



ASTM-F42.07.01 Aviation Status Report for EASA – WG1

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Structures Core, Structures Safety & Airworthiness
Boeing Commercial Airplanes

Aviation Vice-chair: Michael Gorelik (FAA)
Secretary: Lloyd Schaefer (General Atomics)

ASTM-F42.07.01 SME Working Groups

- Established separate small group working meetings
 - Testing (Rogie Rodriguez - Boeing)
 - M&P (Adam Sutton - Lockheed)
 - NDI (Steve James – Castheon & Lloyd Schaefer – General Atomic)
 - Design / Product Definition (John Schmelzle – NAVAIR & Charles Park - Boeing)
- Major Progress
 - WK70164 Part Classifications for Aviation
 - WK75655 Reporting Data for Test Specimens (Revision of F2971-13)
 - WK75329 NDT for Laser Based Powder Bed Fusion for Aerospace Components

Aviation AM Part Classification

- Will NOT “reinvent the wheel” nor interfere with Aviation regulatory eco-system.
- Will adopt existing aviation standards/guidance materials
- Downstream ASTM documents will reference this document
- Accounts for structural and non-structural applications
- Initial draft “mapping” reviewed by civilian and non-civilian regulators with general concurrences
- Coordinating with EAAMIRG (John van Doeselaar), SAE AM – Repair (David Abbot), F44.30 (Joel Heck) and AIA working group (Eric Sager),
- Target date for the subcommittee pre-ballot review: Dec. 2021
- Also coordinating with Energy Subsection (F42.07.10 on “energy storage units” made from AM (e.g. battery & hydrogen). F42.07.10 Workshop planned on Dec 2021

Date: 11-4-2021
To: Subcommittee F42.07
Tech Contact: John Schmelzle / Chul Park
Work Item #: WKXXXXX
Ballot Action: New Standard
Rationale: See introduction.

Standard for
Additive Manufacturing – Standard Specification for Classifications of Additively Manufactured Parts Used in Aviation

This standard is issued under the fixed designation FXXXX; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last ~~reapproval~~. A superscript epsilon (ϵ) indicates an editorial change since the last revision or ~~reapproval~~.

INTRODUCTION

Additive manufacturing (AM) is quickly growing for use in aviation industry due to many benefits. Since AM technology in general is less mature than traditional manufacturing methods, it is important to understand the risk associated with the AM usage by understanding the consequence of failure of the usage. Such information is also essential in establishing the level of rigor in developing data to support the aviation regulatory approval of an AM part. In this sense, a part classification scheme can provide a consistent metric for aviation parts based on a part's consequence of failure. Without carefully defined part classes, the ability to accurately gauge the consequence of failure associated with additively manufactured aviation parts within and across programs, projects, and suppliers becomes exceedingly difficult, resulting in mitigations that are either not commensurate or inconsistent. The part classification system documented here does not affect a part's functional requirements, but rather is used to group additive manufacturing aviation parts into categories which can be used in downstream standards. For example, this classification system can be used in material and process specifications to determine the appropriate levels of process control, thermal post processing, qualification, and inspection to ensure AM parts meet their application requirements. This classification system does not specify how the classification is used in any downstream processes. The use of the classification shall be left to the cognizant engineering or production entities, or downstream documents which reference this standard.

1. Scope

- 1.1. This Standard is intended to be used to assign part classifications across the aviation industries that use AM to produce parts.
- 1.2. This Standard is applicable to all AM technologies defined in ISO/ASTM 52900 used in aviation.
- 1.3. This specification is intended to be used to establish a metric for AM parts in downstream documents.
- 1.4. This part classification metric could be utilized by the engineering, procurement, NDI, testing, qualification or certification processes used for AM aviation parts.
- 1.5. This standard is not intended to establish criteria for any downstream processes, but rather to establish a metric that these processes can utilize.
- 1.6. The classification system in this standard establishes a consistent methodology to define and communicate the consequence of failure associated with AM aviation parts.
- 1.7. This specification is not intended to supersede the requirements and definitions of the applicable regulations or policies, including but not limited to the ones listed in the Appendix.
- 1.8. The material and/or process does not affect the consequence of failure of a part, therefore the classification scheme defined in this document may be used outside AM
- 1.9. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

2.1. *ISO/ASTM Standards*:¹

52900	Terminology for Additive Manufacturing – General Principles – Terminology
52901	Guide for Additive Manufacturing – General Principles – Requirements for Purchased AM Parts

Terminology

3.1. *Definitions*:

3.1.1. Terminology in ISO/ASTM 52900 shall apply.

Part Classification Designations

4.1 Classifications:
All aviation parts produced using AM shall be classified in accordance with the four part classifications defined in Table 1.

