Modifications and Alterations Affecting Composite Parts and/or Structures

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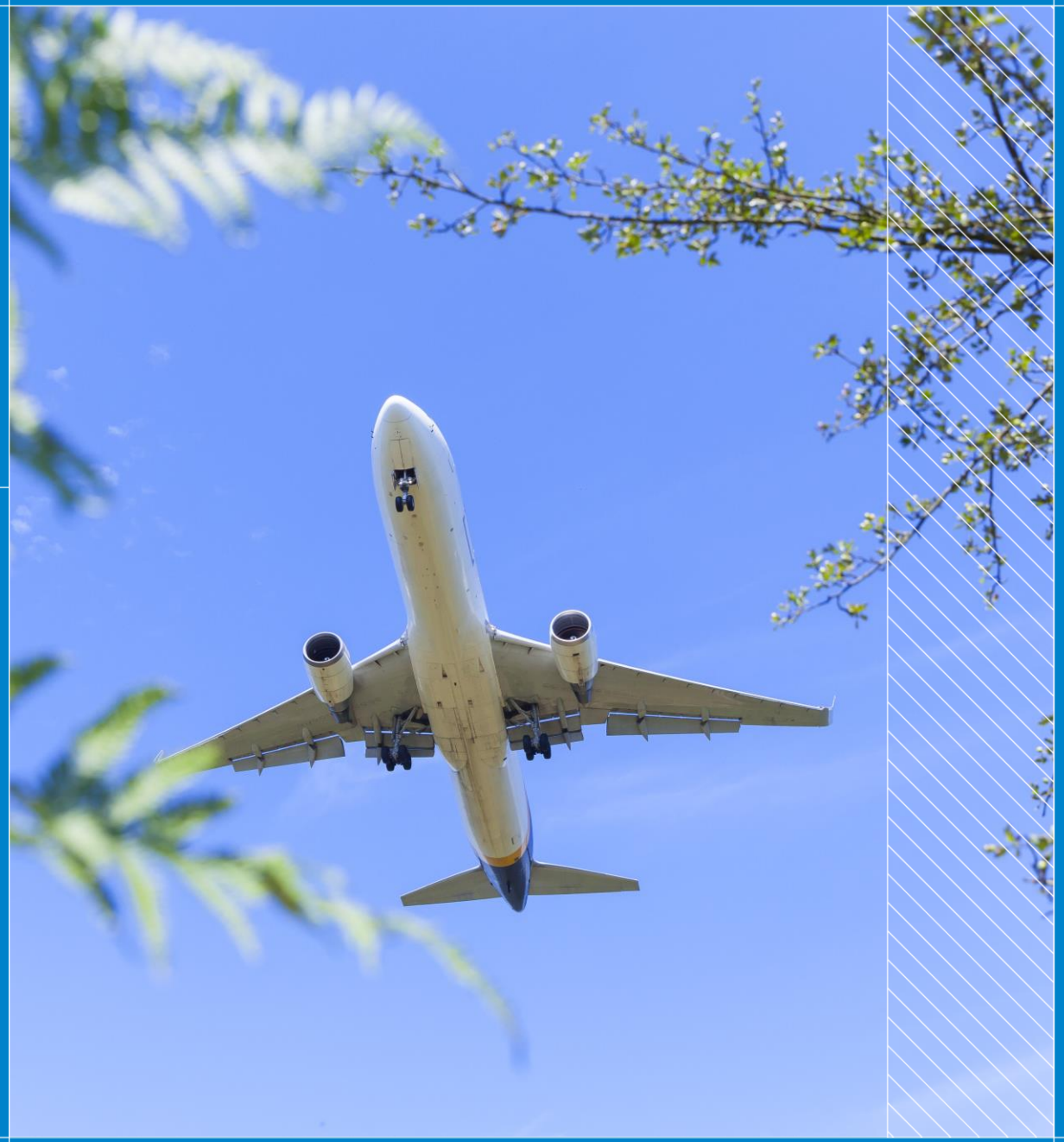

Changes to composite structure... baseline structure, modifications, repairs etc

Why are we interested… composites are not new?

