

# On-Demand Mobility Workshop

## FAA Perspectives on Additive Manufacturing

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Federal Aviation  
Administration



# Outline

- ❖ **Regulatory Requirements**
- ❖ **State of Additive Manufacturing (AM)**
- ❖ **What Is Additive Manufacturing**
  - AM Challenges To Be Addressed
  - *Examples* of Risk Factors for AM
- ❖ **State of Industry in Aviation**
- ❖ **Challenges of AM to FAA**
- ❖ **Recent FAA Activities in AM**
- ❖ **Summary**

# Federal Regulations

## ➤ The Federal Aviation Regulations are:

- Part of Title 14 of the Code of Federal Regulations (CFR).
- Prescribed by the Federal Aviation Administration (FAA) governing all aviation activities in the United States.

## ➤ Regulations that apply to the certification of specific products (aircraft, engines and propellers):

Similar Requirements

- Part 21 – Certification Procedures for Products and Parts
- 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

# FAA Certification/Approval/Authorization

## FAA issues:

- **Type Certificate (TC) – Part 23, 25, 27, 29 and 33**
- **Production Certificate (PC)**
- **Parts Manufacturer Approval (PMA)**
- **Technical Standard Order Authorization (TSOA)**

} Part /  
Components

# State of Additive Manufacturing (AM)

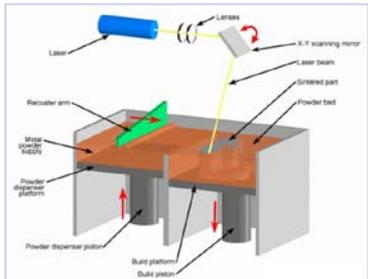
- ❖ **Commonly known as “3D-Printing”**
- ❖ **US government and major US aerospace companies continue to promote research and use of AM.**
- ❖ **AM is rapidly evolving and is being introduced into new aircraft designs, as well as retrofits and repairs**
  - **Most major OEM’s have announced publically that their new aviation products will have some AM parts (metallic)**
  - **Thermoplastic AM parts have been utilized for years by multiple aircraft manufacturers**
  - **Vision would be to widely utilize AM within the next 5-10 years.**

# What Is Additive Manufacturing (AM)

## Additive Manufacturing (AM) --

A process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to *subtractive manufacturing* methodologies

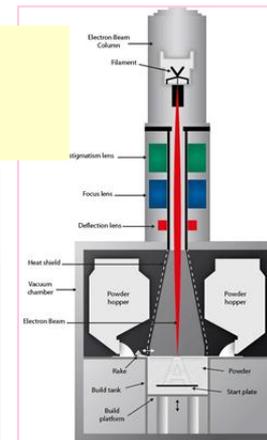
(Ref: **ASTM F2792 – 12a**)



### By Source of Material: **Powder vs. Wire**



### By Source of Energy: **Laser vs. E-Beam**



**New Type and  
Production Certificates**

**Repair and Overhaul  
(MROs)**

**Aftermarket  
Parts (PMAs)**

# AM Challenges To Be Addressed

“top five”

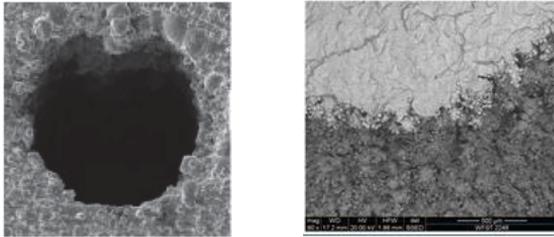
- Limited understanding of acceptable ranges of variation for key manufacturing parameters
- Limited understanding of key failure mechanisms and material anomalies
- Lack of industry databases / allowables
- Development of capable NDI methods
- Lack of industry specs and standards

**Additional level of complexity – these areas are not independent...**

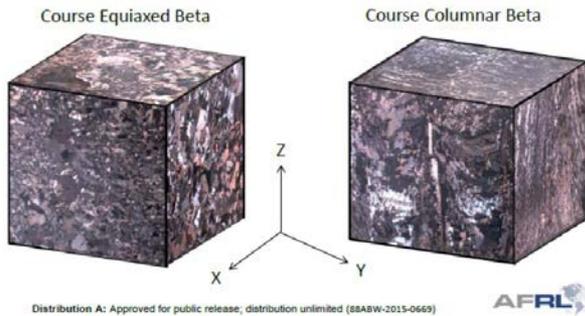
## Other considerations

- *Lack of robust powder supply base*
- *OEM-proprietary vs. commodity type technology path*
- *Low barrier to entry for new (inexperienced?) suppliers*

