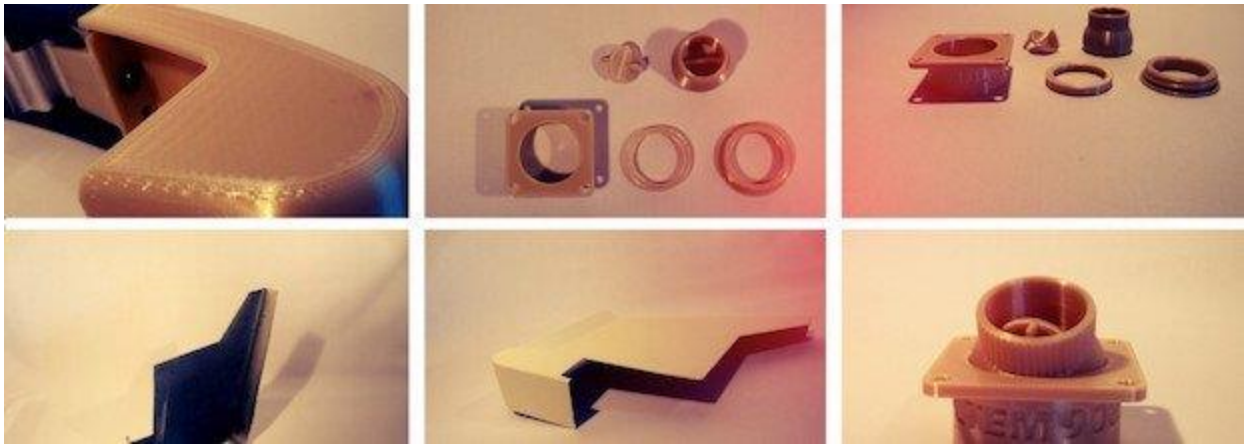
**November 2016** – “GE tests 35% additive manufactured turboprop engine” (Aerospace Manufacturing & Design)



855 conventionally manufactured parts will be reduced to 12 additive parts on the Advanced Turboprop.

# Additive Manufacturing Headlines

**November 2016** – "Magnetic MRO and MAC Interiors Unify Their Forces for 3D Printing of Aviation Approved Parts" (TCT Magazine)



**FAA Part 145 Aircraft Maintenance and Repair Organization, introduces 3D printing into aircraft parts production process, as part of its strategy to offer efficient Total Technical Care MRO services.**

# Potential Applications for AM

- Small, complex parts such as engine/turbo engine
- Small manufacturers (PMA) seeking to produce low production rate replacement parts
- Part 121 operators (Major Airlines) using AM in house for maintenance and repairs
- Repair Stations seeking to replace and/or repair damaged parts reducing lead times and inventory
- MRO use of AM to produce obsolete parts, which are no longer manufactured by the OEM

**Note: All AM produced parts must comply with all current regulations**

# AM Challenges and Concerns

- **Availability and maturity of -**
  - Industry AM Specifications and Standards
  - FAA guidance for Type Certification of AM parts
  - FAA guidance for Production approval of AM parts
- **Limited knowledge & experience in-**
  - Characterizing material defects & their impact on airworthiness of AM produced parts (metallic)
  - Understanding process failure modes & linkage to key production parameters for AM produced parts
  - Characterizing mechanical properties of AM metallic parts
  - Susceptibility of environment on AM metallic parts
  - Substantiating a stable & repeatable AM production process
  - Industry & FAA workforce

# Airworthiness Concerns

- **14 CFR 43.13(b) - Demonstration of equality of AM repair/replacement parts to their original design**
  - Replacement/repair parts produced by AM using metal powders may have very different properties than an original part manufactured by traditional processes with traditional materials
- **14 CFR 2X.603, 605 & 613 - AM produced PMA parts may require much more substantiation than PMA parts produced by traditional methods**
- **Use of 3rd party non-certificated 3D printing organizations by MRO's**
- **ACOs may not be geared up for a influx of PMA applications & additional specific guidance may be required**
- **Designee qualifications that approve AM Repair Specifications**

# FAA Activities in AM

- **Additive Manufacturing National Team (AMNT) chartered by FAA management (Jan 2015)**
  - ***Near-term actions (checklists, education, outreach)***
  - ***Development of agency's AM Roadmap***
- **Initial AM Memos (AIR) & Issue Papers (Directorates) & AFS (Notice)**
- **CSTA Workshop's on AM (2015 & 2016)**
- **Coordination with other government agencies & academia**
- **Benchmarking of major OEMs**
- **Engagement with industry working groups, consortia & standards organizations (SAE, AIA, ASTM etc.)**
- **Development of R&D requirements by AMNT sub-team**

# Recent FAA Activities in AM

- **FAA memorandum "AIR100-16-130-GM18, Engineering Considerations for Powder Bed Fusion Additively Manufactured Parts" for use in certification programs involving AM parts**

- **FAA memorandum "AIR100-16-110-GM26 ASI Job Aid for Additive Manufactured Parts" for use to assess a PAH or one of their suppliers who propose to use an additive manufacturing process**

- **AMNT Engineering Team conducting roadshow to Educate the Aircraft Certification Office engineers on the above memorandum and other important aspects of AM**