- introduction of extensive use of composites in more critical applications,

e.g. A350, B787 pressure hulls

- many in supply chain are exposed to composites for the first time

- industry expects to use composites products much as they have used metallic products, yet 'engineering properties' are different (being defined by material and process at part level))

- TCHs have provisioned for some predicted mods, e.g. likely antenna needs …
however, industry always finds new ways to change the structure, e.g. request for new holes in a VIP aircraft composite pressure hull for bespoke kitchen facility venting

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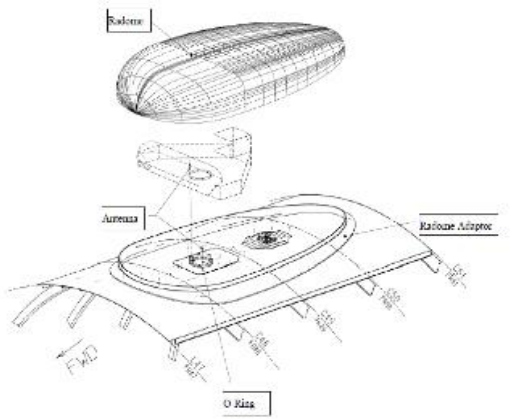
What is the scope of the issue?

- change to composite baseline structure
- composite addition to metal baseline structure
- metal addition to composite baseline structure
- composite addition to composite baseline structure

