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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc): Airframe, Systems, Propulsion, Interiors (including seats)

Is there a need to consider separate documents?:

- a reference regulator guidance/intent
  and/or
- an industry guidance content

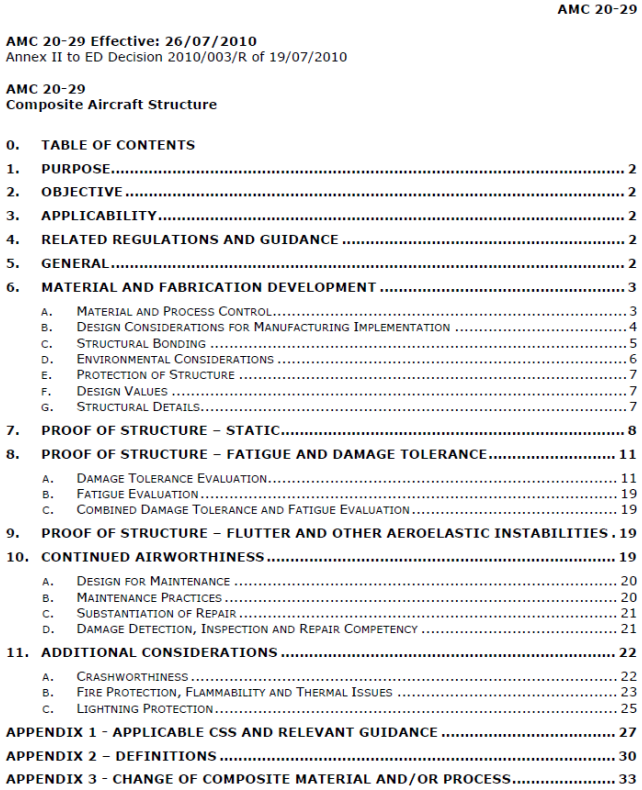
e.g. use existing outline format,
AMC 20-29/AC 20-107B 'Composite Airframe Structure'?
Other possibilities:

- SDO document?
- Composite Modifications Document Format (ref. FAA presentation Tuesday)?

For the purposes of discussion only, assume this format – AMC 20-29 (similar flow/content to the Composite Mod Doc etc)

Is this format reasonable for this task?

Please identify alternatives?



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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc): Airframe, Systems, Propulsion, Interiors (including seats)

For the purposes of discussion, assume this format:

1 and 2. Purpose and Objective:

To provide safe, and practical, industry 'level playing field' guidance and to document good common practice relating to AM 'parts of no/low criticality'

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc): Airframe, Systems, Propulsion, Interiors (including seats)

3. Applicability:

NOTE: Para. 3 'Applicability' may need revision, subject to the discussions in slide 6 onwards.

Metallic and **non-metallic AM parts** (of **no/low criticality**), AM repairs (including repair by replacement), as applicable to a **range of products** (airframe, systems, cabin safety, propulsion etc)

- CS23,25, 27, 29, CS-E, CS-P (+ FAA equivalents)

- type-certificate, restricted type-certificate or supplemental type-certificate; certificate/approval holders; parts manufacturers; material suppliers; and maintenance and repair organisations.

Is this reasonable for this task?

Please identify alternatives?

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3. Applicability continued:

Emphasis: Consider decision makers, typically in the supply chain beyond Type Cert Holder:

Reminder: Decision makers/designers exist in a diverse range of organisations with a broad range of capabilities and experience supporting a broad range of approvals… impact upon safety may not be clear to some of these organisations

NOTE: Para. 3 'Applicability' may need revision, subject to the discussions in slide 6 onwards.

Primary consideration:

- Supplemental Type Cert Holders
- Design Organisation Approval (DOA) Holders supporting MROs etc, e.g. under minor change approval, provided all aspects of the change meet the requirements for minor classification.
- ETSO/TSOs
- PART 145 organisations interpreting PART 145 etc (for information - allows repair by replacement)
- Stakeholders new to aviation, e.g. AM Machine Manufacturers.
- Regulators (in order to help define a 'level playing field' for industry)

Is this reasonable for this task?

Please identify alternatives?

Note: EAAMIRG Action: Standardisation: understanding and use of 'standards'

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc): Airframe, Systems, Propulsion, Interiors (including seats)

4. Related Regulations and Guidance/ 5. General:

- add list of key requirements in Appendix ?
  Airframe, Systems, Propulsion, Interiors (including seats)
- add 'Criticality' definition?
- add need for simplified FHA/RAS content (supporting broader simplified 'criticality' determination across airframe, systems, propulsion, interiors etc)?

Note: Classification stated in TCH documents is partly based upon broader product design understanding and experience than available to many in the supply chains. Changes may inadvertently change the classification!

Is this reasonable for this task?

