



EUROPEAN AVIATION SAFETY AGENCY
AGENCE EUROPÉENNE DE LA SÉCURITÉ AÉRIENNE
EUROPÄISCHE AGENTUR FÜR FLUGSICHERHEIT

Additive Manufacturing (AM)

EASA Workshop

September 2017

Koeln

Dr. S.Waite

Senior Expert - Materials

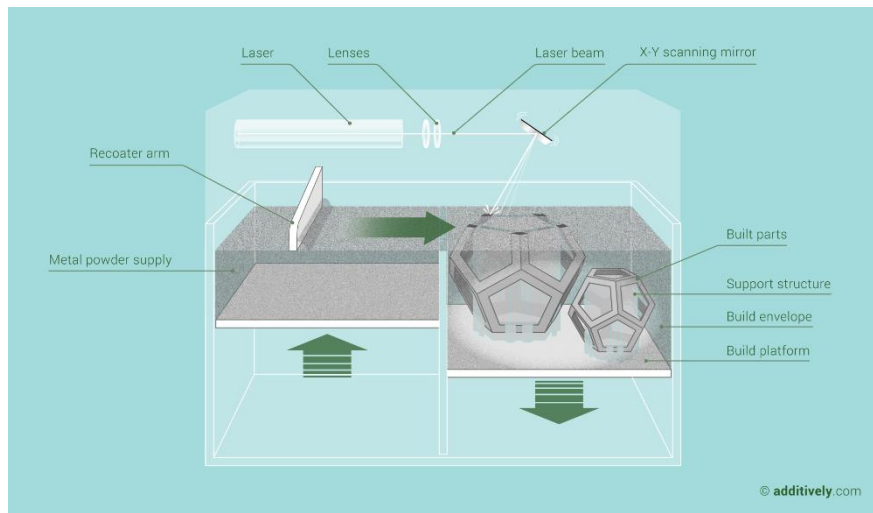
Certification Directorate

Your safety is our mission.

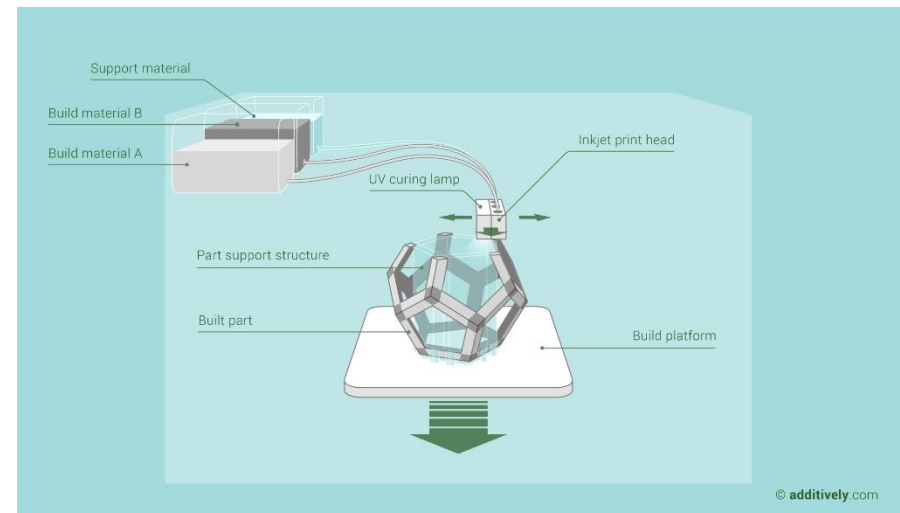


Additive Manufacturing – many methods, and definitions: ‘... make objects...layer upon layer...’

Laser-melting



Photopolymer-jetting



- metallic/non-metallic
- single material, multi-material, + fillers,
- hybrid processes, e.g. icw convention methods
- significant potential commercial benefits, e.g. rapid prototype evolution, reduced part count, weight reduction etc

Illustrations courtesy of **additively**
your access to 3D printing



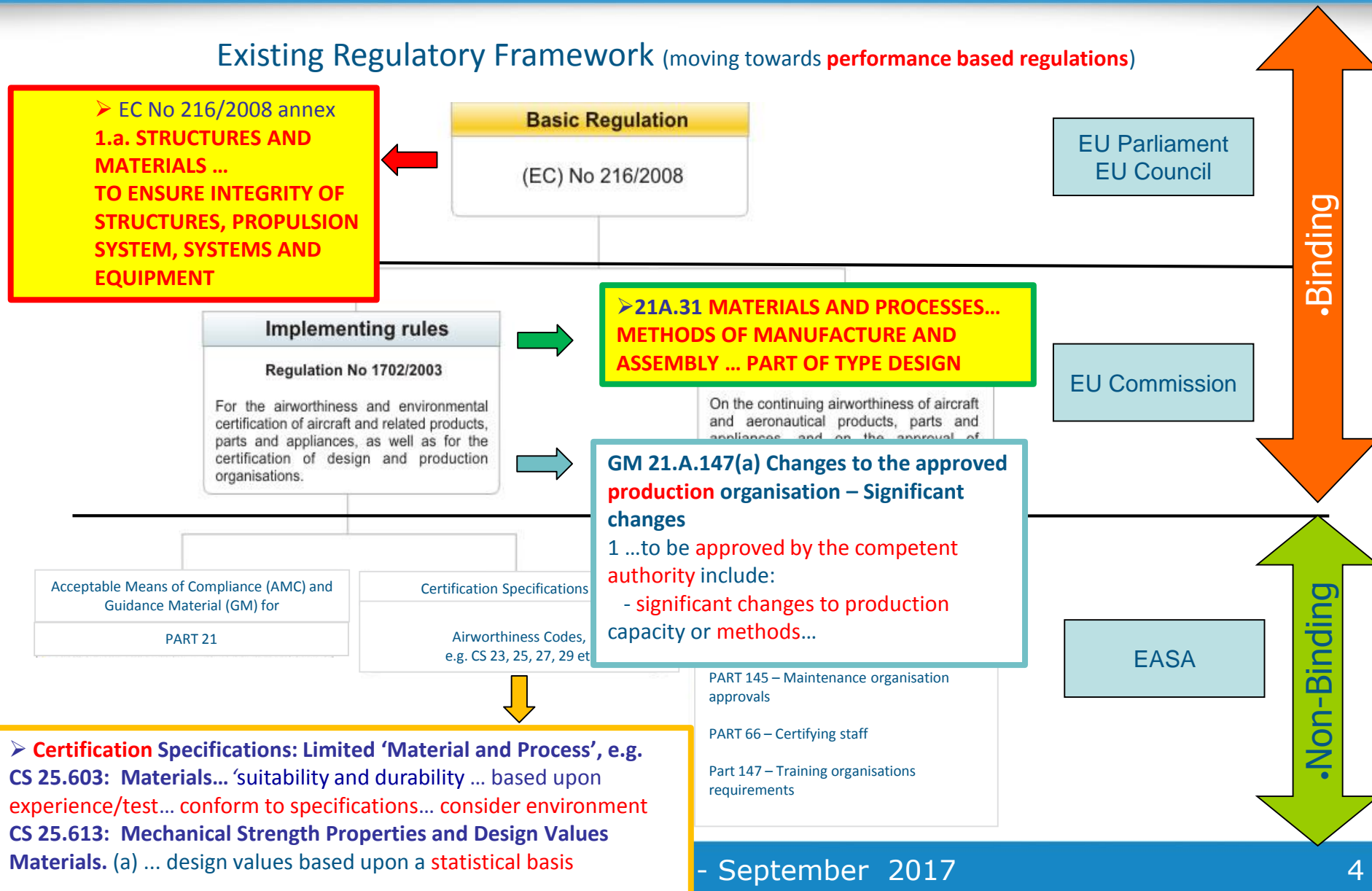
AM – EASA Perspective (see support slides and 2016 Workshop presentation*)