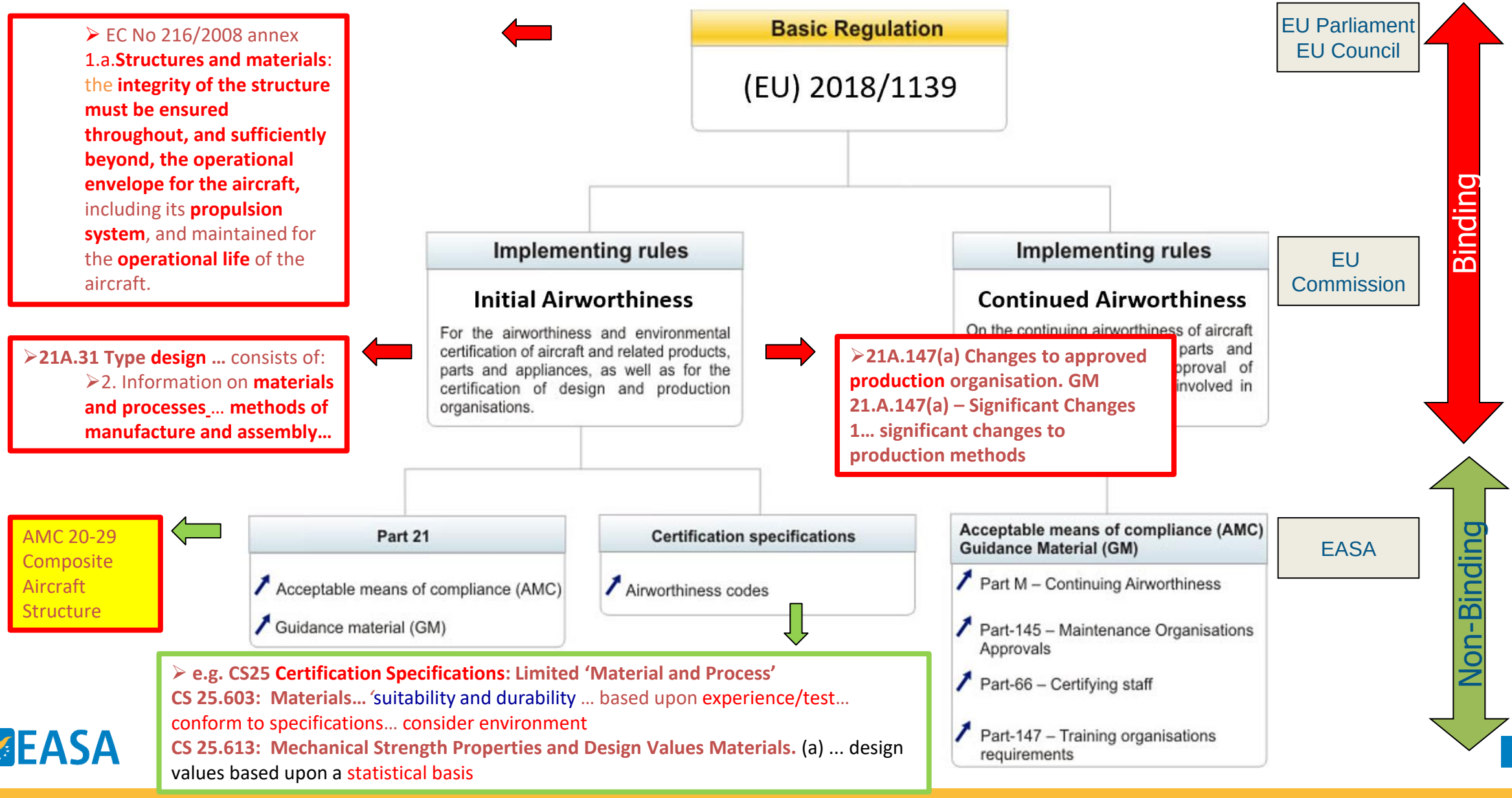


Examples of relevance to composites?

- material and process changes (note: see AMC 20-29 Appendix 3*)
- antenna e.g. loads, flutter, F&DT, birdstrike, Part Departing Aircraft etc (also see EASA CM-S-013)
- winglets/sharklets, e.g. loads, flutter, F&DT, birdstrike, Part Departing Aircraft etc
- interiors structures
- composite seats, e.g. material and process, F&DT (see also SAE ARP 6337)
- bonded structures (see also EASA CM-S-005)
- decals/vinyl wraps, e.g. damage tolerance – damage mode, damage detection, temperature etc

*don't forget EASA/ECHA - Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) material replacement activities required to '*prevent significant harmful effects on climate, environment and human health*', which could be hidden in the supply chain

Material and Process… importance in the Regulations



Composites… ‘engineering properties’

AM ‘Engineering Properties’ are:

- defined by the ‘material and process’
- built directly into the part or repair

a challenge:

- ‘complex parts’ – base pyramid coupon data may not represent the complex part properties (although stable simple base pyramid data can support confidence in M&P control…otherwise, how can the higher pyramid work be trusted?)
- ‘**sensitive processes**’ – a major challenge if completing production activities in a more challenging maintenance environment, e.g. bonding, additive manufacturing etc

Where are the ‘engineering properties’ developed in the pyramid?

Potentially many competing damage modes, some difficult to detect, e.g. disbond, delamination etc

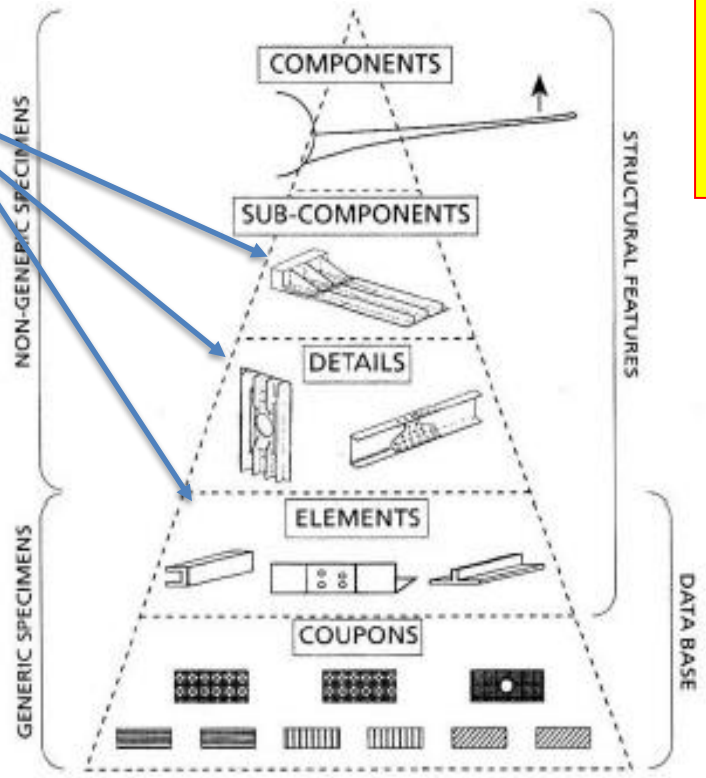


Figure 1 - Schematic diagram of building block tests for a fixed wing.

