EASA
European Aviation Safety Agency

Additive Manufacturing, needed Standards, Quo vadis

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Additive Manufacturing / Content

- Content
  - General
  - Different Techniques
  - Materials
  - Status on Standards
  - Quo vadis

Additive Manufacturing / General

What is Additive Manufacturing

- Additive Manufacturing also known as: 3D printing, additive layer manufacturing, rapid prototyping or free form fabrication
- process of joining materials layer upon layer from 3D-CAD data by a kind of printer
- opposed to subtractive manufacturing methodologies such as machining.
- 3D printing: fabrication of objects through deposition of material using a print head, nozzle, or another printer technology.
- Advantageous: no subtractive manufacturing such as machining, no waste of material through chipping, manufacturing light weight

Additive Manufacturing / Different Techniques

- **2** techniques to focus on for **additive manufacturing technologies:**

  - **Selective Laser Melting (SLM)**, metal powder is melted by a laser beam

  - **Electron Beam Melting (EBM)**, metal powder is melted by an electron beam after a preheating step

  - **Blown powder technology**, also known as Laser Metal Deposition or Laser cladding

    - In this process, the metal powder is blown coaxially to the laser beam which melts the particles on a base metal to form a metallurgical bond when cooled. Already used in aerospace for turbine blade repairs.

- The key benefits of Additive Manufacturing
  - Freedom of design/Flexibility in design changes
  - Complex shape, inner cavities or foam / lattice structures, impossible to produce by machining
  - Thin walls & shapes impossible to produce by casting
  - Light weight parts with lattice / foam inner structures
  - Customized design
  - Multiple pieces built as one
  - No manufacturing/assembly tool needed
  - Short production time (a few hours)

Uncertainties in AM / Materials

Material
(metallic/plastic)

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Process

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Part

Uncertainties in the Input Materials

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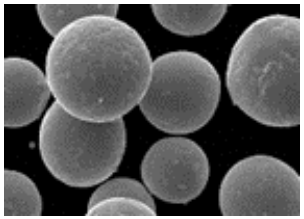
Uncertainties in Equipment and Process Performance

=

Uncertainties in the Final Parts

Challenges in AM / Materials

understand Material and qualify



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understand Equipment, Process and qualify

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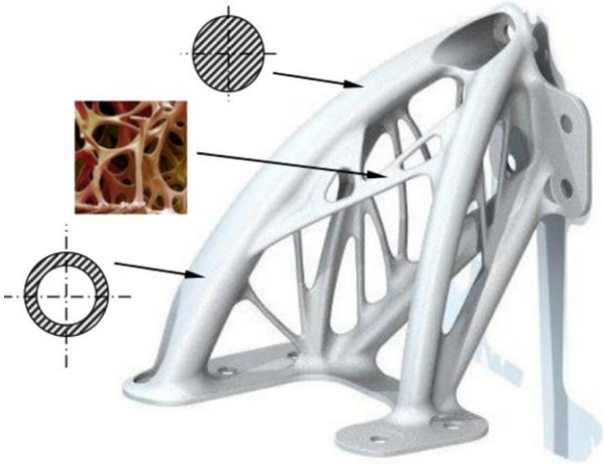
Test Part and qualify



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Industry Activities / Status on Standards

Engine Manufacturer (gathered experience within the last years):

parts manufacturing with cobalt chrome steel alloys, Inconel 718, Inconel 625 and Hastelloy X. Testbed flying of relevant parts has been performed.

Aircraft Manufacturers:

- teaming up with universities and industrial partners (printing machine manufacturers, supplier industry) to gain experience in additive Manufacturing
- Ti6Al4V alloys are going to be applied to airframe and structure parts.
- Classic Al alloys currently being used at airframers side are under ongoing investigation for their use with new manufacturing technology.
- Airframe parts are going to be proposed for certification

Aviation Industry Suppliers:

R&D of integrated systems (actuation systems, air-condition systems etc.)