- rapidly increasing number of materials, processes, and applications, i.e. baseline applications and repair
- potential safety considerations
 - ‘engineering properties’, e.g. anisotropic, new and competing damage modes
 - repeatability - many variables (materials, processes, products), etc
 - changes in relationship between design, production, continued airworthiness (CAW), more integrated than many typical metallic processes (some similarities wrt composites)
 - increasing process driven quality (relative to inspection)
 - pressure for utilisation in increasingly critical applications
 - industry and regulator knowledge base and training
 - are changes required in rules and/or guidance?

*<http://www.easa.europa.eu/system/files/dfu/WORKSHOP%20Additive%20Manufacturing%20-%20Presentations.zip>



Existing Regulatory Framework (moving towards **performance based regulations**)





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**

CS 25.613: Mechanical Strength Properties and Design Values Materials

- (a) **Material strength properties** must be based on enough tests of material meeting approved specifications to establish design values on a **statistical basis**. (*A and B-basis*)



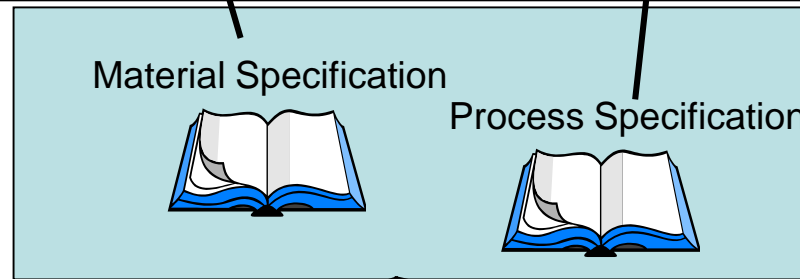
EASA - AM

Material properties built into part, or repair...

Manufacturing Processes

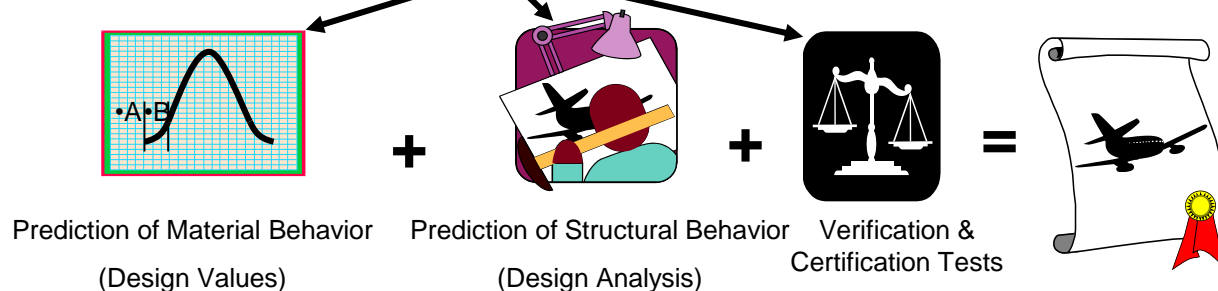


Material & Processing Standards



- close link between DOA, POA, and suppliers, mostly via specifications

Engineering Processes



Note: slide from a CMH-17 composite tutorial – similar for AM



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 is essential...otherwise, how can the higher pyramid work be trusted?)
- 'sensitive processes' – a major challenge if completing production activities in a more challenging maintenance environment

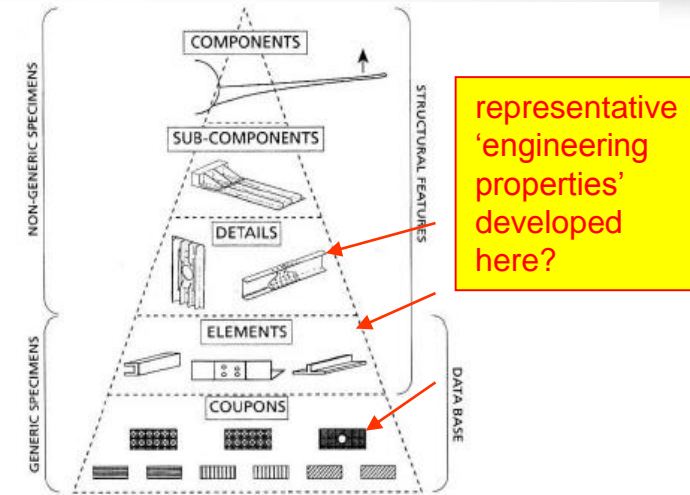
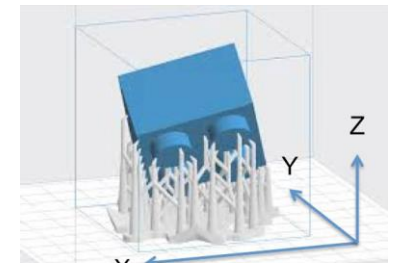


Figure 1 - Schematic diagram of building block tests for a fixed wing.