Change Challenge:

- unlike much established metallic data, there are many composite baseline data IP limitations (Material and Process data, allowables, design concepts etc)
- need for resource limited stakeholders* to generate data

* STCHs, DOAs supporting MROs, ETSOs etc

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CS 25.605: Fabrication Methods

(a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process (such as gluing, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test programme

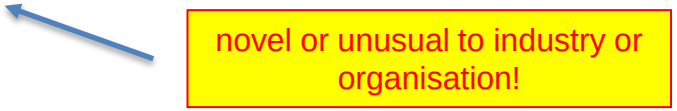
Other regulatory activities of relevance…

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 (LoI): 21.B.100: Certification proportionality:

1…. the novel or unusual features of the certification project, including operational, organisational and knowledge management aspect



3…. the criticality of the design or technology and the related safety and environmental risks, including those identified on similar designs

Composites suggest need for more prescriptive coverage, and development of industry guidance, e.g. supported by standards bodies etc… yet engineering properties are typically product specific!

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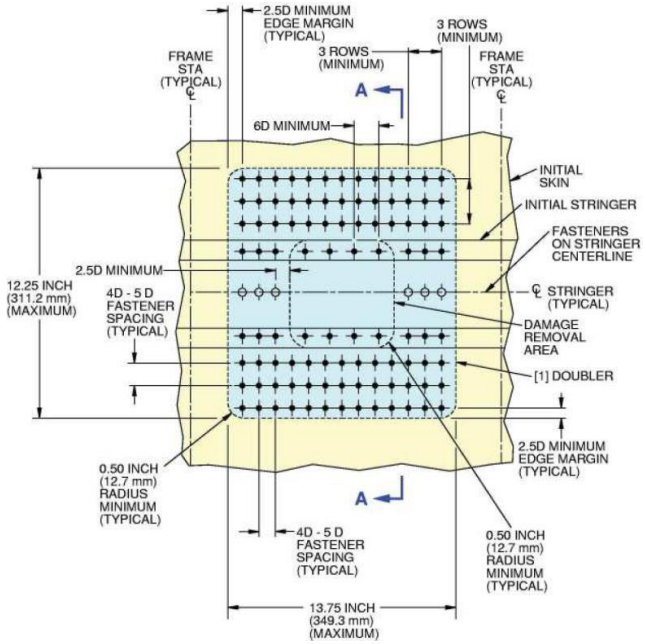
Example of challenge – small antenna mod, small hull penetration

Metallic baseline structure - established practices (many decades!)

- simplified and established loads calculation methods
- use of readily available data, e.g. including SRM data
- fatigue and damage analysis (typically driven by fatigue)
- plus further conservative factors, e.g. inspection interval calculations etc



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Example of challenge – small antenna mod, small hull penetration

Composite baseline structure –

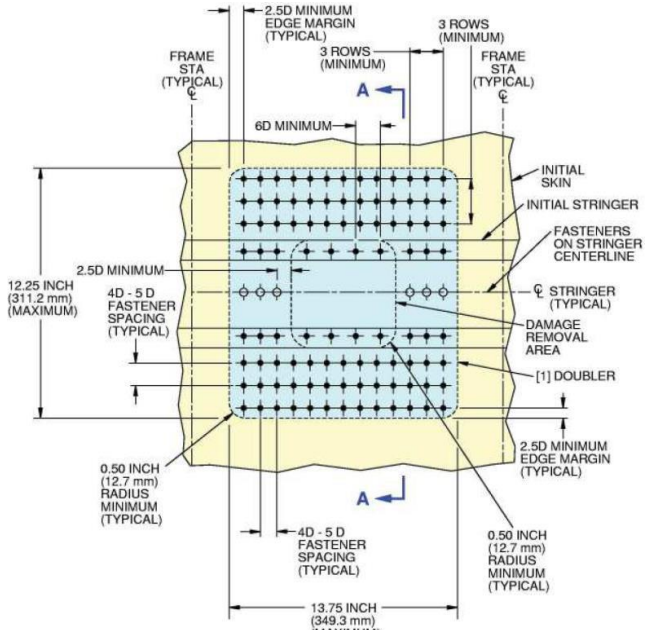
established practices no longer applicable*

material, process, and product specific

- simplified loads calculation
- use of readily available data, e.g. including SRM data
- fatigue and damage analysis
- plus further conservative factors, e.g. inspection interval calculations etc