Table 1

Classification	Consequence of Failure	General Description ⁽¹⁾
A	High	Part whose failure can directly affect continued safe flight and landing ⁽²⁾ Part whose failure can result in serious or fatal injury to passengers or cabin crews or maintenance personnel ⁽³⁾ Part whose failure can result in excessive workload of flight crew ⁽³⁾
B	Medium	Part whose failure can indirectly affect continued safe flight and landing ⁽²⁾ Part whose failure can result in injury to passengers or cabin crews ⁽³⁾ Part whose failure can result in significant increase in workload of flight crew ⁽³⁾
C	Low	Part whose failure has no effect on continued safe flight and landing ⁽²⁾ Part whose failure has no effect on passengers Part whose failure can result in slight reduction in operational/functional capabilities ⁽³⁾ Part whose failure can result in slight increase in workload of flight crew ⁽³⁾
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 Non-flyaway parts

[1] This description is not intended to supersede the definitions in the regulations or policies listed in the Appendix. The user should refer to the original definitions of the regulations or policies such as the ones listed in the Appendix.
[2] Refer to AC33-8 or AC43-18
[3] Refer to AC25.1309

4.2 Applicability
The cognizant engineering or production entity shall determine the part classification considering the consequence of the failure of the part and the functional or systems requirements. The applicant for a design or production approval must seek individual guidance from their respective regulatory body concerning the use of this specification as part of a design or production approval

4.2 Alignment with Regulations and Policies
In order to evaluate if the part classification scheme is practically viable, the scheme was compared with the regulations and the guidance materials which are currently used in the aviation industry. Reference materials from both civilian (Table A1) and military (Table A2) domains covering both structural and non-structural aspects were reviewed. Other non-aviation specific documents were also reviewed (Table A3). Four classification scheme works well with existing aviation regulatory guidance documents.