e.g. AM, composites, bonded joints



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



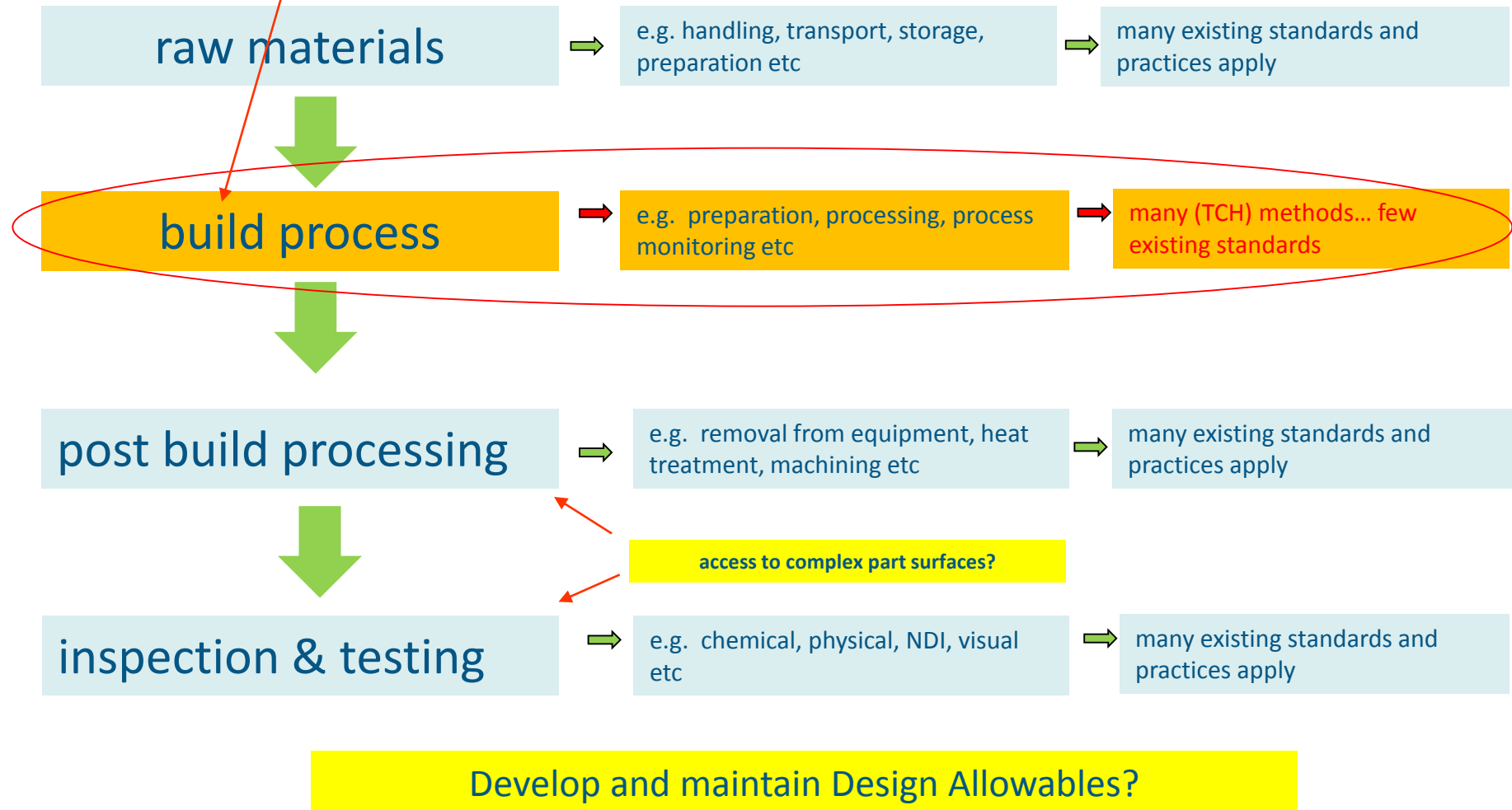
e.g. support structure on the build platform



.... limited to specific machine serial number
... avoid using different materials in the same machine
until variability/equivalence is better understood

EASA - AM

Additive Manufacturing: What is new to manufacturing regarding AM?





The Regulations – EASA priorities and resources:

- **priority is safety...** 'do not reduce the existing level of safety'
- **prioritise activities with respect to novelty and criticality**

e.g. AM within scope of LOI (NPA 2015-03)

21.B.100 Level of Involvement

...(b) The Agency shall establish its **level of involvement** at the level of compliance demonstration items, or groups thereof, following a **safety and environmental risk assessment, taking into account** but not limited to:

1. the **novel or unusual features** of the certification project, including operational, organisational and knowledge management aspects;
2. the **criticality of the design or technology** and the related safety and environmental risks, including those identified on similar designs; and...



The Regulations – EASA priorities and resources:

Example AM challenge - Guidance (what is the appropriate level of detail)?

- FAA *Memorandum AIR100-16-130-GM18 'Engineering Considerations for Powder Bed Fusion (PBF) Additively Manufactured Parts' ↑

*...addresses one method, PBF, which refers to (but does not address in detail) '100 control parameters... '**

*many variables – materials, process, configurations...
Who is going to do this for every method...?*

- *need to standardise strategy to identify key parameters and manage sensitivity?*
 - *failure modes wrt hazard analysis?*
- *other mitigating factors?... e.g. batch mixing in multi-load path structure etc*



e.g. does a static part remain a static part if produced using AM?

* one of a number of useful developing FAA AM documents



EASA AM Strategy - current activities:

- EASA AM WG (as identified in CM):

| | |
|---|---|
| - Cert. Directorate (Chief Expert - Airframe) | R. Minter – richard.minter@easa.europa.eu |
| - Structures | S. Waite (AM WG chair) – simon.waite@easa.europa.eu W. Hoffmann - wolfgang.hoffmann@easa.europa.eu |
| - Propulsion | M. Mercy - matthew.mercy@easa.europa.eu |
| - Systems | M. Weiler - michael.weiler@easa.europa.eu |
| - Cabin Safety | T. Ohnimus - thomas.ohnimus@easa.europa.eu |
| - DOA | A. Enache - alexandru.enache@easa.europa.eu |
| - POA | D. Lamothe - dominique.lamothe@easa.europa.eu |
| - Maintenance | R. Tajas - rosa.tajes@easa.europa.eu |
| - ETSO | TBD |

- Risk and Mitigation Matrix

- Certification Memo (CM)

- Workshops (first meeting - September 2016)

- Regular communication with other regulators



Certification Memo: EASA CM–S-008 Issue 01: Additive Manufacturing*

Requirements: CS X.571, CS X.603, CS X.605, CS X.613, CS-E 70, CS-E 100 (a), CS-P 170, CS-P 240, CS-APU 60, GM 21.A.91, 21.A.101, 21.A.133, 21.A.433, GM 21.A.435, 21.A.437, 21.A.447, 21.A.805, AMC 145.A.42(c)

Purpose/Scope: ...provide guidance regarding regulator expectations relating to the **usage of AM technologies** in products (**Aircraft, Rotorcraft and Propulsion**) subject to **EASA Type Certification**

simple 'early engagement' message...