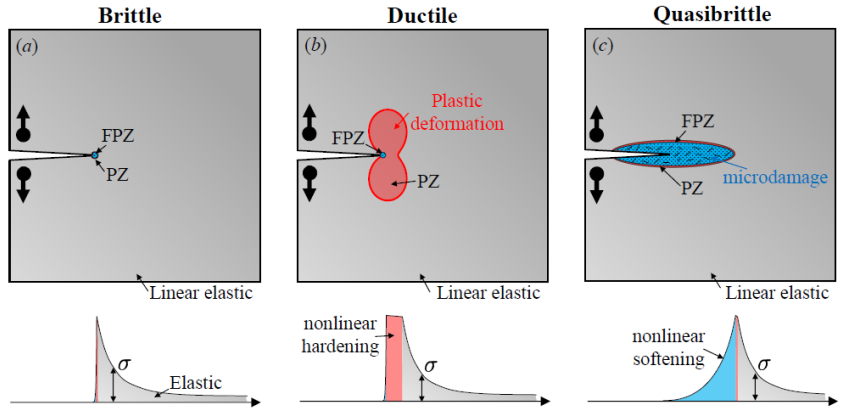
anisotropy: strength and stiffness variation – load redistribution challenge due to any cut-out and/or addition of mass, e.g. equipment

repair data typically not appropriate to 'reverse engineering' for complex part build



damage no-growth substantiation typically established in certification test

design typically driven by 'notch' data - material, process, application configuration specific…

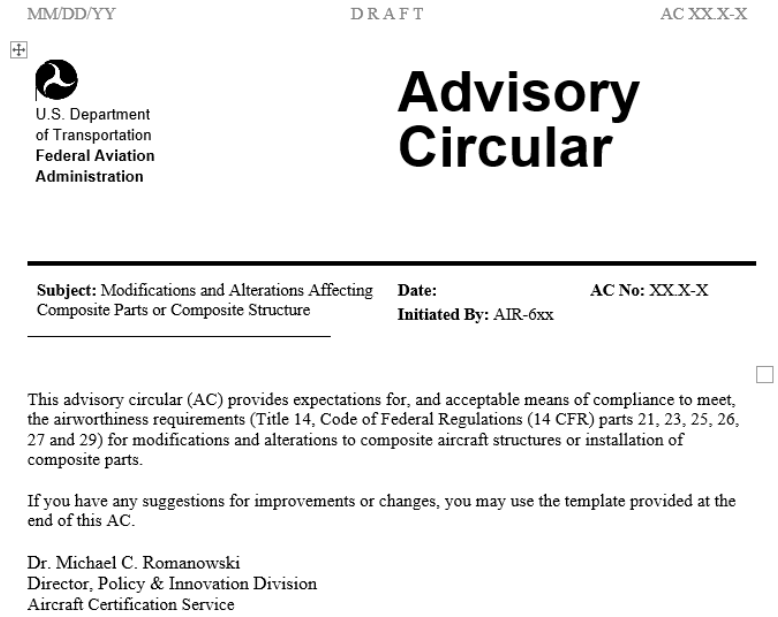


*see 'A Conceptual Framework for Practical Progressive Damage Analysis of Stiffened Composite Aircraf Loading' – Tom Walker CMH-17, SLC March 2015, for a summary of the 'large notch' challenge

Changes to composite structure... baseline structure, modifications, repairs etc

Developing Industry – Regulator activities:

- Industry – Regulator Workshops
  - July 2016
  - August 2017
- FAA Draft AC ‘ Modifications and Alterations Affecting Composite Parts and Components’ (50+ pages)



MM/DD/YY DRAFT AC XX.X-X

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Modifications and Alterations Affecting Composite Parts or Composite Structure

Date: **AC No:** XX.X-X
Initiated By: AIR-6xx

This advisory circular (AC) provides expectations for, and acceptable means of compliance to meet, the airworthiness requirements (Title 14, Code of Federal Regulations (14 CFR) parts 21, 23, 25, 26, 27 and 29) for modifications and alterations to composite aircraft structures or installation of composite parts.

If you have any suggestions for improvements or changes, you may use the template provided at the end of this AC.