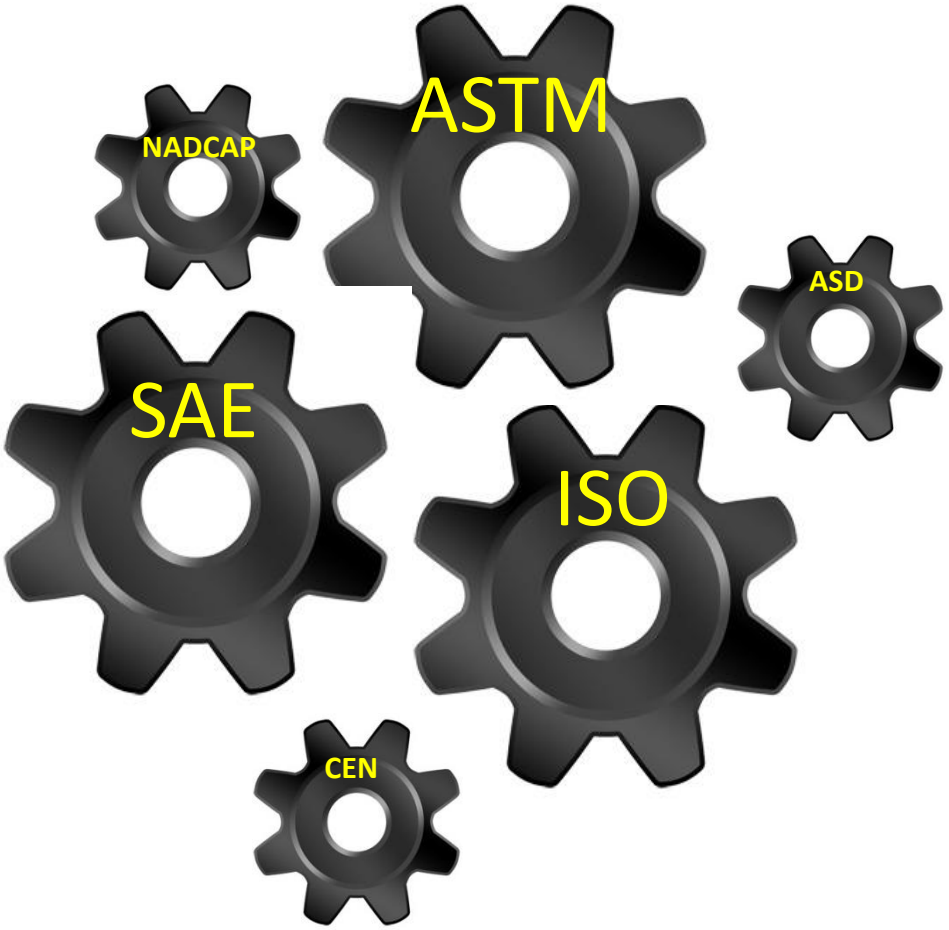
Industry Activities / Status on Standards

- We need technical Standards!
  - **feedstock material** (metal powder, polymer material etc.)
  - **Process** (knowing the machine)
  - **Design**
  - **Testing** (NDI)
  - **Data** security and format
  - **Terminology**

Standardization Bodies / Status on Standards

- ASTM International (American Society of Testing and Materials)
- SAE International (Society of Automotive Engineers)
- ISO (International Organization for Standardization)
  - ASD (AeroSpace and Defence Industries Association of Europe)
  - CEN (European Committee for Standardization)
  - NADCAP (National Aerospace and Defense Contractors Accreditation Program)
  - AFNOR (Association Française de Normalisation)
  - DIN (Deutsche Industrie Norm)