EASA Certification Policy and Guidance for DOA and POA Holders

- is a change of material or/and process iaw GM 21A.91
- in repair, repair design would normally be classified Major, applicants are advised to consult EASA when introducing AM in repairs, including cases where they hold a privilege for repair approval.

not intended to make everything Major...
'case by case' approach...

*<https://www.easa.europa.eu/system/files/dfu/EASA%20CM-S-008%20Additive%20Manufacturing.pdf>



CM: EASA Certification Policy and Guidance for DOA and POA Holders

- **Design Organisation Approval Holders** are advised to involve the Agency at the earliest opportunity during the development and implementation of AM.AM will be subject to increased oversight by the agency and that specific audits will be scheduled to examine the introduction and use of AM within the scope of the design organisation audit cycle. ... audits may take place concurrently with the review of AM applications rather than post approval.
- **Production Organisation Approval** holders are advised to inform their respective competent authorities at the earliest opportunity before the implementation of AM processes. ...implementation of a new AM process by a POA holder is a change which may be identified as a significant change in accordance with Part 21.A.147 + GM

simple 'early engagement' message...

PART145s typically have no access to TCH hazard analysis, damage modes, criticality etc – which AM might change

EASA - AM

potential need for more guidance regarding expectations proportional to criticality recognised

CM: Maintenance/Operators: Existing DOA, POA, PART145 regulations apply...

PART 145.A.42 Acceptance of components:

'...organisation may fabricate a restricted range of parts to be used in the course of undergoing work within its own facilities... procedures are identified in the exposition.'

'All necessary data to fabricate the part ...approved by the competent authority, TC holder, or Part-21 design organisation approval holder, or supplemental STC holder;'

'Para.7. Examples of fabrication under the scope of an Part-145...:

a) Fabrication of bushes, sleeves and shims... b) ...secondary structural elements and skin panels... etc

All the above fabricated parts, should be in accordance with data provided in overhaul or repair manuals, modification schemes and service bulletins, drawings or otherwise approved by the competent authority. Note: It is not acceptable to fabricate any item to pattern unless an engineering drawing of the item is produced which includes any necessary fabrication processes and which is acceptable to the competent authority.'



Certification Memo (lessons learned):

- **working well with large TCHs**, e.g. Airbus, Rolls Royce, Safran (see 2016 Workshop Slides)
 - evolution towards more critical applications in progress
- need strategy to **better identify and understand 'key parameters'**, e.g. machine parameters, statistical strategy, enable shared databases (e.g. SAE AM-P, NIAR work) etc
- some **challenges** to be addressed regarding **optimisation of evolving use in maintenance/operator environment**
 - less critical interior part applications....
 - strength, fire, failure modes (sharp edges preventing evacuation, fatigue), statistics etc
- rapid technology integration...
 - **knowledge base/training for industry/regulators is likely to be a challenge**

e.g. DRAFT AMS 7003 – agree upon
'Significant Process Characteristics' SPCs





New!
support
CM

EASA – NAA activities: NAA Materials Network (NAAMN)*

- improve communication/standardisation between NAA and EASA regarding broader ‘material and process’ issues

NAAMN – Terms of Reference:

To identify, and address as necessary, common **Materials and Process** (metallic, non-metallic, ceramic, Additive Manufacturing (AM) etc) issues with potential safety implications from an **European NAA perspective**.

To consider all aspects of Materials and Processes in the context of all activities, including design, supply, production, and maintenance.

To consider Materials and Processes issues ranging from detailed technical issues (airframe, propulsion, systems, cabin safety, maintenance etc) through to organisational and regulatory structural issues, including certification, material qualification, complex part substantiation, training, standardisation, R&D, and rulemaking.

* see support slide for current membership (all European NAAs invited, currently 11 NAAs)



Conclusions – 2017 (see 2016 presentation): AM is rapidly evolving:

- EASA does not approve materials or processes, but accepts them as part of a project - provided that they are shown to be validated, applicable, and repeatable
- Technology, and technology application, changes must not reduce the existing 'acceptable' level of safety
- EASA AM Working Group in place to review and assess risk, and risk mitigation, and to work with other regulators and industry (CM) to help ensure safe integration of the evolving technologies into aviation
- EASA AM CM in place

CM approach seems to work
- additional NAA communication path established to support process (NAAMN)



Conclusions: AM is rapidly evolving:

Rules: **limited/possibly no rule change expected** by EASA...

Guidance: some guidance development expected (level of content/detail unclear), a function of:

- criticality of applications
- identification of any common underlying philosophy development* associated with maturing technologies e.g. icw international standards bodies etc, e.g. SAE, ASTM.
- would an AM equivalent to AMC 20-29 'Composite Structures' potentially useful?

R&D: EASA increasingly working with EU funded projects

Workforce knowledge base and training (industry and regulators)

– likely to be a limiting factor in this rapidly developing technology

* it is understood that IP will not be shared. However, applicants are required to meet the requirements, e.g. show stable process, repeatable 'engineering properties' etc



Questions?