Dr. Michael C. Romanowski
Director, Policy & Innovation Division
Aircraft Certification Service

Content relevant to various stakeholders (directly, or for awareness):

- Supplemental Type Cert Holders
- Design Organisation Approval (DOA) Holders supporting MROs etc
- ETSOs
- PART 145 organisations interpreting PART 145 etc (for information - allows repair by replacement)
- Regulators (in order to help define a ‘level playing field’ for industry)

Changes to composite structure... baseline structure, modifications, repairs etc

Draft AC content:

- CS 23: Surveillance Camera with Clamshell Doors
- CS 25:
  1/ Large Antenna, and
  2/ Winglet Installation
- CS27: Installation of Rotorcraft Tail Damper

Changes to composite structure... baseline structure, modifications, repairs etc

Evolving efforts addressing certification expectation ‘proportionality’ to ‘criticality’: Fabrication Methods…

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Proposed - Four levels of structural criticality (icw AC, FAA, C. Ashforth April 2021):

- New or modified structure whose failure poses a direct risk to continued safe flight and landing
- New or modified structure whose failure poses an indirect risk to continued safe flight and landing
- New or modified structure whose failure does not pose a risk to continued safe flight and landing, or parts whose failure could pose a risk to passengers or crew.
- Everything else

Changes to composite structure... baseline structure, modifications, repairs etc

Evolving efforts **(DRAFT)** addressing certification expectation 'proportionality' to 'criticality': Fabrication Methods…

Content Example Showing Scaled Criticality and Degree of Rigor

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- **Material Properties for Critical Structures**
  - If failure of the composite structure directly or indirectly affects continued safe flight and landing, and has a single load path, then A-basis design values are required. If the installation includes redundant load paths, then B-basis allowables are allowed. More specimens and batches are required to generate A-basis allowables than B-basis allowables. Material equivalency testing is also acceptable if there is an existing database for the material …
- **Material Properties Non-Critical Structure**
  - Design values for structures whose failure does not affect continued safe flight and landing may focus only on the material properties that are critical to the design …
- **Material Properties for Non-Structural Parts**
  - Non-structural parts may not require design values. Many of these types of use a systems-type approach for certification, such as DO-160, which demonstrates strength (inertial loads) directly by test under required normal operating and emergency conditions. However, when required, published industry or supplier data is acceptable for compliance to § 2x.613.

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Fatigue and Damage Tolerance – Example of Degree of Rigor

- **F&DT differentiated between by criticality**
  - For parts whose failure can directly affect continued safe flight and landing, follow guidance in AC-20-107B
  - Parts whose failure can indirectly affect continued safe flight and landing may have some, but not all, F&DT considerations to avoid catastrophic failure
    - Best practice is to design composite parts to have fail-safe structural details and redundant attachments with base structure.
    - Perform an up-front threat assessment for a significant discrete source event (e.g., rotor burst or bird strike) that could cause the part to depart the airplane, or cause aeroelastic instability
    - This type of structure that is subjected to significant repeated loads may also require some F&DT with coupons or point-design tests

Additional details for how this can work are provided in the Appendix

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Large Antenna F&DT Requirements

- **Example of an acceptable method for structure whose failure indirectly affects continued safe flight and landing:**
  1. Perform coupon level cyclic tests to determine the fatigue characteristics for the specific material system, design detail, and manufacturing process.
     - Cyclic coupon test data (OHC or specific joint detail) can demonstrate no joint degradation over selection inspection intervals and be used to demonstrate suitability for the lifetime of loading.
  2. Perform cyclic testing of an element representing the radome edge band fastened joint can be used to further evaluate the edge band under cyclic loads (with intentional damage).
  3. Perform some residual strength testing (without repeated loads) of elements with cover panel details to demonstrate sufficient capability for Category 2 and 1 damage under limit and ultimate load levels, respectively.
- **Note this combination of tests eliminates the need for full-scale cyclic loading of the antenna/radome.**

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Developing Industry – Regulator activities:

- increasing use of ‘performance’ based regs
  - FAA Draft AC to be developed into an SAE standard
- SAE - Commercial Aircraft Composite Repair Committee (CACRC)
  - tasked by FAA to develop draft AC guidance into industry standard

FAA AIR-610

4. Objectives for the use of the SAE Document:
To develop a method of compliance for modifying composite aircraft structures and installing composite parts, whether on a metallic or composite structure.

release planned May 2022

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THANK YOU