Please identify alternatives?

AMC 20-29

NOTE: Para. 4 content may need revision, subject to the discussions in slide 6 onwards.

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4. Related Regulations and Guidance.. continued: (see also following slide)

- add 'Criticality' definition for the purposes of this task?

Note: this needs to be developed for other applications… propulsion etc – see also MONDAY EAAMIRG/F42 Presentation

e.g. Parts of no/low criticality: Parts being of no, or minimal, safety concern either at aircraft or passenger level, e.g. airframe, systems, propulsion, interiors (including seats)

Application		Categorisation from Critical -> Less critical			
		Fatigue critical Parts	Fatigue sized parts	Static sized parts	Non loaded-remaining parts
Structures and system installation	Examples:	PSEs	non-PSE primary structure sized by fatigue	Mainly secondary structure parts sized by static	Remaining secondary structure parts

Is this reasonable for this task?

Please identify alternatives?

Where do 'parts of **low criticality**' fit? a subset of the above? TBC

Where do 'parts of **no criticality**' fit? a subset of the above? TBC

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4. Related Regulations and Guidance.. continued: (see previous slide, to be discussed and linked)
Based upon Composite Mod Document (and others comments):

Further 'criticality' definitions:

All AM structures and systems need to comply with the applicable regulations; however, the level of rigor in compliance findings may be scaled depending on the risk to continued safe flight and landing. The level of necessary rigor for a given structure/system is established considering the classification of structure/system.

Classification of AM Structure and Systems:

- **Critical Structure/Systems***: Structure/Systems whose failure directly or indirectly affects continued safe flight and landing. This category includes PSE, primary structure, and may include secondary structure whose failure could cause collateral damage to PSE, if it breaks into large fragments.
- *** Structure/System refers to airframe, systems, propulsion, interiors (including seats) etc**

***For reference only, not part of this no/low criticality discussion**

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4. Related Regulations and Guidance.. continued: (see previous slide, to be discussed and linked)
Based upon Composite Mod Document (and others comments):

- **Structural Substantiation** – The structure is substantiated for static strength* and fatigue and damage tolerance (F&DT). However, DT substantiation of secondary structure may be limited to discrete source evaluation or may not be required if the design is proven to be failsafe.

  ** strength includes stiffness considerations when applicable throughout this document.

- **System Substantiation - insert systems input TBD****
- **Material and Process** – A complete test program is likely required to demonstrate a reproducible and reliable design. The responsible design organization must have a full understanding of the structural/system performance of the base structure/system . Coordination and data-sharing with the DAH is recommended for the material and process specifications and the design values of the base structure. Identifying the base structure material and process using reverse engineering is possible but may be a challenging task.
- **Loads** – Define the loads f[illegible] DAH is recommended for the static and cyclic internal [illegible]

***For reference only, not part of this no/low criticality discussion**

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4. Related Regulations and Guidance.. continued:
Based upon Composite Mod Document (and comments Cezar):

Non-Critical Structure/Systems: Structure/Systems whose failure does not affect continued safe flight and landing. This category includes some secondary structures.

- **Structural Substantiation** – The structure is substantiated for static strength

- **Material and Process** – Since the structure/system does not have the same level of risk as critical structure/system, a limited test program with focus on material properties critical to the design may be acceptable.

- **Loads** – Define the loads for the AM structure/system.

***For reference only, not part of this no/low criticality discussion?**

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

Non-Structural/System Parts: Components whose failure would be inconsequential from a structural or system perspective.

Equivalent to 'parts of **low criticality**'?

- **Structural Substantiation** – If required, the part strength may be substantiated by analysis, using published industry design values or supplier data, if large margins of safety can be demonstrated.

- **System/Propulsion/Interiors/Seats Substantiation** - **insert systems input TBD**

- **Material and Process** – Published industry or supplier data may be acceptable.

- **Loads** – Define inertia loads for normal operation and emergency conditions.

Is this reasonable for this task?

Please identify alternatives?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

- **Everything else:** These are parts whose failure can be **easily?** demonstrated to not pose any risk to continued safe flight and landing, or to passengers or crew safety, e.g. resulting in injury, distraction from duty etc, having been subjected to an FHA considering all potentially impacted disciplines, e.g. airframe, system, propulsion, interiors (including seats), and all potential failure modes. Failure of these articles, are inconsequential from a structural/system standpoint, but may have other regulatory requirements.

Is this reasonable for this task?

Please identify alternatives?