Support Slides

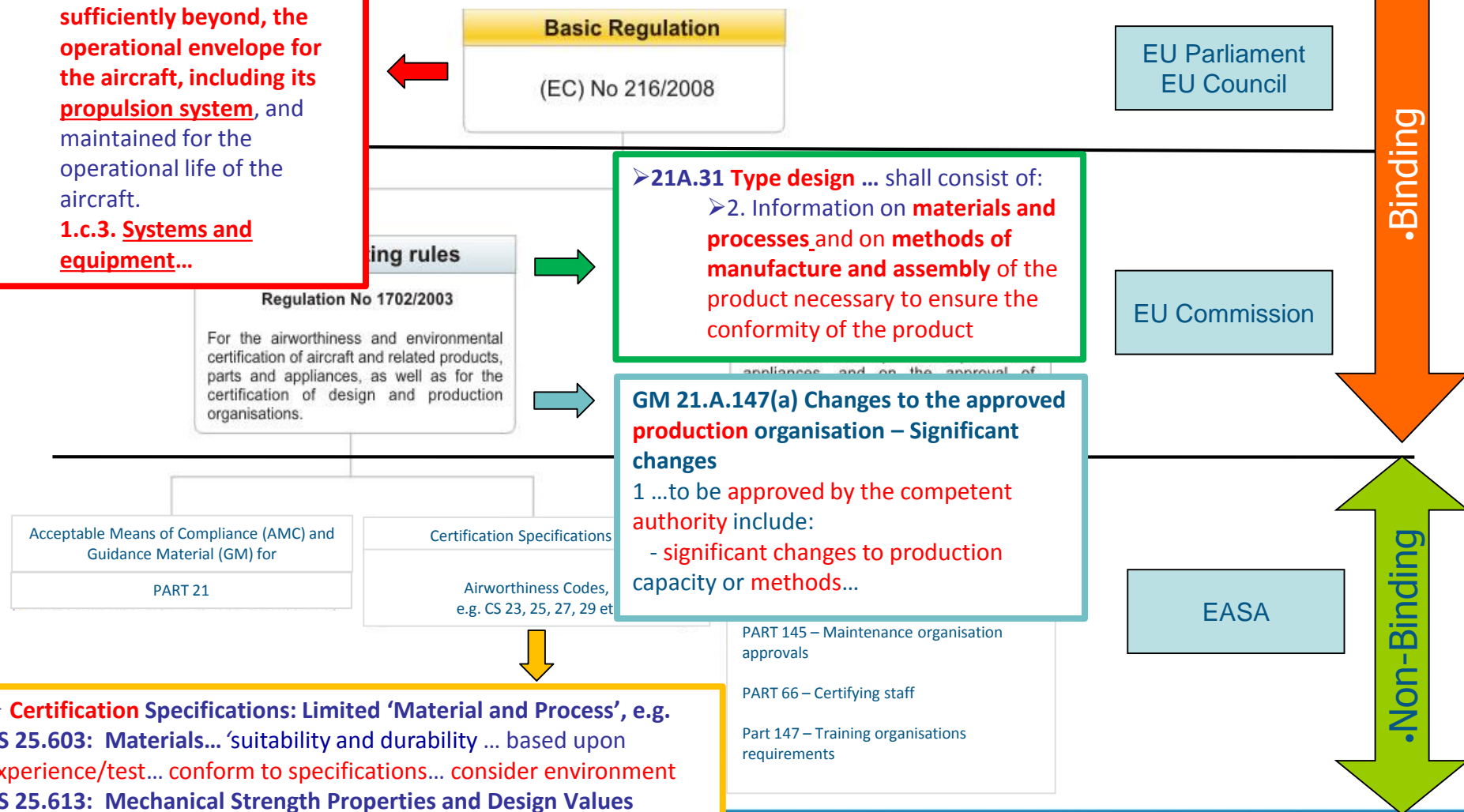


EASA - AM

➤ EC No 216/2008 annex 1.a. **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.

1.c.3. **Systems and equipment...**

Regulatory Framework (moving towards performance based regulations)



➤ **Certification Specifications: Limited 'Material and Process', e.g.**

CS 25.603: Materials... 'suitability and durability ... based upon experience/test... conform to specifications... consider environment

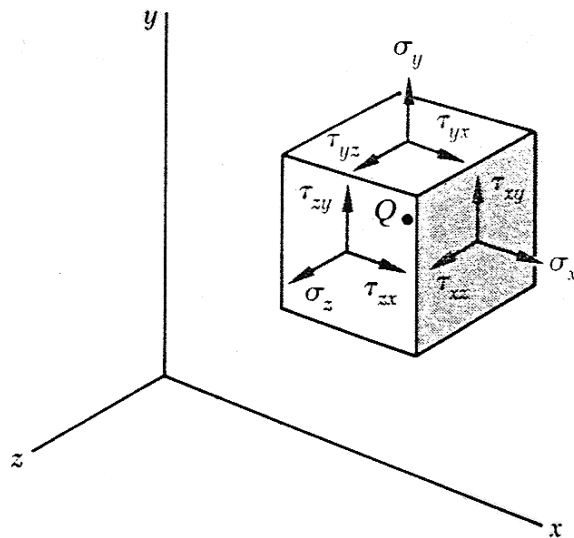
CS 25.613: Mechanical Strength Properties and Design Values

Materials. (a) ... design values based upon a statistical basis



'Engineering Properties'*: '... historically, many materials used in aviation are **isotropic**

- properties similar in all directions of load application, e.g. mechanical, thermal etc (+ **similar/limited damage modes**)



Isotropic: similar strength in X,Y, and Z directions

Anisotropic: different strengths in X and/or Y and/or Z directions

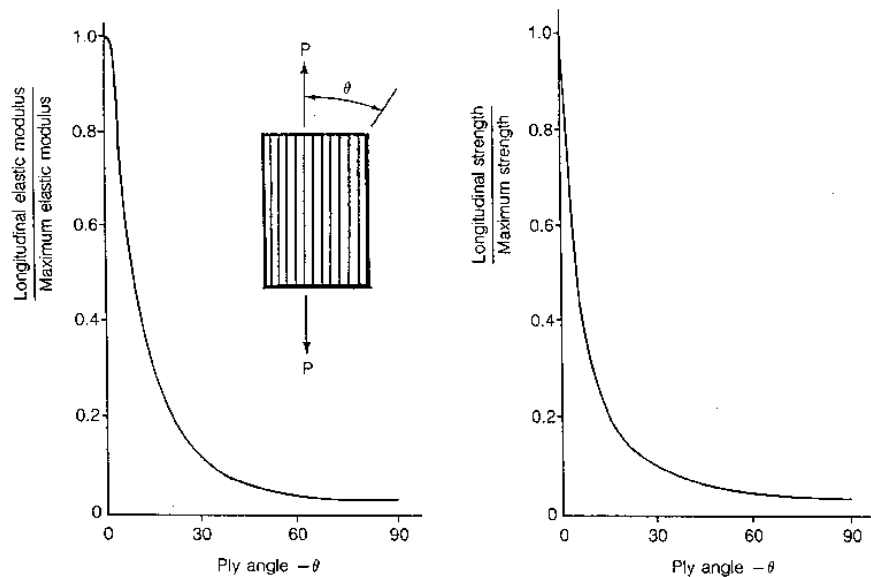
* 'engineering properties', e.g. strength + stiffness (local and global buckling) which define the structure performance



'Engineering Properties': '... make objects...layer upon layer...'

