EASA
European Union Aviation Safety Agency

Additive Manufacturing

CM-S-008

Presentation by:

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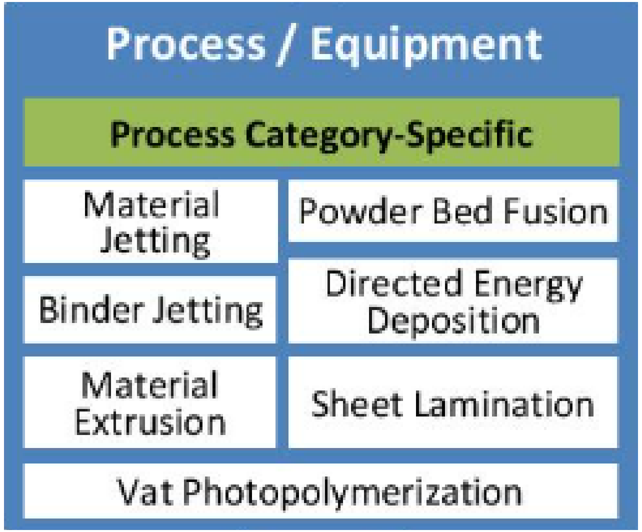
Contents

Many processes and methods



ISO/ASTM 52900

- → metallic/non-metallic
- → single material, multi-material, + fillers,
- → hybrid processes, e.g. icw conventional methods
- → Many benefits, e.g. rapid prototype evolution, reduced part count, weight reduction, ‘optimised’ design, etc.

Material and Process in the Regulations

EC No 216/2008 Annex II
1.1 Structures and materials
the **integrity of the structure must be ensured throughout, and sufficiently beyond, the operational envelope for the aircraft,** including its **propulsion system**, and maintained for the **operational life** of the aircraft.

Part 21.A.31 Type Design
[…] consists of:
2. Information on **materials and processes** […] **methods of manufacture and assembly**
[…]

AMC 20-29 Composite Aircraft Structure

Basic Regulation

(EU) 2018/1139

Implementing rules

Initial Airworthiness

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.

Implementing rules

Part 21.A.133 Eligibility
- Any process that can have an impact/effect on a part needs to be evaluated

Part 21.A.147(a) Changes in the production management system
- Changes in production

Part 21

- Acceptable means of compliance (AMC)
- Guidance material (GM)

Certification specifications

- Airworthiness codes

Acceptable means of compliance (AMC) Guidance Material (GM)

- Part M – Continuing Airworthiness
- Part-145 – Maintenance Organisations

- CS2X.603 Materials
  'suitability and durability […] based upon experience/test […] meet approved specifications, […] consider environmental effects
- CS2X.613 Mechanical Strength Properties and Design Values Materials
  (a) […] design values based upon a statistical basis

EU Parliament
EU Council

EU Commission

EASA

Binding

Non-Binding

LoI and other regulatory activities of relevance…

Performance Based Regulation* (PBR):

“A regulatory approach that focuses on desired, measurable outcomes”

(*https://www.easa.europa.eu/sites/default/files/dfu/Report%20A%20Harmonised%20European%20Approach%20to%20a%20Performance%20Based%20Environment.pdf)

Level of Involvement (21.B.100):

Novelty
- Maybe novel, if the technology or application is novel to the applicant, e.g. new manufacturing process, new materials

Complexity
- Maybe complex, e.g. increased complexity of design, inspection techniques in areas difficult to access,

Criticality
- Maybe critical, e.g. a failure of the affected structure being potentially catastrophic

Prescriptive Guidance:

More prescriptive guidance requested, e.g. supported by standards bodies etc.

Even though engineering properties are typically product specific!

Engineering properties

- AM Engineering Properties are defined:
  - by the material/process/fabrication method
  - during consolidation of the complex part or repair

- challenges:
  - complex parts – base pyramid coupon data may not represent the complex part properties
    (although stable simple base pyramid data is important…otherwise, how can the higher pyramid work be trusted?)
  - sensitive processes – a major challenge if completing production activities in a more challenging maintenance environment

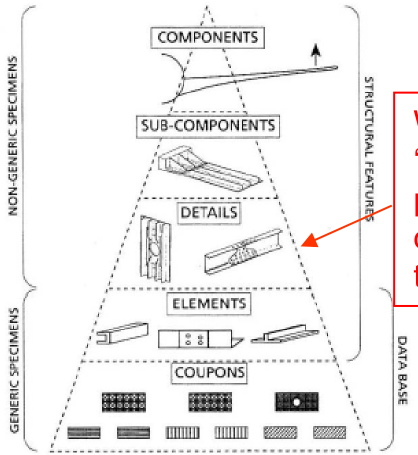
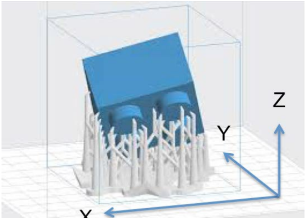


Figure 1 - Schematic diagram of building block tests for a fixed wing.