Equivalent to 'parts of **no criticality**'?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

SAE Draft Standard for Composite Modifications

Criticality	Material Control	Process Control	Design Values	Static Strength	F&DT	Flammability
1. High – parts whose failure directly affects continued safe flight and landing	X	X	X	X	X	As Required
2. Medium-High – parts whose failure indirectly affects continued safe flight and landing	X	X	X	S	S	As Required
3. Medium-Low – (1) structure whose failure does not affect continued safe flight and landing and (2) parts whose failure can affect passengers and crew	S	S	S	S	N	As Required
4. Low – all other parts	S	S	S, As Required	S, As Required	N	N

Notes:

- May need other columns/categories for engine regulations
- X = "full" compliance, S = simplified compliance, N = compliance not applicable
- Simplified methods of compliance are not the same between the levels

Is this reasonable for this task? Please identify alternatives?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

Medium-Low Criticality Parts

Criticality	Material Control	Process Control	Design Values	Static Strength	F&DT	Flammability
3. Medium-Low – (1) structure whose failure does not affect continued safe flight and landing and (2) parts whose failure can affect passengers and crew	S	S	S	S	N	As Required

- **Structure whose failure does not affect continued safe flight and landing (often called secondary or tertiary structure), or parts whose failure can affect passengers and crew**
  - Example composite parts: winglets, interior monuments, fairings
  - Example AM parts: structural brackets, interior components subject to 2x.853, ducting

Is this reasonable for this task? Please identify alternatives?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

Note: this needs to be developed for other applications… propulsion etc

Medium-Low Criticality Parts

- **Methods of Compliance**
  - F&DT not applicable
  - For composite:
    - Material qualification and design values may focus only on the material properties that are critical to the design. A moderate level of testing may be required in order to adequately control the material to ensure compliance with the other applicable regulations. For non-structural parts, the focus may be on properties such as flammability or conductivity.
    - The process specification must control the key process parameters that will govern final part performance but may incorporate less frequent receiving inspections, less receiving inspection parameters, and more MRB capability for deviations.
    - For design values, published data and equivalence testing may be used to meet many, if not all, requirements.
    - Structural substantiation may use a limited testing program if reliable analysis tools with conservative design values are utilized
  - What would we do for AM parts?

Is this reasonable for this task? Please identify alternatives?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

Low Criticality Parts

Criticality	Material Control	Process Control	Design Values	Static Strength	F&DT	Flammability
4. Low – all other parts	S	S	S, As Required	S, As Required	N	N

- **All other parts**
  - ~~Example composite parts: access panels~~
  - Example AM parts: (need examples)
- **Methods of Compliance**
  - For composites:
    - Limited material and process control with minimal testing, *but not zero*
    - Many of these applications use a systems-type approach, such as DO-160, which demonstrates strength (inertial loads) directly by test. However, when required, published industry or supplier data is acceptable for compliance to § 2x.613 and may be used for structural substantiation, if large margins of safety can be demonstrated.
  - What would we do for AM parts?

Note: this needs to be developed for other applications… propulsion etc

Is this reasonable for this task? Please identify alternatives?

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4. Related Regulations and Guidance.. continued:

Based upon Composite Mod Document (and comments Cezar):

Everything else?
also see slide 11

Another Category?

- **Are there truly parts with <u>no</u> criticality?**
  - Non-fly-away parts? (e.g., molds, shop aids, jigs)
    - *While they don't demonstrate compliance to airworthiness regulations in parts 23-35, they are defined and controlled under production approval requirements. Do we want to provide guidelines for those regulations?*
  - Are there any fly-away parts?
    - Small decal or component with a limit on size and number installed?
    - What would its reduced requirements look like? How could we further reduce M&P control and still meet §21.31 requirements to "define the configuration and the design features of the product"

Criticality	Material Control	Process Control	Design Values	Static Strength	F&DT	Flammability
5. No Criticality	?	?	N	N	N	N

November 9, 2021 AM Parts with Low or No Criticality Federal Aviation Administration 11

Is this reasonable for this task? Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

For the purposes of discussion, assume this format:

6. Material and Fabrication Development:

- add similar level content for AM?
- address need to identify key parameters?
- generic simplified AM checklist, e.g. AIA (next slide)?

Industry Document?

Is this reasonable for this task?

Please identify alternatives?

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6. Material and Fabrication Development continued: Add simplified material agnostic version of this list?

AIA: Recommended Guidance for Cert of AM Components (Feb. 2020):

AIA: Recommended Guidance for Cert of AM Components (Feb. 2020):

Is this reasonable for this task?

Please identify alternatives?

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6. Material and Fabrication Development continued

- **shared database use (potential use in complex supply chains?)**
  - use of minimal statistical strategy (‘low criticality’)
  - focused upon design driver dominant design values?
  - ‘proportionate’ and/or simplified use of NCAMP ULTEM 9085 data?

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

7. Proof of Structure - Static:

- simple management of test v analysis?
- 'point design' v coupons?
- load cases?
- test numbers?
- level of data/data source required required?

Is this reasonable for this task?

Please identify alternatives?