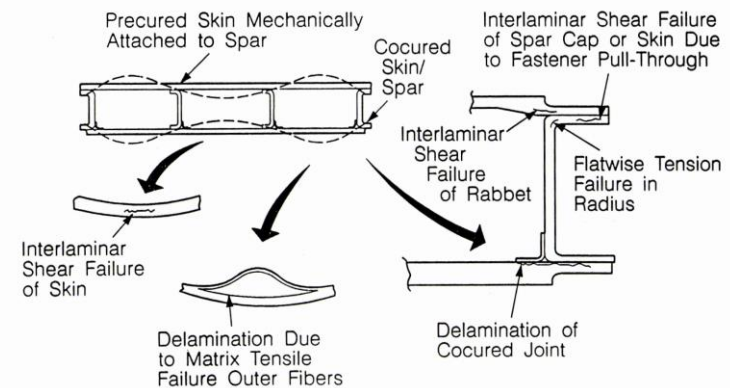
- initially assume AM **potentially anisotropic** – properties change with direction of load application (+ **competing damage modes**)

Anisotropy: Significant strength/stiffness reduction with orientation relative to load



Strength/Stiffness v Ply Angle
(non-dimensionalised)

Out-of-Plane Failure Modes



Anisotropy: potentially difficult to predict:

- **failure loads**
- **damage modes**
- **damage locations**
- **damage sequence**



Identification and control of key process steps essential... look for substantiated tolerance sensitivity data

Example AM challenge...*

CS 25.613: Mechanical Strength Properties and Design Values Materials

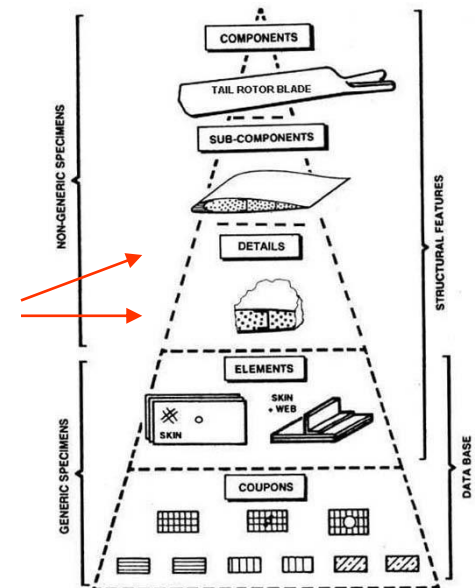
How do we statistically manage inaccessible free edges in complex laser melt parts?

- free edge coupons produced in parallel with parts
- coupons produced from part cut-up
- use higher pyramid component testing (small data set statistics?)

Non-TCH DOA unlikely to have this information...
e.g. acceptable free edge details etc



Free Edge –
fatigue issue?



AMC 20-29 Figure 2 - Schematic diagram of building block tests for a tail rotor blade

* similarities to how castings are addressed in CS25.621 'Castings Factors'?

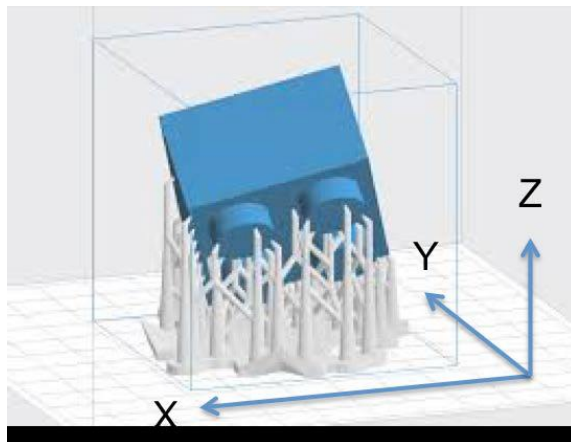


Identification and control of key process steps essential... look for substantiated tolerance sensitivity data

Example AM challenge...

CS 25.613: Mechanical Strength Properties and Design Values Materials

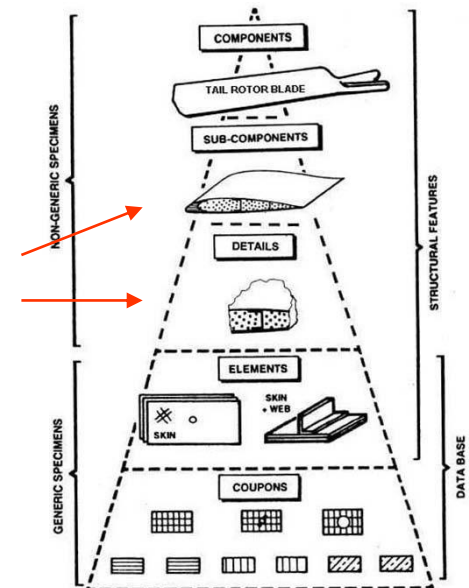
How do we statistically manage complex supported parts?*



PBF part (blue) and Support Structure (white) on the Build Platform



Unsupported "roof"



AMC 20-29 Figure 2 - Schematic diagram of building block tests for a tail rotor blade

* *support provides physical support and/or thermal management*



EASA AM: Strategy:

- 1 - Understand the technology / process / product and its actual, planned or potential uses.
- 2 - Identify potential safety / environmental risks.
- 3 - Define and implement means to mitigate risks working closely with industry and NAAs.
- 4 - Monitor evolution of technology / product / process and effectiveness of mitigation.
- 5 - Review and revise implementation of strategy as necessary.



CM:

EASA Certification Policy and Guidance for DOA and POA Holders

applicants to demonstrate:

- complies with appropriate CS's
- suitable for intended use
- source materials purchased to spec
- produce consistent product to process spec
- statistically significant design values wrt defined facilities/equipment
- control of equipment/process



Risk and Mitigations Matrix:

Preliminary (initial) areas of risk list (under EASA AM WG review/development*):

Scope and definition of AM not standardised

New materials

Many process parameters to control (see Appendix)

Anisotropic properties of finished part

Variation in the types of AM equipment / processes and lack of standardization

Limited understanding of acceptable ranges of variation for key manufacturing parameters

Limited understanding of key failure mechanisms

Transfer from small scale manufacture to high levels of production

Lack of broad industry databases / allowables (each implementation is unique)

Development of capable NDI methods

Repairs

Current rules: Note: ARAC Composite and Metallics group also has to consider new technology in F&DT recommendations)

Insufficient guidance (Likely)

POA related

DOA related

DOA and POA link

Certification related

Higher risk of bogus parts

* including identification of existing mitigations and the need for new additional actions