Standardization Bodies / Status on Standards



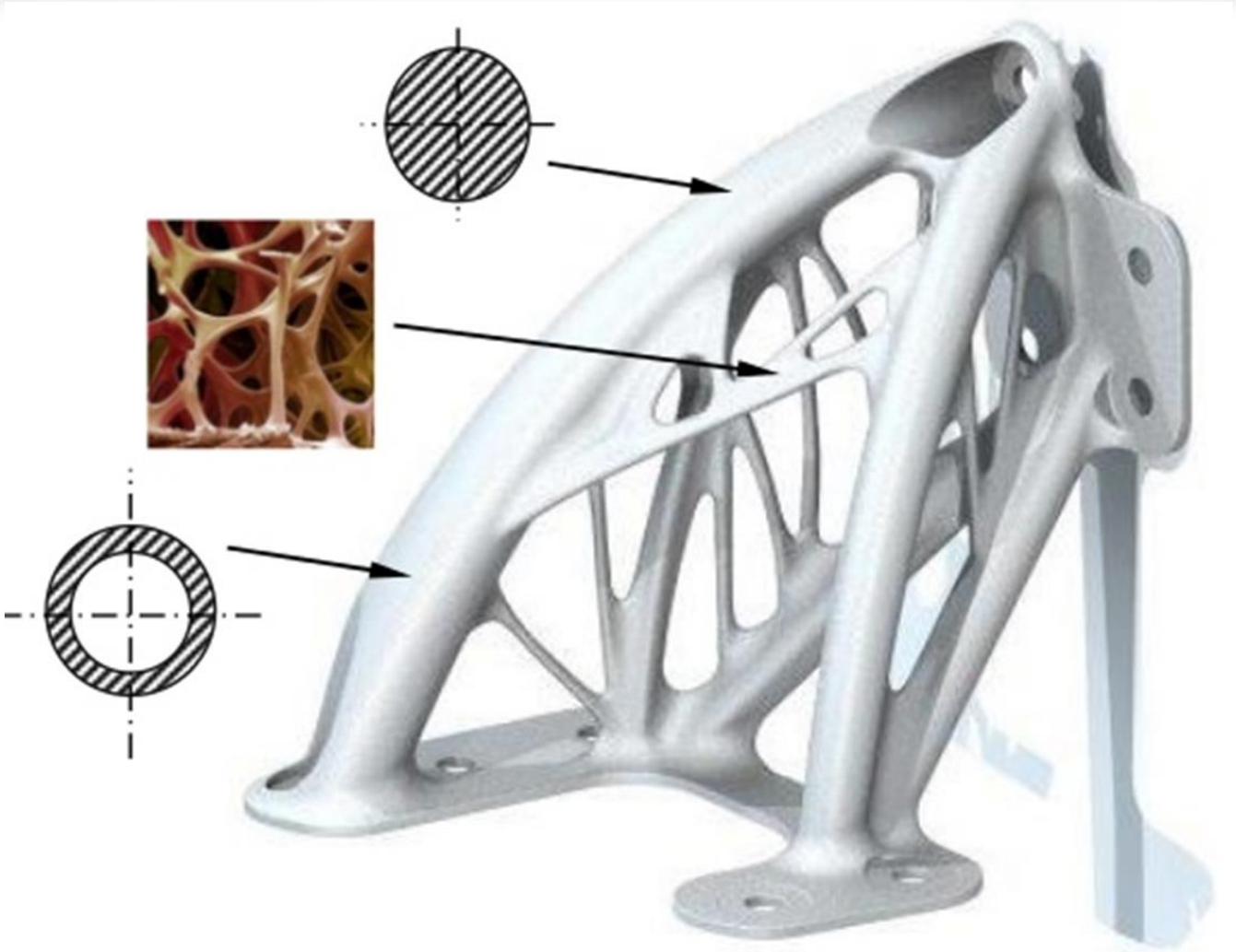
Standardization Bodies / Status on Standards

Barriers for acceptance and harmonization of technical standards are high and compliance issues may result in long periods of certification and qualification.

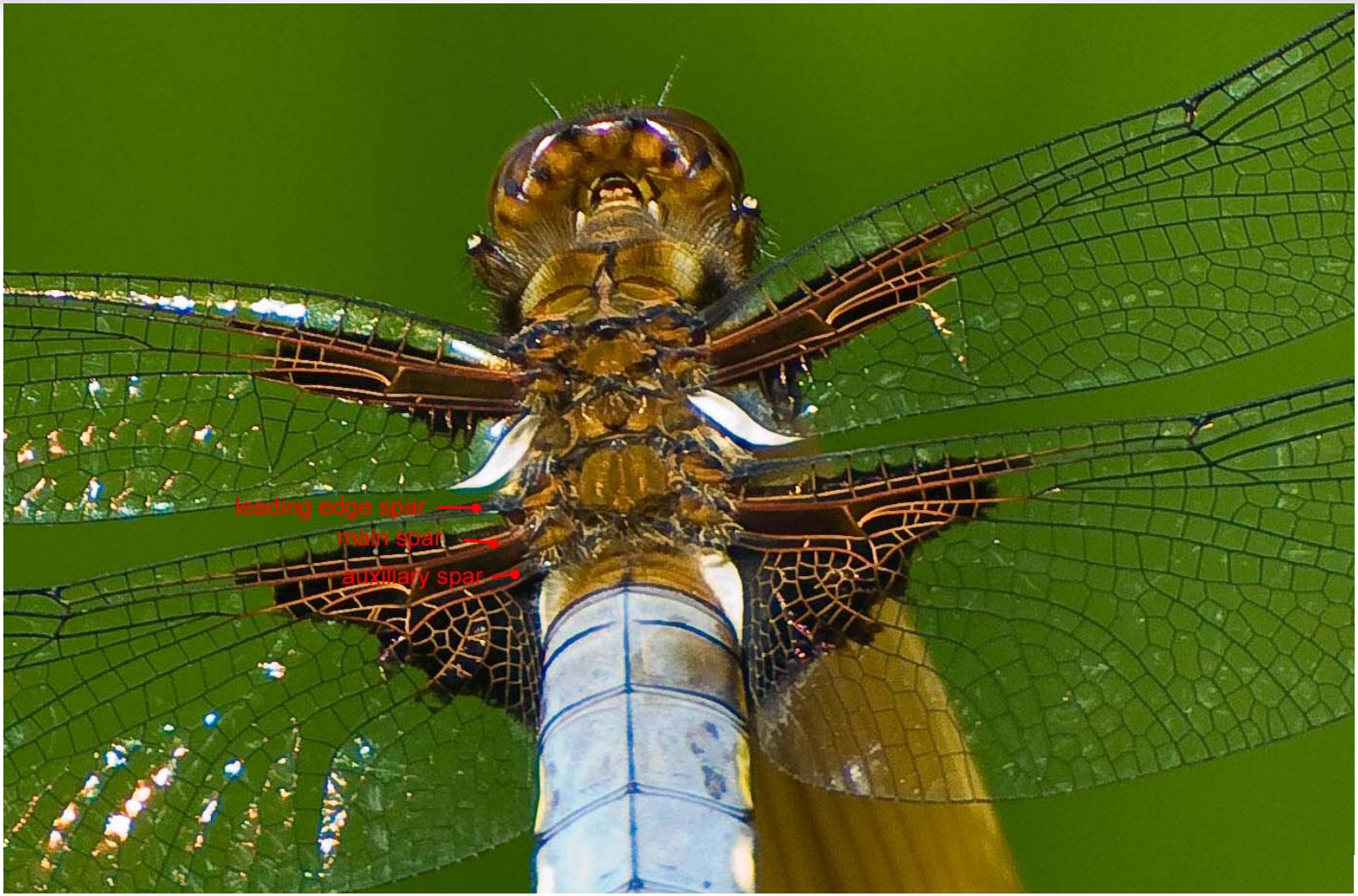
That takes time to do it properly!