- **Issue Papers developed for use in AM certification programs**

# Recent FAA Activities in AM cont.

- **AMNT has engineering and manufacturing personnel participating in the core teams developing SAE Aerospace Material Specifications**
- **FAA tasked Aerospace Industries Association (AIA) to recommend guidance for the certification of AM parts**
- **Flight Standards published FAA Notice 8900.391- "Additive Manufacturing in Maintenance, Preventive Maintenance, and Alteration of Aircraft, Aircraft Engines, Propellers, and Appliances"**

# FAA AM Roadmap

- **FAA is developing an AM Strategic Roadmap, with teams dedicated to defining the plan to develop AM;**
  - **Certification policy and guidance**
  - **Manufacturing policy and guidance**
  - **Maintenance policy and guidance**
  - **COS policy and guidance**

# FAA Roadmap Goal

- **Evaluate need for policy, guidance, & rulemaking**
  - OEM parts (TC/PC)
  - Aftermarket (PMA, spare part)
  - Repair parts
- **Research to support policy, guidance & rulemaking**
  - Allowable development guidance
  - Potential impact on design practices
  - Manufacturing process validation & control
- **Training for engineers & inspectors**
- **Harmonization with other agencies**
- **ICAs for maintenance & inspection**
- **Production process conformity & inspection**

# Federal Regulations

- **Regulations that apply to the certification of specific products (aircraft, engines and propellers):**
  - Part 21 – Certification Procedures for Products and Parts
    - § 21.8 – Approval of Articles
    - § 21.9 – Replacement and Modification Articles
    - Part 21 Subpart “K” PMA
    - Part 21 Subpart “O” TSOA
  - Part 23 – Airworthiness Standards: Normal, Utility, Acrobatic and Commuter Airplanes
  - Part 25 – Airworthiness Standards: Transport Category Airplanes
  - Part 27 – Airworthiness Standards: Normal Category Rotorcraft
  - Part 29 – Airworthiness Standards: Transport Category Rotorcraft
  - Part 33 – Airworthiness Standards: Aircraft Engines
  - Part 35 – Airworthiness Standards: Propellers

# Federal Regulations

- **Regulations that apply to Maintenance of products (aircraft, engines and propellers):**
  - **Part 43 - MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION**
    - 14 CFR § 43.13(b)
      - Each person maintaining or altering, or performing preventive maintenance, shall do that work in such a manner and use materials of such a quality, that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on will be at least equal to its original or properly altered condition (with regard to aerodynamic function, structural strength, resistance to vibration and deterioration, and other qualities affecting airworthiness).

# Summary

- **The use of AM in aviation is rapidly expanding.**
- **As industry gains experience with AM, the level of part criticality is expected to increase.**
- **Key AM considerations include:**
  - Identification and characterization of key failure modes and anomalies
  - Control of Significant process variables for AM by process specifications to ensure that sound structure can be consistently produced.
  - Creation of public specifications for AM materials and processes
  - Development of design values
  - QA, Process Monitoring and NDI methods
- **The FAA AM National Team will continue to engage with other government agencies, standards organizations, academia, and industry to ensure the safe introduction of AM parts into service.**

# FAA Contact Information

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# Questions

# Information Slides

# PMA / TSOA

**Applicants may receive Production Approval (PMA), Authorization to build TSO parts (TSOA).**

- **PMA (Part 21, Subpart K)**

  **Is a combined design and production approval for modification and replacement articles. It allows a manufacturer to produce and sell these articles for installation on type certificated products.**

- **TSOA (Part 21, Subpart O)**

  **It allows a manufacturer to produce and sell these articles that meet minimum performance set by Technical Standard Order (TSO).**

  - ✓ **Applicant still must show that PMA/TSO component meets the TC requirements prior to installation**

# Basic Airworthiness Refresher

**14 CFR 21.1**

**Airworthiness approval -** means a document, issued by the FAA for an aircraft, aircraft engine, propeller, or article, which certifies that the aircraft, aircraft engine, propeller, or article *conforms to its approved design and is in a condition for safe operation*, unless otherwise specified. FAA form 8100-2

**14 CFR 21.181**

a) Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the [FAA*], airworthiness certificates are effective as follows*:

(1) Standard airworthiness certificates, special airworthiness certificates-primary category, and airworthiness certificates issued for restricted or limited category aircraft are *effective as long as the maintenance, preventive maintenance, and alterations are performed in accordance with Parts 43 and 91 of this chapter* and the aircraft are registered in the United States.

**14 CFR 43.13(b)**

Each person maintaining or altering, or performing preventive maintenance, *shall do that work in such a manner* and *use materials of such a quality*, that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on *will be at least equal to its original or properly altered condition (with regard to aerodynamic function, structural strength, resistance to vibration and deterioration, and other qualities affecting airworthiness).*

# FAA Regulations, 'cont'

**§ 2X.613 Material strength properties and design values.**

- Material strength properties must be based on enough tests of materials meeting specifications to establish design values on a statistical basis.
- Design values must be chosen to minimize the probability of structural failure due to material variability. Design values must assure material strength with the following probability:
  - Single load paths, where failure would result in loss of structural integrity of the component , 99% probability with 95% confidence.
  - Redundant load path, 90% probability with 95% confidence statistics

# FAA Regulations, 'cont'

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- *aerodynamic function,*
- *structural strength,*
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- *deterioration,*

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