



UK Regulatory Activity on Additive Manufacturing

EASA AM Workshop II

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UK Regulatory Activity on Additive Manufacturing

Content

Civil Requirement Activity

Military Requirement Activity

Civil Regulatory Activity

Civil Requirements

- EASA CM-S-008 “Additive Manufacturing”
 - Certification Specifications
 - Design Organisations
 - Production Organisations

Military Regulatory Activity

UK Military Aviation Authority (MAA)

- The MAA (Military Aviation Authority) is the competent authority for Military Aviation in the UK.
 - Approval Schemes –
 - Design Organisation
 - Maintenance Organisations
 - Continuing Airworthiness Management Organisations
 - Military Air Systems Certification

MAA Regulatory Framework

- Regulations and Regulatory Articles
- Handbooks (Regulatory Article Guidance)
- Def-Stan 00-970 Design and Airworthiness Requirements for Service Aircraft (Aircraft Design/Certification Standards)

Military Aircraft Structural Airworthiness Advisory Group - MASAAG



- MASAAG supports the MAA with regard to the development and renewal of the structural requirements of Def-Stan 00-970.
- MASAAG convened a working group of UK industry, academia and government (military and civilian) personnel to draft a guidance document on the qualification and certification of metallic AM parts.

MASAAG Paper 124

Qualification and Certification of Additive Manufacturing in Military Aviation

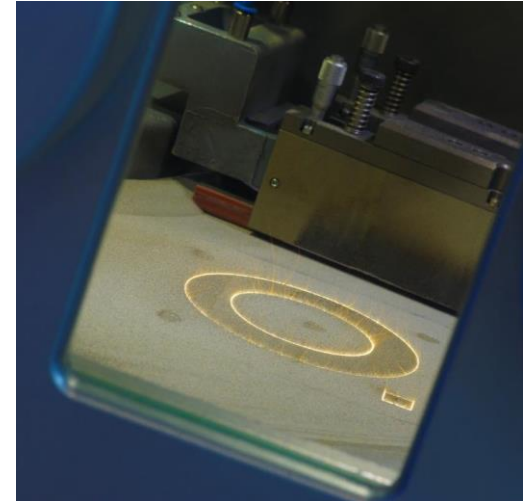
- 9 Chapters, 2 Appendices and a number of case studies discussed in annexes.
- Currently Chapters 1, 2, 3 and 5 have been drafted.

Chapter 3 - Airworthiness Assurance for Manufactured Parts (Aircraft Structures)

- Purpose
To provide a guided “walk through” of the regulations and certification standards used for airworthiness assurance of structural components of military aircraft.
- In the context of the chapter AM is simply another manufacturing process, which will produce scatter in materials properties that needs to be accurately reflected in the material allowables and fatigue properties used during the design and certification of the component.

Chapter 3 – Noteworthy Elements of Def Stan 00-970

- Static Strength and Deformation
- Fatigue
- Material Selection
- Materials and Processes
- Strength of Materials
- Material Design Allowables
- Establishing Fatigue Properties



Chapter 3 – Concluding Remarks

- CS-25 Premium Castings [AMC25.621(c)(1)] approach of ensuring quality for a specified part, alloy, source organisation, and specific process via qualification of the process, proof of product and monitoring of the process.
- The establishment of material design allowables and fatigue properties should use the test pyramid philosophy, starting with large number of coupons/samples testing through smaller numbers of element, detail, and sub-component tests to a few full-scale component tests.

The issue is that AM processes are not mature and thus it is recommended that:

- For Grade A metallic aircraft structures that both the AM process AND the part should be qualified and certified to establish, and provide confidence and assurance, in the variability in their properties.

Chapter 4 - Airworthiness Assurance for Manufactured Parts (Aircraft Engines)

- **Purpose**

To provide a guided “walk through” of the regulations and certification standards used for airworthiness assurance of military aircraft engines.

Chapter 5 – Part Design and Build

- The 4 Main Metallic AM Processes
 - Selective Laser Melting (SLM)
 - Laser Blown Powder
 - Electron Beam Melting (EBM)
 - Arc – WAAM

- It clearly states that there is a necessity for the Design and Production Organisations to work together to develop, and agree the manufacturing specifications that control the process variables and detail the testing required to give confidence that the material/part has been produced to specification.

Chapter 5 – Introduction

- Common Defects
 - Porosity
 - Distortion
 - Stoppage Defects
 - Chemical Defects
- Melting and Solidification
 - Energy Input
 - Primary Heat Source
 - Secondary Heat Source
 - Energy Losses
 - Melt Pool Formation
 - Solidification

Chapter 5 – Part Design

- Part design – the generation of a suitable computer aided design (CAD) model based on the part specification and manufacturability.
 - Physical and Mechanical Properties
 - Part Geometry
 - Design for Anisotropy

Chapter 5 – Build Design

- Build design – the process of taking a CAD model and determining how it will be built using AM.
 - Machine Choice
 - Facilities
 - Health and Safety
 - Heat Sources
 - Robotic Systems
 - Atmospheric Risks
 - Feedstock
 - Part Configuration and Build Support
 - File Conversion
 - Part Orientation
 - Part Location
 - Witness/Test Specimens
 - Scan Strategy
 - Build Parameter / Parameter Set

Chapter 5 – Build Key Performance Variables (KPVs)