¹ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website

Aviation specific guidance materials

Non-aviation reference

NAVAIR coordinating with DoD counterparts to review

Review with FAA participants

F42 Classification	ARMY Policy 070-062	MIL-STD-1530 (ASIP)	NAVAIR	JAMA (Joint AM Acceptability)	MIL-STD-1798	MIL-STD-882	AC43-18 Fabrication of Aircraft Parts by Maintenance Personnel	AC25.571 Damage Tolerance and Fatigue Evaluation of Structure	AC25.1309 System Design and Analysis	AC33.70-1 Guidance Material for Aircraft Engine Life-Limited Parts Requirements	14 CFR§33.75 Safety Analysis	AC 33-8 Parts Manufacturer Approval of Turbine Engine and Auxiliary Power Unit Parts under Test and Computation	NASA-STD-6030	AWS D20.1	AMS2175
Class A	Category 6 Flight Parts/Components that Pose a Safety Impact to Include CSIs	Fracture Critical Traceable Part A fracture-critical traceable part is a safety-of-flight structural component that is either single load path or judged to require serialization and traceability. Fracture Critical Part A fracture-critical part is a safety-of-flight structural component that is not single load path nor judged to require serialization and traceability.	Class IV Part consequence of failure: High	Category 3 Items that pose a severe risk of damage to other equipment or personnel (e.g. CSI)	Safety Critical Component	Category 1	Category 1 A fabricated part, the failure of which could prevent continued safe flight and landing, resulting consequences could reduce safety margins, degrade performance, or cause loss of capability to conduct certain flight operations.	Principal Structural Element (AC25.571-1D) An element that contributes significantly to the carrying of flight, ground, or pressurization loads and whose integrity is essential in maintaining the overall structural integrity of the airplane	FHA = Hazardous or Catastrophic Large reduction in functional capabilities or safety margins on airplane. Serious or fatal injury to passengers or cabin crew. Excessive workload of flight crew.	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.	SA = Hazardous Engine Effects: (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	Category 1. A product, i.e. engine, or part(s) thereof, whose failure could prevent continued safe flight and landing; resulting consequences could reduce safety margins, degrade performance, or cause loss of capability to conduct certain flight operations. A Category 1 part, for the purpose of this AC, meets the definition of a critical part defined in Order 8110.42.	Class A	Class A Critical application. A component, whose failure would cause significant danger to personnel, loss of control, loss of a system, loss of a major component, or an operating penalty.	Class 1 A casting, the single failure of which would endanger the lives of operating personnel, or cause the loss of a missile, aircraft, or other vehicle.
Class B	Category 5 Flight Parts/Components that Pose an Operational Impact but no Safety Impact Category 4 Flight Parts/Components with a Readiness Impact, but no Safety or Operational Impact	Durability Critical A non-safety-of-flight structural component that is judged to require additional controls beyond those for normal-controls parts.	Class III Part consequence of failure: Medium	Category 2 Items that pose a risk of damage to other equipment or personnel (e.g. CAI)	Mission Critical Component	Category 2	Category 2 A fabricated part, the failure of which would not prevent continued safe flight and landing, but would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions or subsequent failures.	N/A	FHA = Major Significant reduction in functional capabilities or safety margins on airplane. Physical distress, possibly including injuries to the occupants. A significant increase in workload of flight crew.	N/A	SA = Major Engine Effects: An effect whose severity falls between those effects identified as minor engine effects and hazardous engine effects.	Category 2. An engine or part(s) thereof whose failure would not prevent continued safe flight and landing; resulting consequences may reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions or subsequent failures. For the purpose of this AC, a Category 2 engine part is typically a complex part that may affect a critical part.	Class B	Class B Semi-critical application. A component whose failure would reduce the overall strength of the equipment or system or preclude the intended functioning or use of equipment, but loss of the system or the endangerment of personnel would not occur.	Class 2 A casting, the single failure of which would result in a significant operational penalty. In the case of missiles, aircraft, and other vehicles, this includes loss of major components, unintentional release or inability to release armament stores, or failure of weapon installation components.
Class C	Category 3 Flight Parts/Components with no Safety, Operation or Readiness Impact	Normal Controls Part A normal-controls part is a non-safety-of-flight structural component where standard aerospace practices are sufficient in the design, manufacturing, and maintenance of the part to ensure structural integrity.	Class II Part consequence of failure: Low	Category 1 Items that pose little to no risk of damage to other equipment or personnel (e.g. not CSI or CAI)	Durability Critical Component Durability Non-Critical Component	Category 3 & Category 4	Category 3 A fabricated part, the failure of which would have no effect on the continued safe flight and landing of the aircraft.	N/A	FHA = Minor Slight reduction in functional capabilities or safety margins on airplane. Slight increase in workload of flight crew	N/A	SA = Minor Engine Effects: The only consequence is partial or complete loss of thrust or power (and associated engine services) from the engine.	Category 3. An engine or part(s) thereof whose failure would have no effect on continued safe flight and landing of the aircraft. The only consequence would be partial or complete loss of engine thrust or power (and associated engine services). For single engine applications, consider changing part categorization to category 1 or 2 if complete loss of thrust could prevent continued safe flight and landing or reduce the ability of the crew to cope with adverse operating conditions or subsequent failures.	Class C	Class C Noncritical application. A component whose failure would not affect the operation of the system or endanger personnel.	Class 3 Castings not included in Class 1 or Class 2 and having a margin of safety of 200 percent or less.
Class D	Category 2 Aviation Ground Support Equipment Category 1 Fixtures, Jigs, Shop Aids and Tooling	N/A	Class I Part consequence of failure: Negligible	Category 0 Items that pose no risk of damage to other equipment or personnel (e.g. not CSI or CAI)	Other/Expendable Component	N/A	N/A	N/A	No Safety Effect. No effect on operational capabilities or safety, and not effect on occupants or flight crew.	N/A	N/A	N/A	N/A	Class C Noncritical application. A component whose failure would not affect the operation of the system or endanger personnel.	Class 4 Castings not included in Class 1 or Class 2 and having a margin of safety greater than 200 percent.

EAAMIRG Activity (led by John van Doeselaar - Airbus)

Companies	Application field	Categories used by EAAMIRG companies from Critical -> Not Critical			
Response of 11 companies	Structures, systems, systems installation, engines	Fatigue critical Parts	Fatigue sized parts	Static sized parts	Non loaded-remaining parts
		Class 1	Class 2	Class 3	Class 4
		Class 1	Class 2		Class 3
		Critical part	Significant parts	Business sensitive parts	Other parts
		Critical part	Important part		other part
		Critical part	Important part	Structural part	Non-structural part
		Critical	Classified parts	Un-classified secondary load carrying parts or un-classified parts with severe business impact	Un -classified parts with low load requirements

- EAAMIRG companies use 3 to 4 different categories
- Proposed F42 part classification scheme aligns with business practices

