



# Certification Memorandum

## Additive Manufacturing

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**Regulatory requirement(s):** CS X.571, CS X.603, CS X.605, CS X.613, 25 X.853, CS E 70, CS E 100 (a), CS P 170, CS P 240, CS APU 60, 21.A.20, 21.A.31, GM 21.A.91, 21.A.101, 21.A.131, 21.A.133, 21.A.147, 21.A.247, 21.A.433, GM 21.A.435(a), 21.A.437, 21.A.447, 21.A.805, AMC 145.A.42(c)

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## Log of issues

Issue	Issue date	Change description
01	04.04.2017	First issue.

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## 1. Introduction

### 1.1. Purpose and scope

The purpose of this Certification Memorandum is to provide complementary guidance regarding the introduction and use of Additive Manufacturing (AM) technologies in Products (Aircraft, Rotorcraft and Propulsion) and Parts and Appliances subject to EASA Type Certification.

Note: AM is a term used to cover a broad range of new and emerging manufacturing processes (also known as 3D printing) that involve sequential-layer material addition throughout a 3D work envelope under automated control. This CM does not address established and approved methods which may demonstrate similarities with the evolving definitions of AM, e.g. a repetitive weld build-up repair process accepted prior to the issue of this CM.

### 1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
PART 21, Subpart B	TYPE CERTIFICATES AND RESTRICTED TYPE CERTIFICATES	---	---	---
PART 21, Subpart D	CHANGES TO TYPE CERTIFICATES AND RESTRICTED TYPE CERTIFICATES	---	---	---
PART 21, Subpart E	SUBLEMENTAL TYPE CERTIFICATES	---	---	---
PART 21, Subpart G	PRODUCTION ORGANISATION APPROVAL FOR PRODUCTS, PARTS AND APPLIANCES	---	---	---
Part 21, Subpart J	DESIGN ORGANISATION APPROVAL	---	---	---
Part 21, Subpart M	REPAIRS	---	---	---
Part 21, Subpart O	European Technical Standard Order Authorisations			
GM to Part 21	Guidance Material for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations	---	---	---

### 1.3. Abbreviations

ADOA	Alternative Procedures to Design Organisation Approval
AM	Additive Manufacturing
AMC	Acceptable Means of Compliance



CM	Certification Memoranda
CRI	Certification Review Item
CS	Certification Specification
DO	Design Organisation
DOA	Design Organisation Approval
EASA	European Aviation Safety Agency
GM	Guidance Material
POA	Production Organisation Approval
TCH	Type Certificate Holder
X	Place holder for Certification Specifications 22, 23, VLA, 25, VLR, 27, 29

## 2. Background

Additive Manufacturing (AM), also known as 3-D printing, refers to a range of manufacturing methods where the as-purchased material (i.e. metallic powder, wire, etc.) is consolidated by a machine into a near-finished part. For example, for metallic materials, typically the as-purchased material is deposited in the machine by various methods and fused using lasers, electron beams, plasma or electrical arc into a near final shape component or surface, whilst non-metallic materials may be heated and extruded through a moving nozzle to create a final part. As such, AM materials are process dependent, which will need special attention in the preliminary implementation phase for each manufacturer. It is essential that design values used for AM materials reflect not only the variability of the constituent materials as purchased by the suppliers, but also the variability introduced by the manufacturing process used to fabricate production parts. AM variability is to be shown to be controlled through material specifications in combination with process controls defined in process specifications, including post processing operations. As required by 21.A.31, these specifications (for both, material and process) as well as the method(s) of manufacture, shall be introduced in the type design under the design approval applicant or holder responsibility.

The significance of any change, including the introduction of new materials and processes, will be a function of part criticality and/or the magnitude of the change relative to any particular organisations experience and will be assessed by EASA on a case by case basis.

## 3. EASA Certification Policy and Guidance for DOA, ADOA and POA Holders

All aviation parts and products are required to meet the relevant certification specifications respectively, including the ETSO minimum performance standards, according to the type certification basis, e.g. regarding strength, durability, flammability etc., regardless of the material and process combination used to generate the engineering properties.

Independent of the facility where parts are to be fabricated the applicant should demonstrate by test or experience, that the material is suitable for the intended use of the part being fabricated and that the material is being purchased per an approved material specification and controlled by approved inspection methods. The applicant should show that the derived AM design values are based upon representative statistically significant test data (to the level required by the applicable CS code and application) which is adequately robust to addresses all key production parameters and which is sufficiently robust to capture machine-to-machine variation within and between facilities. Furthermore, it should be shown that values obtained from tests conducted on simple specimens accurately represent the mechanical properties of the



intended parts. However, complex parts and processes may require testing in the test/analysis pyramid above coupon level to truly represent the engineering properties resulting from the material and process combination.

In addition to the established production process parameters, actual part properties are influenced by multiple other factors, including part orientation during the build process and the support structure required during the build operation (which is subsequently removed). Furthermore, the part configuration may include inaccessible surfaces (which cannot be machined or surface treated) such that the engineering properties may be different to those of the bulk material and/or other machined or surface treated material. There may also be a potential anisotropy resulting from sequential layer-by-layer addition of material.

The applicant is responsible for ensuring that design values used in the evaluation of any parts produced using AM are applicable to the material and process specifications used to fabricate the parts and that the design values are applicable to the facilities at which the parts are fabricated. This should be supported by appropriate process and inspection controls such that Product integrity is maintained.

Applicants should also provide evidence that materials and processes are addressed by specifications that are under revision control.