NAA Materials Network (NAAMN): Current Members

| Organisation | Focal First Name | Focal Family Name | Focal Function within NAA | e-mail address |
|---|-----------------------|-------------------|--|--|
| CAA-NL | Bart | Abbes | Aircraft Structures Specialist | bart.abbes@ilent.nl |
| CAA-CZ | Tomaz | Franc | Specialist - Aircraft Design Section | franc@caa.cz |
| CAA-CH | Andreas | Boss | Inspector | Andreas.boss@bazl.admin.ch |
| LBA 1 | Dietmar | Goldschmidt | National Standardisation Coordinator (NSC) Luftfahrt-Bundesamt | dietmar.goldschmidt@lba.de |
| LBA 2 | Karen | Mueller | | Karen.Mueller@LBA.DE |
| CAA-SI | Bostjan | Palcic | Airworthiness Inspector | bostjan.palcic@caa.si |
| CAA-RO | Alexandru George | Musat | Airworthiness Inspector | alexandru.musat@caa.ro |
| ECAA-EE | Margus | Keerman | Senior Inspector Airworthiness | margus.keerman@ecaa.ee |
| Austro Control | Flrian | Glatzl | Airworthiness and Certification Surveyor | Florian.Glatzl@austrocontrol.at |
| Trafi (Finland) | Jyrki | Laitila | Head of Unit, Airworthiness | jyrki.laitila@trafi.fi |
| CAA- Poland - Institute of Aviation | Małgorzata (Margaret) | Zalewska | Composites Testing Laboratory Manager in the Institute of Aviation | malgorzata.zalewska@ilot.edu.pl |
| CAA-UK | Ted | Blacklay | Airworthiness Survey - Subject Matter Expert for Materials, Special Processes and NDT | ted.blacklay@caa.co.uk |



Standardisation of Certification Requirements Applicable to AM

- limited material specific specific rules/guidance
(although significant to design and throughout CSs)
- governing rule is **CS 2x.603**:

CS 25.603: Materials (For Composite Materials see **AMC 20-29***)

'The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must.....'

- *be based upon experience/test*
- *conform to **specifications** (meeting design data)*
- *consider environmental effect (temperature, moisture etc)*

*AMC 20-29 - harmonised with FAA AC20-107B



CS- E – different words, similar intent as CS 2x-603, 605

CS-E 70 Materials and Manufacturing Methods (See AMC E 70)

(a) The suitability and durability of materials used in the Engine must be established on the basis of **experience or tests**. The assumed design values of properties of materials must be suitably **related to the minimum properties stated in the material specification**.

(b) Manufacturing methods and **processes must be such as to produce sound structure and mechanisms which retain the original mechanical properties under reasonable service conditions**.



CS- E – different words, similar intent as CS 2x-613
(statistical credibility - safe-life - metal assumption)

CS-E 515 Engine Critical Parts

...the factors used to account for **scatter should be justified**. In order to utilise this approach the test should be designed to be representative of the critical engine conditions in terms of the temperature and stress at the specific features...

...**test data should be reduced statistically in order to express the results in terms of minimum LCF capability (1/1000 or alternately -3 sigma)**. The fatigue life should be determined as a minimum life to initiation of a fatigue crack, defined typically as a crack length of 0.75mm.



CS25.571: **Damage-tolerance & fatigue evaluation of structure**

*'(a) General. An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to **fatigue**, **corrosion**, or **accidental damage**, will be avoided throughout the operational life of the aeroplane...'*

Environmental Damage - ED

Accidental Damage - AD

Historically: metal/fatigue/corrosion focused



Existing CS25 Structures Regulations of particular interest and potential relevance include:

CS 25.571: Damage Tolerance and Fatigue Evaluation of Structure:

‘(3).....inspections or other procedures must be established as necessary to prevent catastrophic failure, and must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by CS 25.1529’

Does not need to be visual,
Note: 80-90% of inspections are visual
ref. also CS25.611

Does not need to be an
‘inspection’

Notes:

1/ **EASA does not approve inspection standards**, but accepts them as part of a process, project etc - provided that they are shown to be validated, applicable, and repeatable

2/ **technology and technology application changes must not reduce the existing ‘acceptable level of safety’**



AM - Maintenance/Operating Environment:

Example AM challenge – existing requirements/awareness**...*

PART 145.A.42 Acceptance of components:

'...organisation may fabricate a restricted range of parts to be used in the course of undergoing work within its own facilities provided procedures are identified in the exposition.'

AMC 145.A.42 Acceptance of components:

'All necessary data to fabricate the part should be approved either by the competent authority or the type certificate (TC) holder or Part-21 design organisation approval holder, or supplemental type certificate (STC) holder;'

* AM similarities wrt composites

** applies to industry and regulators



AM - Maintenance/Operating Environment:

*Example AM challenge – existing requirements/awareness***

PART 145.A.42 Acceptance of components:

'7. Examples of fabrication under the scope of an Part-145 approval can include but are not limited to the following:

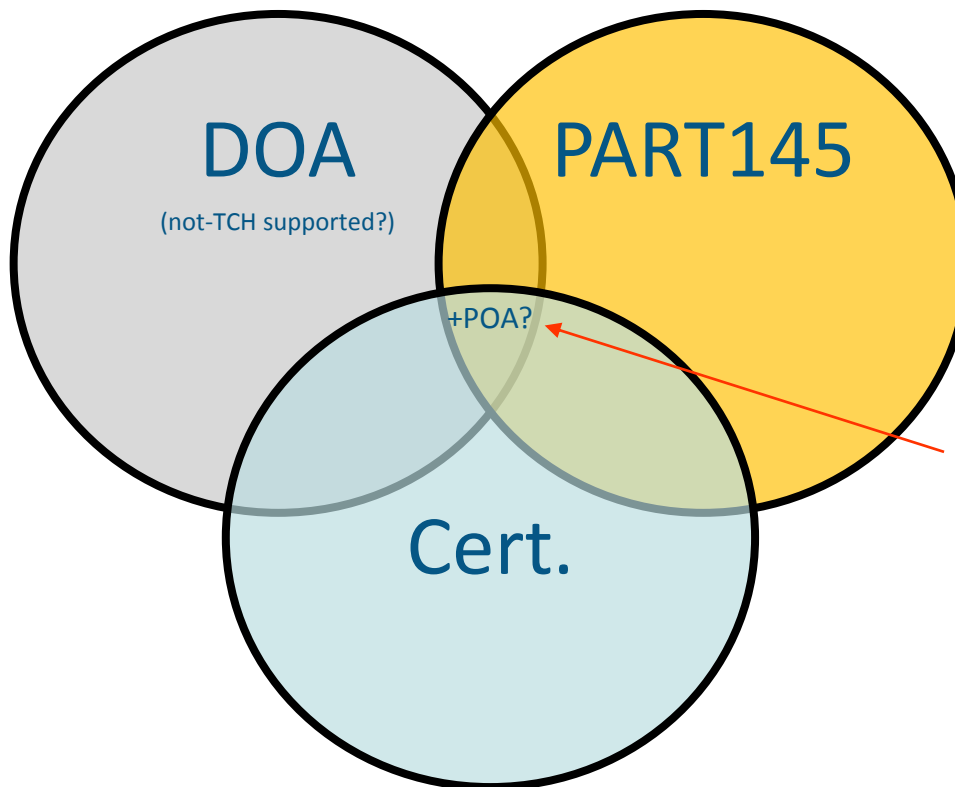
- a) Fabrication of bushes, sleeves and shims.*
- b) Fabrication of secondary structural elements and skin panels.*
- c) Fabrication of control cables.*
- d) Fabrication of flexible and rigid pipes.*
- e) Fabrication of electrical cable looms and assemblies.*
- f) Formed or machined sheet metal panels for repairs.*

changed material:
changed damage mode/debris?
- consider downstream critical part
consequences...

