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WICHITA STATE UNIVERSITY

2024 FAA/EASA Workshop
Working Group 4: Part Classification

IMI3

INDUSTRIAL MODERNIZATION
OF MATERIALS & MANUFACTURING

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Day 1: WG4

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AM Part Classification

F3572 – 22 *(Standard Practice for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation)* **is the most well-known reference for this topic and has been the reference for WG1 focused on class C & D.**

1. Scope

1.1 This practice is intended to be used to assign part classifications across the aviation industries that use AM to produce parts.

1.2 This practice is applicable to all AM technologies defined in ISO/ASTM 52900 used in aviation.

1.3 This practice is intended to be used to establish a metric for AM parts in downstream documents.

1.4 This practice is not intended to establish criteria for any downstream processes, but rather to establish a metric that these processes can use.

1.5 The part classification metric could be utilized by the engineering, procurement, non-destructive inspection, testing, qualification, or certification processes used for AM aviation parts.

1.6 The classification scheme in this practice establishes a consistent methodology to define and communicate the consequence of failure associated with AM aviation parts.

1.7 This practice is not intended to supersede the requirements and definitions of the applicable regulations or policies, including but not limited to the ones listed in Annex A1.

1.8 Tables A1.1-A1.3 align the existing regulations and guidance with the four part classes established herein. However, this alignment should not be construed as an alignment of the existing regulations to each other.

1.9 The material or process, or both, in general does not affect the consequence of failure of a part, therefore the Classification scheme defined in this document may be used outside AM.

1.10 The user of this standard should not assume regulators' endorsement of this standard as accepted mean of compliance.

F3572 – 22

TABLE 1 Part Classifications

Classification	Consequence of Failure	Non-exhaustive Examples
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 Part whose failure requires exceptional piloting skill of flight crew to compensate
B	Medium	Part whose failure can indirectly affect continued safe flight and landing Part whose failure can result in minor injury to flight crew, passengers, or cabin crews Part whose failure can result in significant increase in workload of flight crew
C	Low	Part whose failure has no effect on continued safe flight and landing Part whose failure has no effect on flight crew, passengers, or cabin crew 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
D	Negligible or No Effect	Part whose failure would pose no risk of damage to other equipment or injury to the ground personnel Parts not affecting operational/functional capabilities

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FAA FAR Criticality Examples

Part 27 Airworthiness Standards: Normal Category Rotorcraft

§ 27.602 Critical parts.

(a) *Critical part.* A critical part is a part, the failure of which could have a catastrophic effect upon the rotocraft, and for which critical characteristics have been identified which must be controlled to ensure the required level of integrity.

(i) Non-containment of high-energy debris;

(ii) Concentration of toxic products in the engine bleed air intended for the cabin sufficient to incapacitate crew or passengers;

(iii) Significant thrust in the opposite direction to that commanded by the pilot;

(iv) Uncontrolled fire;

(v) Failure of the engine mount system leading to inadvertent engine separation;

(vi) Release of the propeller by the engine, if applicable; and

(vii) Complete inability to shut the engine down.

Part 33 Airworthiness Standards: Aircraft Engines

§ 33.70 Engine life-limited parts.

By a procedure approved by the FAA, operating limitations must be established which specify the maximum allowable number of flight cycles for each engine life-limited part. Engine life-limited parts are rotor and major static structural parts whose primary failure is likely to result in a hazardous engine effect. Typically, engine life-limited parts include, but are not limited to disks, spacers, hubs, shafts, high-pressure casings, and non-redundant mount components. For the purposes of this section, a hazardous engine effect is any of the conditions listed in § 33.75 of this part. The applicant will establish the integrity of each engine life-limited part by:

§ 33.75 Safety analysis.

(g) Unless otherwise approved by the FAA and stated in the safety analysis, for compliance with part 33, the following failure definitions apply to the engine:

(1) An engine failure in which the only consequence is partial or complete loss of thrust or power (and associated engine services) from the engine will be regarded as a minor engine effect.

(2) The following effects will be regarded as hazardous engine effects:

(3) An effect whose severity falls between those effects covered in paragraphs (g)(1) and (g)(2) of this section will be regarded as a major engine effect.

(1) An engine failure in which the only consequence is partial or complete loss of thrust or power (and associated engine services) from the engine will be regarded as a minor engine effect.

FAR 21, 25, 27, 33, & 43 define different levels of criticality/effect with different definitions

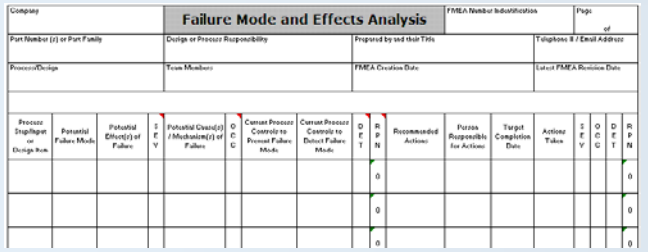
Criticality vs Risk vs FMEA

Criticality (or Severity) x **Likelihood** (or Probability, or Occurrence) x **Detectability** (or controls)

Criticality

Risk (quantitative) **or FMECA** (qualitative)

FMEA



RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

MIL-STD-882E FMECA (Distribution A)

Quantitative Risk Assessment

§ 33.75 Safety analysis.

(4) The applicant must show that major engine effects are predicted to occur at a rate not in excess of that defined as remote (probability range of 10^{-5} to 10^{-7} per engine flight hour).

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Common Definition for AM Part Classification

Pros

- Notes…

Cons

- Notes…

What is the intended value in defining AM part classifications?

- Notes…

Can part classification provide a path to common certification requirements?

- Notes…

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Day 2: WG4 + WG1

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Combined WG1 and WG2

- WG1 Debrief
- WG4 Comments on WG1 debrief

- WG4 Debrief
- WG1 Comments on WG4 debrief

WG4 comments on WG1 Debrief

- Singling out AM for part classification creates risk and reinforces the idea that AM automatically means higher risk.
- Designer and regulator should and could work out the classification decision and requirements while producers receive requirements and execute.
- Part classification could create uniform verbiage, framework for classification requirements, assured quality and product safety, and reduced costs by minimizing barriers to entry and unnecessary requirements (particularly for lower classes).
- Part classification guidance documentation is more targeted towards SMB and would help provide framework for qualification/certification efforts.

WG1 comments on WG4 Debrief

- Notes…

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Recommended path forward

- Consider items such as:
  - How should differences in FAR requirements be handled?
  - How should criticality vs risk be handled?
  - Should military classifications be included with the FAA/EASA?
  - If the creation of AM discrete part classifications is not recommended, is there an alternate approach to provide guidance of the application of FAR classifications to AM parts?
  - How do we mitigate the risk of AM defining discrete part classifications while other manufacturing methods does not.
    - From 3572: *"The material or process, or both, in general does not affect the consequence of failure of a part, therefore the Classification scheme defined in this document may be used outside AM".*
  - Beginning with the end in mind: Consider the intended value of defining discrete AM part classifications
  - What is the intended use of AM part classifications within the context of FAA certification?
  - Should this working group continue? If, so what is the charter?

Recommendations

- Notes…