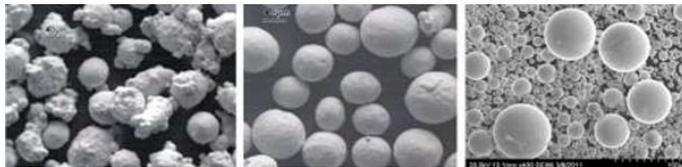
# Examples of Risk Factors for AM



## Surface Quality



## Microstructure Variability



## Powder Control

Powder feed rate (g/min)

Laser Power (W)

Scan speed (in/min)

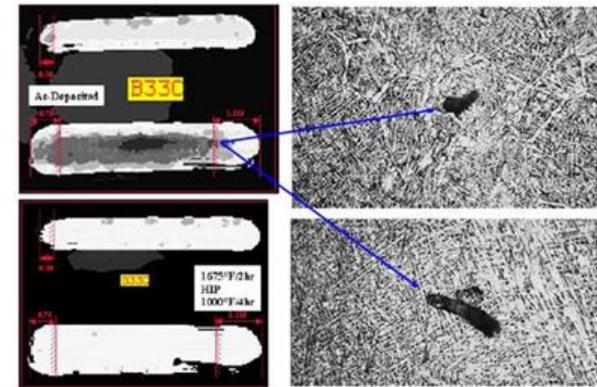
Laser spot size (in)

Substrate temp (°F)

Hatch spacing (% of calculated)

*over 100  
process  
parameters  
identified*

## Process Controls



## HIP Effectiveness

*Many More Identified by Experts...*

# State of Industry in Aviation

“Additive manufacturing is the new frontier. It has taken the shackles off the engineering community, and gives them a clean canvas...”

Mr. David Joyce, GE Aviation President and CEO



“We are on the cusp of a step-change in weight reduction and efficiency – producing aircraft parts which weight 30 to 55 %, while reducing raw material used by 90 % ...”

Mr. Peter Sander, Airbus



"Metal parts from some AM systems are *already on par with their cast or wrought counterparts*. As organizations qualify and certify these and other materials and processes, the industry will grow very large..."