- Feedstock
 - Chemical Composition and Entrapped Porosity
 - Storage
 - Powder Feedstock
 - Powder Manufacture
 - Rheology
 - Particle Size Distribution and Morphology
 - Reuse, Reconditioning and Batch Control
 - Wire Fed Systems
 - Feed Rate
 - Electrical Conductivity/Resistivity
 - Diameter
 - Cross-sectional Shape
- Heat Source
 - Powder Bed Systems
 - Layer Thickness
 - Laser/Electron Beam Calibration
 - Direct Energy Systems
 - Calibration of Robotic Movement Systems
 - Material Pre-heating
- Environment
- In Line Measurement and Control

Chapter 5 – Post Processing Techniques

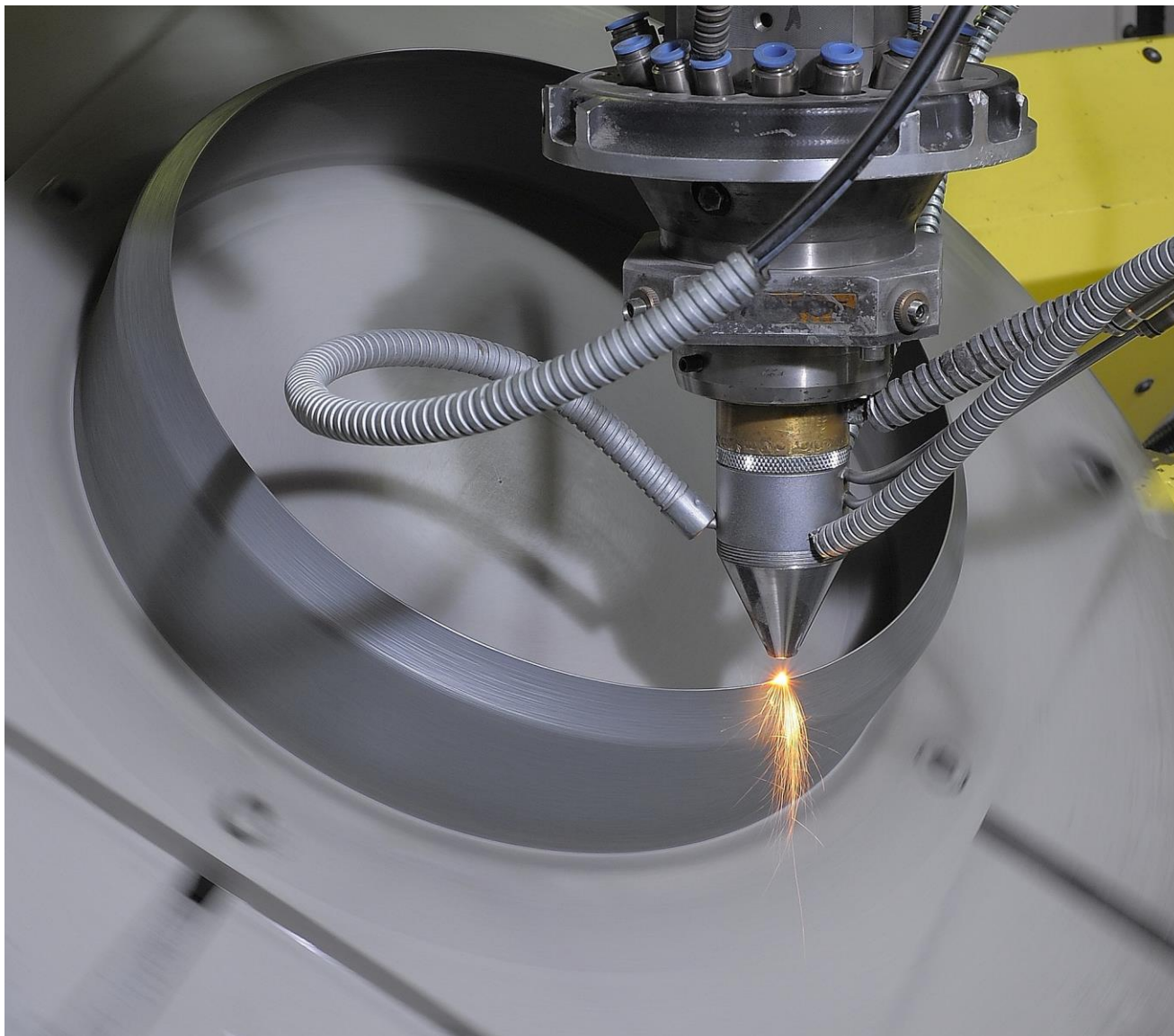
- Post processing – any processes performed on the part once it has been built using AM e.g. machining, surface finishing, stress relieving.
- Part Removal Form Build Plate
- Thermal Post-Processing
 - Heat Treatments
 - Homogenisation and Normalisation
 - Hot Isostatic Pressing (HIP)
 - Solution Treatment and Aging
- Cold Working
- Surface Finishing

Chapter 5 – Component Validation

- Part validation – testing of both the final part and any test specimens to determine whether the part meets the specification.
- Witness, Traveller and Test Specimens
- Inspection
- Part Geometry
- Surface Finish
- Destructive Testing
 - Mechanical Properties
 - Composition
 - Microstructure
- Non-Destructive Evaluation
- Residual Stress Determination

Chapter 5 – Component Handover

- Component handover – documentation and test results required when a final part is handed over to the user.
- Release Documentation



- <https://www.gov.uk/government/publications/military-aircraft-structural-airworthiness-advisory-group-masaag-documents>

Thank You
Any Questions