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# Airbus approach for F&DT stress justification of Additive Manufacturing parts

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**Abstract**

Additive Manufacturing (AM) is rapidly expanding in aviation due to the advantages it offers compared to conventional manufacturing routes. It allows the production of geometry optimized complex parts with an efficient use of material. However, in order to design reliable parts using this novel manufacturing route, the changes it involves in material properties, defects and shape of parts need to be understood. This paper presents an industrial structural analysis approach applied by AIRBUS to justify newly introduced AM parts on aircraft. Some areas for future development and improvement are also presented.



*Keywords:* Additive Manufacturing; Powder Bed; Fatigue; Defects;

## 1. Introduction

Additive Manufacturing (AM) is rapidly expanding in aviation due to the advantages it offers compared to conventional manufacturing routes. It allows the production of geometry optimized complex parts with an efficient use of material and in a relatively simple and quick manner. However, in order to design reliable parts using this

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novel manufacturing route, the changes it involves in material properties, defects and shape of parts need to be understood.

This paper presents an industrial structural analysis approach applied by AIRBUS to justify newly introduced AM parts on aircraft. It shows that the Fatigue & Damage Tolerance (F&DT) stress justification approach for answering the certification requirements is consistent with the conventional process already applied on plates and forgings. The paper initially discusses the certification requirements to be met by aircraft parts. The types of defects generated by AM, and the associated inspection techniques are presented. Stress methods and design values are explained after. Finally, areas for future development and improvement are highlighted before reaching the conclusions.

This document focuses on Titanium 6Al-4V material with Powder Bed technology.

## 2. Certification requirements

AIRBUS determined that the current certification standard is fully applicable for AM parts. The AIRBUS processes for material qualification, design value definition and stress analysis approach for AM have been agreed with the European Aviation Safety Agency (EASA). Although current regulation is found to be appropriate, Airworthiness Authorities and OEMs are working to set an industrial standard specific to AM technology.

The main applicable certification standards chapters are discussed below in the context of AM application:

- Materials - 25.603 (a)(b)(c) : Approved technical and material specifications are in place specific to the AM technology. These specifications have been established on the basis of experience and tests. Suitability and durability of materials are accounting for the environmental conditions expected in service.
- Fabrication methods - 25.605 (a)(b) : The manufacturing processes used are qualified according to approved process specifications. Close control of all the produced parts and a consistent sound structure is ensured through the qualification test programme and the inspection procedures defined in these specifications.
- Material design values - 25.613 (a)(b)(c) : The material strength properties are defined from tests with material produced following the approved specifications for AM. Results obtained from different machines, powders and material directions are considered and design values derived following statistical treatments. Approved material design values are available for static, fatigue and damage tolerance evaluations. Comparisons with data from same material but conventional technologies (plates, forgings, castings) are also performed.
- Damage tolerance and fatigue evaluation of structure - 25.571 : Fatigue & Damage Tolerance approaches applied on conventional technologies remain applicable. The only differences being the inclusion of fatigue knock-down factors related to the surface finish process of the AM part. For damage tolerance based inspection thresholds, the initial flaw size currently used on conventional technologies is found to remain valid for AM Powder Bed technology.

## 3. Type of defects

Understanding the type of defects created by AM technology is a key point in order to properly address the certification requirements and implementing appropriate F&DT justification approaches.

In the frame of effect of defects, some work was conducted to characterize the influence of various parameters. As part of the research phase, a catalogue of typical defects was built so that the right technique to detect them could be down-selected. Defects can be classified in two categories: internal defects and surface defects.

### *3.1. External: possible defects and inspection means*

External defects can be classified in two main categories: the ones inducing cracks or voids and the ones inducing roughness or printing artefacts.

In the defect category inducing cracks or voids, the defects described in Table 1 may exist (non-exhaustive). This first category of defects can be detected quite easily by classical liquid penetrant testing inspection. The challenge is to have an appropriate surface preparation allowing good interpretation of the results.