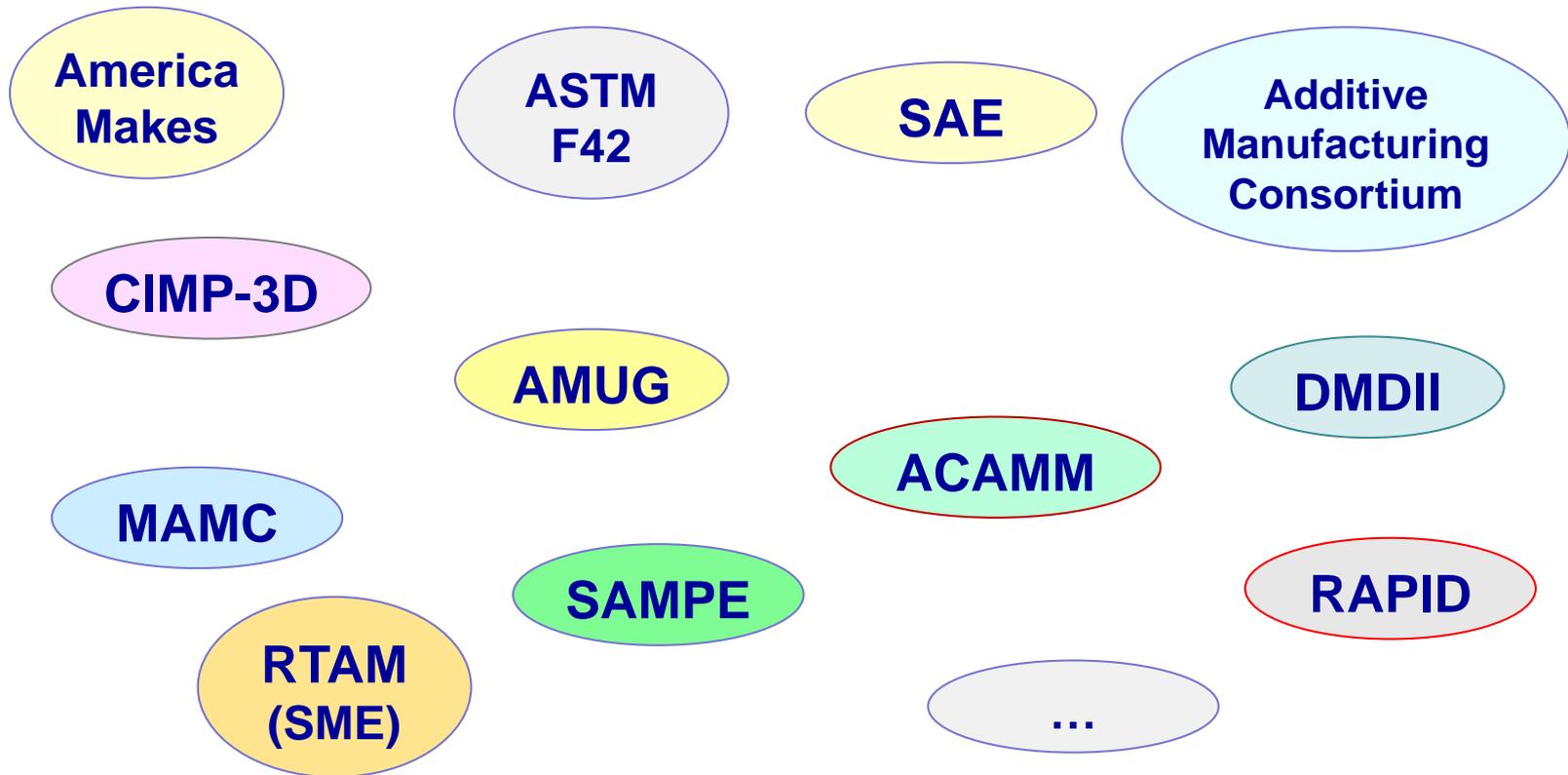
*Source: Wohlers Report 2012*



"3D printing opens up new possibilities, new design space... Through the 3D printing process, you're not constrained [by] having to get a tool in to create a shape. You can create any shape you like."

*Dr. Henner Wapenhans, Rolls-Royce  
Head of Technology Strategy*

# Industry and Government Collaboration on AM is Rapidly Expanding ...



*Vision of several organizations is to Develop a National Strategy for AM*  
*However ... few are focused on Qual and Cert issues*

# Challenge of AM to FAA

❖ **Current regulations are written to traditional aircraft manufacturing.**

➤ **Challenge**

***The FAA is not staffed to interact directly with individual AM suppliers or manufacturers who are not Type Design or Production Approval Holder.; i.e., TC, STC, TSOA, PMA.***

# Recent FAA Activities in AM

- **AMNT (Additive Manufacturing National Team) chartered by FAA management (Jan 2015).**
  - *Includes representatives of four Directorates, AFS, Tech Center, MIDO, Chief Scientists and H/Q*
  - *Near-term actions (checklists, education, outreach)*
  - *Development of agency's AM Roadmap*
- **Initial AM Memos (AIR) and Issue Papers (Directorates)**
- **CSTA Workshop on AM**
- **Coordination with other government agencies and academia**
- **Benchmarking of major OEMs**
- **Engagement with industry working groups, consortia and standards organizations**
  - *Kicked off new AIA Working Group on AM*

# Summary

- Expected (rapid) expansion of AM in Aviation
  - Expected increase in the levels of AM parts criticality
  - Appropriate regulatory framework is a key enabler
  - Most OEMs and agencies support *risk-based approach*, including “system-level” considerations:
    - Manufacturing process controls and specs development
    - Identification and characterization of key failure modes and anomalies
    - Life prediction system and certification criteria
    - QA, Process Monitoring and NDI methods
- ***Industry, agencies and societies collaboration is needed to ensure safe introduction of AM in the National Airspace***



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# Information Slides



# Key FAA Definitions

- **Applicant:** Person or persons seeking to certify a product.
- **Product:** An aircraft, aircraft engine, or propeller.
- **Type Design** consists of the drawings and specifications, and a listing of those drawings and specifications, necessary to define the configuration and the design features of the product shown to comply with the requirements of the part of the subchapter applicable to the product.
- **Production approval:** A document issued by the FAA to a person that allows the production of a product in accordance with its approved design and approved quality system, and takes the form of a **production certificate (PC)**.

# For Applicants to build certified product they need two FAA certificates

## ❖ Type Certificate:

An applicant is issued a Type Certificate once they have demonstrated through test and analysis that the type design data (drawings, specifications and other documents needed to describe a design) meets all relevant regulatory requirements.

## ❖ Production Certificate:

An applicant is issued a Production Certificate once their manufacturing facilities are capable of repeatable producing product per the approved Type Certificate.

# 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**