Where are the 'engineering properties' developed in the pyramid?

e.g. AM, composites, bonded joints, advanced alloys

e.g. no access to free edges – fatigue issue?



e.g. support structure on the build platform

CM content overview

<u>Section 2</u>
<u>(not policy)</u>

'background/discussion/ context/future development potential

Table of Content

<u>Section 3</u>
<u>(policy)</u>

- initial application information expectations
- 'no and low' criticality applications only at this CM revision (supported by Appendix 2,3,and 5)

CM – Criticality

2. Background – increasing development of AM use in aviation and the EASA regulations

Design certification 'Criticality' and proportionate certification effort demonstration:

→ **Criticality** is used extensively throughout the regulations and in industry in various contexts which may impact product and/or passenger safety

→ **Part criticality** is a measure of the significance of a part to the overall safety of a product or its occupants. (Possibility: FMEA for Design Assessment)

→ **Manufacturing process criticality** is a measure of the significance of sensitivity of AM engineering properties to M&P and the process variations.

→ **Procedural/administrative criticality** e.g. inappropriate use of certification processes

Criticality classification

Based on ASTM F3572-22

Focus of current draft revision:
Class C and D
(No / Low Criticality)

ASTM F3572-22 Classification	Consequence of Failure	General Description	Application for engine products (CS-E 510), propellers (CS-P 150) and APU (CS-APU 210)	Application for aircraft products (CS-25.1309, CS-23, CS-27, CS-29, CS-22, CS-VLA)
A	High	Part whose failure can directly affect continued safe flight and landing Part whose failure can result in serious or fatal injury to passengers or cabin crews or maintenance personnel Part whose failure can result in excessive workload of flight crew	**HAZ** engine/propeller/APU Effects	**CAT/HAZ** aircraft effects
B	Medium	Part whose failure can indirectly affect continued safe flight and landing Part whose failure can result in minor injury to passengers or cabin crews or maintenance personnel Part whose failure can result in significant increase in workload of flight crew	**MAJ** engine/propeller/APU Effects	**MAJ** aircraft effects
C	Low	Part whose failure has no effect on continued safe flight and landing Part whose failure has no effect on passenger or cabin crew or maintenance personnel safety Part whose failure can result in slight reduction in operational/functional capabilities Part whose failure can result in slight increase in workload of flight crew	**MIN** engine/propeller/APU Effects	**MIN** aircraft effects
D	Negligible or No Effect	Part not covered above Part whose failure would pose no risk of damage to other equipment or personnel Parts not affecting operational/functional capabilities	No effect	No effect

Appendix 4: Certification effort proportionality to part criticality

			Material and Process control	Design Values	Static Strength	Fatigue / Damage Tolerance
Requirements for Structures & CS 27/29.1309 Equipment, systems and installations (7)	Helicopters		CS 27/29.603 Materials and CS 27/29.605 Fabrication methods	CS 27/29.613 Material strength properties and Material Design Values	CS 27/29.305 Strength and deformation CS 27/29.307a Proof of structure	CS 27.571 Fatigue evaluation of flight structure CS 29.571 Fatigue tolerance evaluation of metallic structure CS 27/29.573: Damage tolerance and fatigue evaluation of composite rotorcraft structures
Part Classification (see new ASTM-F42 standard)	**A**	(CAT)	X	X (3)	X (4)	X
		(HAZ)	X	X (3)	X (4)	TBD(9)
	B	(MAJ)	X	X (3)	X (4)	TBD(9)
	C	(MIN)	S (2)	S (5)	S (4)	TBD9)
	D	(NSE)	N (1)	N (1)	N(1)	N (1)

Engagement with EASA

(NSE parts without EASA?)

DOA

- → AM introduction impacts the Design Management System (DMS) of a DOA.
- → A new process/technology to be used needs to be covered in the DOA Handbook
- → Gap Analysis by the applicant necessary if introducing new processes including
  - → Criticality determination
  - → Material control
  - → Competent people

POA

- → A POA shall either (as per 21.A.133)
  - → Hold or have applied for approval of a specific design
  - → Show satisfactory coordination and communication between POA and DOA
    - → This includes airworthiness data including material specifications and processes
- → AM considered a significant change under POA
  - → GM1 21.A.147: “significant changes to the production capacity or **methods**”

Engagement with EASA

- Importance of
  - the End to End format including design, production, in-service, raw material, equipment suppliers (e.g. AM Machine Manufactures, Suppliers)
  - the interfaces along the supply chain, between stakeholders, and between disciplines, e.g. airframe - propulsion

Conclusion

- → Existing requirements already cover AM (including LOI)
- → Engineering properties are defined during part consolidation
  - → Identify Key Process Parameters and demonstrate an understanding of engineering properties and their sensitivity (no industry standards yet)
  - → statistical coverage of engineering properties
    - → considering variability, competing damage and failure modes
    - → appropriate use of “Point Design” strategy (testing details, not coupons)
- → Proportionate certification effort under discussion
- → Early EASA engagement is important

Reminder: the intent of all appropriate regulations should be met!