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7. Proof of Structure… continued:

Simple parts: reduced dataset + factors – simple coupon data, open hole/close hole data?

Complex parts: '**point design**'?

Meaningful load cases?
Test Boundary Conditions?

Point Design – Test Number Statistics?
wrt, design optimisation and competing damage modes and equivalence wrt 'conventional' technologies?

AM Example: Point Design

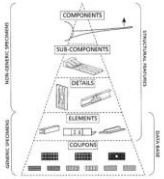

Figure 1 - Schematic diagram of building block tests for a fixed wing.

- **Demonstrate material and in-process controls yield repeatable parts**
  - Base material qualification tests and procurement specifications
  - Initial part destructive inspections
  - Define post-process inspections
- **Estimated/base design values for structural sizing**
  (developed from test data with geometrically similar parts)
  - Attachment data (+ preload retention)
  - Pin-loaded lug data
- **Flammability tests**
- **Point design tests with actual parts, using a logical representation of the floor beam attachment and loads for a pin-loaded interiors element**
  - Minimum tests: 7 fittings tested to failure (with failure load CV less than 10%)
  - Margin of Safety: lowest single test failure of 40% greater than loading requirement
  - Repeatable failure mode, including early local failures may exist within a "process zone"

Additive Manufacturing Interior Fitting (attached to passenger floor beam)

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

8. Proof of Structure - Fatigue and Damage Tolerance:

- not necessary for 'no' criticality
  - use of existing database for similar product?
  - use other material selection criteria
- necessary static test for 'low' criticality?
  - with and without damage?

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

9. Proof of Structure – Flutter and Other Aeroelastic Instabilities:

- simple 'engineering consideration' of mass, stiffness, and aerodynamic load impact potential?
- use other mitigations, e.g. progressive flight test envelope expansion?
- part departing aircraft?

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

10. Continued Airworthiness:

- should be none for no criticality/minimal for low criticality?
- other mitigations, e.g. fleet leader, sampling for low criticality parts?

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Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

11. Additional Considerations:

- Crashworthiness – should not be adversely impacted
  - living space (sharp edges?)
  - escape routes (sharp edges?)
  - item of mass release (mass thresholds?)
  - pax loads

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

11. Additional Considerations:

- **Fire Protection, Flammability and Thermal Issues**
- likely lead concern, interiors, propulsion etc
- acceptable test expectations relative to material and process control (para.6)?

(note: AMC 20-29 addresses structure, pointing to 'interiors' needs, but does not include content)

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

11. Additional Considerations:

- **Lightning Protection**
- do not adversely impact conduction network

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

Appendix: Add Examples:

- from each product range?
- for 'No' and 'low' criticality?

Is this reasonable for this task?

Please identify alternatives?

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Appendix: Add Examples… continued: What information is required:

- brief description of the item, including
  - approx.. dimensions, mass (or total weight if the item is an attachment supporting other mass etc)
  - material and process (also original material and process if replacing a more conventional item)
  - dominant **concept defining design**, e.g. static strength, dynamic impact, flammability, system function
- the assessment of the **criticality** (including the reference for the assessment/criteria used), including
  - original OEM documents referenced (e.g. existing item classification available?)
  - any regulations or regulatory guidance referenced
- **type and extent of substantiation**,
  - test v analysis used, and reason for selected decision
  - test numbers
  - key parameters identified and criteria used to define them
  - dominant failure modes
- any other information of significance to the WG1 discussion

Is this reasonable for this task?

Please identify alternatives?

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Guidance format? e.g. very short simplified material and process agnostic version of titles and format from the following (for the purpose of consistency of data delivery etc):

Appendix: Applicable Requirements:

- add key requirements for airframe, systems, propulsion, interiors (including seats)

Is this reasonable for this task?

Please identify alternatives?

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AMC 20-29
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Where to best place WG1 ‘industry’ content?:

- EASA CM-S-008 revision (temporary measure)*?
- Existing/developing document, e.g. SDO?

*Regulatory intent could become AMC, or similar

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Identify useful supporting references:

- GAMA Pub. No.13 etc?

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by Friday 19th November 2021

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Further comments:

Sensitive AMP process production/maintenance supply chain guidance:

- SAE CACRC 6291‘Guidelines for Repair Process Evaluation of Aluminium Bonded Structure’

  - ‘checklist of best practices in implementation of tooling, process steps, and quality controls that help ensure a previously substantiated repair design and process requirements’
  - ‘intended to promote consistency and reliability’

Provides useful generic process level guidance (not an approval!) regarding non-specific sensitive AMPs

A possible example for AM?

EASA POA Guidance Checklist:

https://www.easa.europa.eu/domains/aircraft-products/production-organisations-approvals

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Questions?

easa.europa.eu/connect

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