- ASTM founded Committee F42 on additive manufacturing in Jan. 2009
- SAE established AMS-AM working group in 2014

Participation in committee F42 / AMS-AM is open to all the technical experts with an interest in stake in the future of additive manufacturing technologies including consumers, federal agencies, manufacturers, suppliers, trading professional associations and members of academia.



Frame work light weight designed structure



Wing Structure of a Dragonfly

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ISO / ASTM / Status on Standards

- International Organisation Standardisation / ASTM under developement:

ISO/ASTM DIS 52903-1

Additive manufacturing -- Standard specification for material extrusion based additive manufacturing of plastic materials -- Part 1: Feedstock materials More details

ISO/ASTM NP 52902

Additive manufacturing -- General principles -- Standard test artefacts More details

ISO/ASTM CD 52903-2

Additive manufacturing -- Standard specification for material extrusion based additive manufacturing of plastic materials -- Part 2: Process – Equipment More details

ISO/ASTM NP 52905

Additive manufacturing -- General principles -- Non-destructive testing of additive manufactured products

ISO/ASTM DIS 52910

Standard practices -- Guidelines for design for additive manufacturing

ISO/ASTM DIS 52901

Additive manufacturing -- General principles -- Requirements for purchased AM parts

ISO / Status on Standards

- International Organisation Standardisation Published:

ISO 17296-2:2015

Additive manufacturing -- General principles -- Part 2: Overview of process categories and feedstock

ISO 17296-3:2014

Additive manufacturing -- General principles -- Part 3: Main characteristics and corresponding test methods

ISO 17296-4:2014

Additive manufacturing -- General principles -- Part 4: Overview of data processing

ISO/ASTM 52921:2013

Standard terminology for additive manufacturing -- Coordinate systems and test methodologies

ISO/ASTM 52900:2015

Additive manufacturing -- General principles – Terminology

ISO/ASTM 52915:2016

Specification for additive manufacturing file format (AMF) Version 1.2

SAE / Status on Standards

materials, processes, equipment, post-processing (such as heat treatment, machining, surface treatment, etc.),

Processes

- **AMS7000 -** Additive Manufacture of Aerospace parts from Ni-base Superalloy 625 via the Laser Powder Bed Process
- **AMS7001 -** Ni Base 625 Super Alloy Powder for use in Laser Powder Bed AM Machines
- **AMS7002 -** Process Requirements for Production of Powder Feedstock for use in Laser Powder Bed Additive Manufacturing of Aerospace parts
- **AMS7003 -** Laser Powder Bed Fusion Process

Materials

Aerospace Standard AMSXXXX for the additive manufacture of parts from Ni-base super alloy 625 via the laser powder bed process

- **AMS5917 -** Metal Injection Molded Nickel Based Alloy 718 Parts Hot Isostatically Pressed, Solutioned and Aged
- **AMS5832G –** Nickel Alloy, Corrosion and Heat Resistant, Welding Wire 52.5Ni – 19 Cr – 3.0 Mo – 5.1 Cb (Nb) – 0.90 Ti – 0.50 Al – 18 Fe Consumable Electrode or Vacuum Induction Melted
- **AMS4999 –** Titanium Alloy Direct Deposited Products 6Al – 4V Annealed
- **AMS4998 –** Titanium Alloy Powder 6Al – 4V

Test Methods (NDI, and mechanical testing)

Design

Terminology