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EASA-FAA AM Workshop 2025

21st to 23rd of October 2025

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Thank you for your attention!

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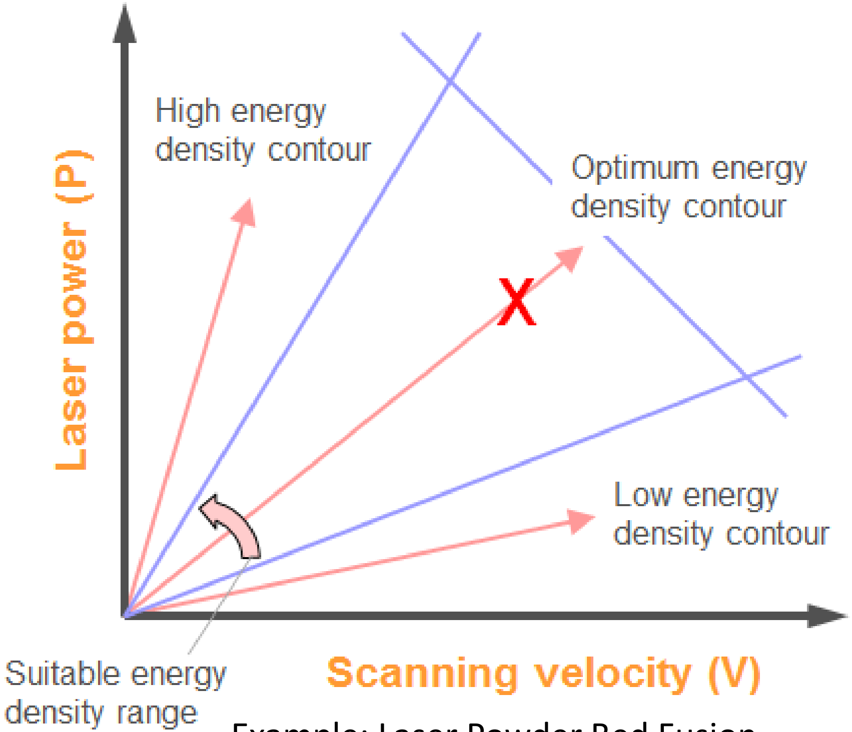
Support Slides

Influence of parameters



Example: Laser Powder Bed Fusion

- **100+ control parameters**
- **Multiple 'Key Process Parameters '**

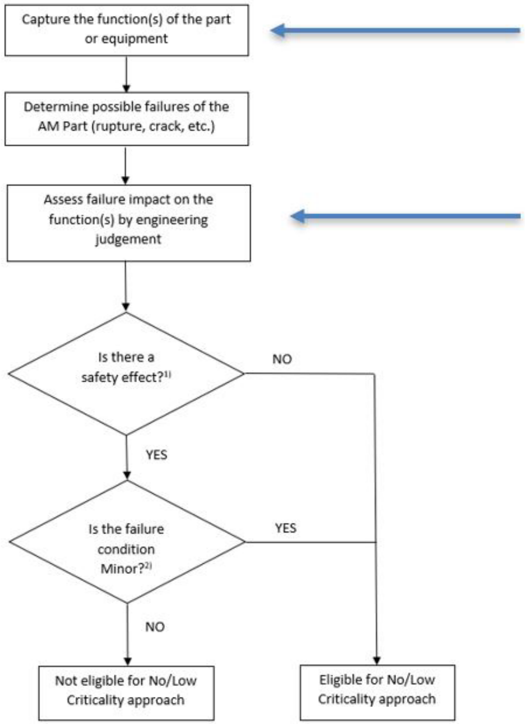
Metallic/non-metallic and many processes generalisation:

Boundary definitions:

- **KPP** definition?
- **Competing defect/damage modes**?
- **Statistical credentials** (A, B-Basis, or C, D-Basis)?
- **Sensitivity** (% change in '**engineering properties**' wrt **KPPs**?)

Appendix 3. Design safety assessment for AM parts of no or low criticality (Class C and D)

Intended to support 'top down' and 'bottom up' Safety Assessments



Consider any potential for interaction between functions
- Airframe, Systems, Propulsion, Interiors (including seats) etc

Also consider potential for any new failure modes (relative to conventional technologies and applications) to change the safety outcome beyond direct functionality of the part to include other potential threats, e.g. debris, PDA impact, system ingestion, flammability, introduction of sharp interior edges etc

1) <u>**No Safety Effect (Cat.D)**</u> Part the failure of which would pose no risk of damage to other equipment, personnel, or reduce operational/functional capabilities

2) <u>**Minor (Cat.C):**</u> Part the failure of which has no affect on continued safe flight and landing, no affect on pax or cabin crews, but can result in a slight reduction in operational/functional capabilities or a slight increase in workload for the flight crew