The use of additive manufacturing should also be considered when establishing the certification programme in accordance with 21.A.20.

### **Repairs and Design Changes:**

In accordance with the Guidance Material contained in Appendix A to GM 21A.91 the use of AM in Changes and Repairs to Type Certificates and Supplemental Type Certificates is considered to be a change to the material, process and method of manufacture and should be evaluated as such when classifying changes and repairs. For repair and repair design the guidance contained in this Certification Memoranda (relevant requirements under appendix 1 of this CM) should also be considered when evaluating the use of AM. The use of AM in repairs and design changes may be classified Major based upon the level of substantiation required. Applicants are advised to consult the Agency when introducing AM in repairs including cases where they hold a privilege for repair design approval.

### **Impact of AM on design organisations:**

Design Organisation Approval Holders as well as ADOA are advised to involve the Agency at the earliest opportunity during the development and implementation of AM. It is envisaged that the use of AM will be subject to increased oversight by the agency and that specific audits will be scheduled to examine the introduction and use of AM within the scope of the design organisation audit cycle. These audits may take place concurrently with the review of AM applications rather than post approval.

Note: The introduction of additive manufacturing may represent a significant change to the Design Assurance System of the DOA Holder according to 21.A.247 and the approval process for such a change should be followed by the respective DOA Holder.

### **Impact of AM on production organisations:**

Production Organisation Approval holders are advised to inform their respective competent authorities at the earliest opportunity before the implementation of AM processes.

Implementation of an AM process by a POA holder is controlled through the applicable design data identified and transferred to the POA holder under the responsibility of the design approval applicant or holder. The design approval applicant or holder is also responsible for showing that the applicable design data complies with the requirements of 21.A.31. The POA holder shall ensure compliance to the applicable design data of the items it produces under its POA.



Implementation of an AM process by a POA holder that is new for the POA holder is a change that may be identified as a significant change in accordance with Part 21.A.147 and related guidance material. Depending on circumstances, such a change may not necessarily be a significant change.

It is ultimately the responsibility of the TCH to ensure the method, or any changes, are appropriately addressed. Therefore, a robust communication process between the POA and the DOA should be demonstrated. Applicants are therefore reminded of the published design data requirements in Part 21.A.131.

To ensure that such a change does not result in any non-compliance with Part 21 Section A Subpart G, it is in the interest of both the competent authority and the POA holder, to establish a relationship and exchange information that will permit the necessary evaluation work to be conducted before the implementation of the change. In case of such a change, the competent authority is recommended to inform the EASA Certification Directorate, and, as usual, these parties are also recommended to cooperate closely. It is recommended that the use of AM will be subject to specific oversight by the competent authority, either in the frame of significant change(s) according to Part 21.A.147 (when applicable) and/or continued surveillance of the POA.

#### 4. Whom this Certification Memorandum affects

This Certification Memorandum is applicable to applicants introducing AM during certification of Products, Parts and Appliances, Design Changes to Products, Parts and Appliances and Repairs to Products in compliance with the material and fabrication related requirements in CS-22, CS-VLA, CS-23, CS-25, CS-VLR, CS-27, CS-29, CS-E, CS-P, CS-APU, or equivalent requirements. It is also relevant to DOA and POA Holders and their competent authorities.

Note: The intent of this CM is also applicable to ETSO applicants and to PART 145 organisations for awareness purposes and limitations associated with interpretation of AMC 145.A.42(c).

#### 5. Remarks

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail [CM@easa.europa.eu](mailto:CM@easa.europa.eu).
2. For any question concerning the technical content of this EASA Certification Memorandum, please contact the appropriate EASA focal point as identified in Appendix 2.



## Appendix 1

All aviation parts and products are required to meet the relevant certification specifications according to the type certification basis, e.g. regarding strength, durability, flammability etc., regardless of the material and process combination used to generate the engineering properties. However, those likely to require particular attention associated with the introduction of AM include:

- CS X.603 Materials
- CS X.571 Fatigue & Damage Tolerance
- CS X.605 Fabrication Methods
- CS X.613 Material Strength Properties and Material design Values
- CS X.853 Compartment Interiors
- CS E 70 Materials and Manufacturing Methods
- CS E 100 Strength (a)
- CS P 170 Materials and Manufacturing Methods
- CS P 240 Strength
- CS APU 60 Materials
- PART 21.A.20 Compliance with the type-certification basis, operational suitability data certification basis and environmental protection requirements
- PART 21.A.31 Type Design
- GM 21.A.91 Classification of Changes to type design
- PART 21.A.101 Designation of applicable certification specifications and environmental protection requirements
- PART 21.A.131 Scope – Applicable Design Data
- PART 21.A.133 Eligibility
- PART 21.A.147 Changes to the approved production organisation
- PART 21.A.247 Changes in design assurance system
- PART 21.A.433 Repair Design
- GM 21.A.435 (a) Classification of Repairs
- GM 21.A.437 Issue of Repair Design Approval
- PART 21.A.447 Record keeping
- AMC 145.A.42(c) Acceptance of Components



## Appendix 2

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Propulsion (Engines, Propellers & APU)	M. Mercy	<a href="mailto:matthew.mercy@easa.europa.eu">matthew.mercy@easa.europa.eu</a>
Cabin Safety	T. Ohnimus	<a href="mailto:thomas.ohnimus@easa.europa.eu">thomas.ohnimus@easa.europa.eu</a>
Design Organisation Approvals	A. Enache	<a href="mailto:alexandru.enache@easa.europa.eu">alexandru.enache@easa.europa.eu</a>
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