All the above fabricated parts, should be in accordance with data provided in overhaul or repair manuals, modification schemes and service bulletins, drawings or otherwise approved by the competent authority. Note: It is not acceptable to fabricate any item to pattern unless an engineering drawing of the item is produced which includes any necessary fabrication processes and which is acceptable to the competent authority.'



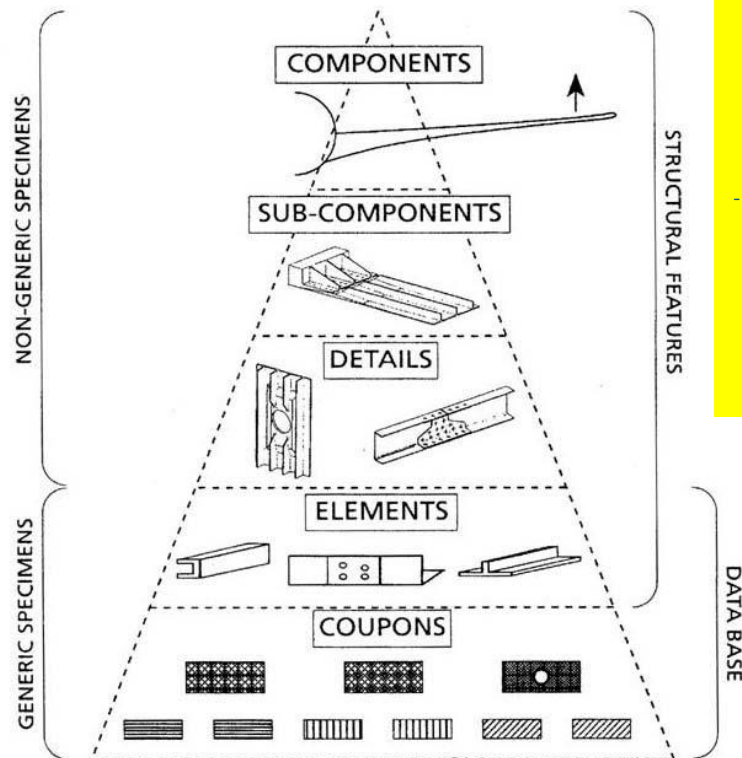
AM - Maintenance/Operating Environment:



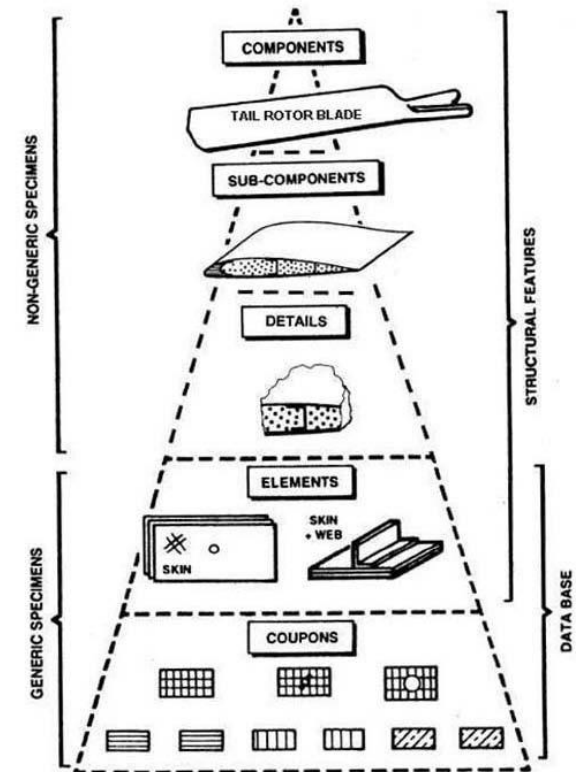
Existing rules:

- POA?
- Improve links between EASA and NAAs

Substantiation: Test/Analysis Pyramid (Building Block)?



AMC 20-29 Figure 1 - Schematic diagram of building block tests for a fixed wing.



AMC 20-29 Figure 2 - Schematic diagram of building block tests for a tail rotor blade

Design Philosophy: robust design concept, e.g. Large Damage Capability (LDC)

- to be similar to established metallic structure except:
 - potentially different/more competing damage modes,
 - some damage modes not so readily detected

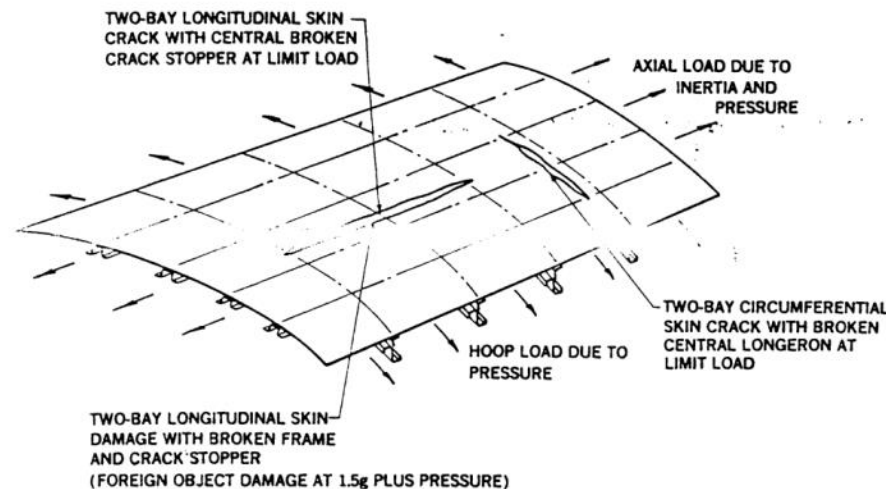


FIGURE 2. FUSELAGE DAMAGE TOLERANCE SIZES FOR STRUCTURAL DESIGN

Metal Design - Design for Redundant Structures' - T. Swift

- additional consideration may be required for technologies which change design concepts



Design philosophy changes:

Do not reduce the existing Level of Safety

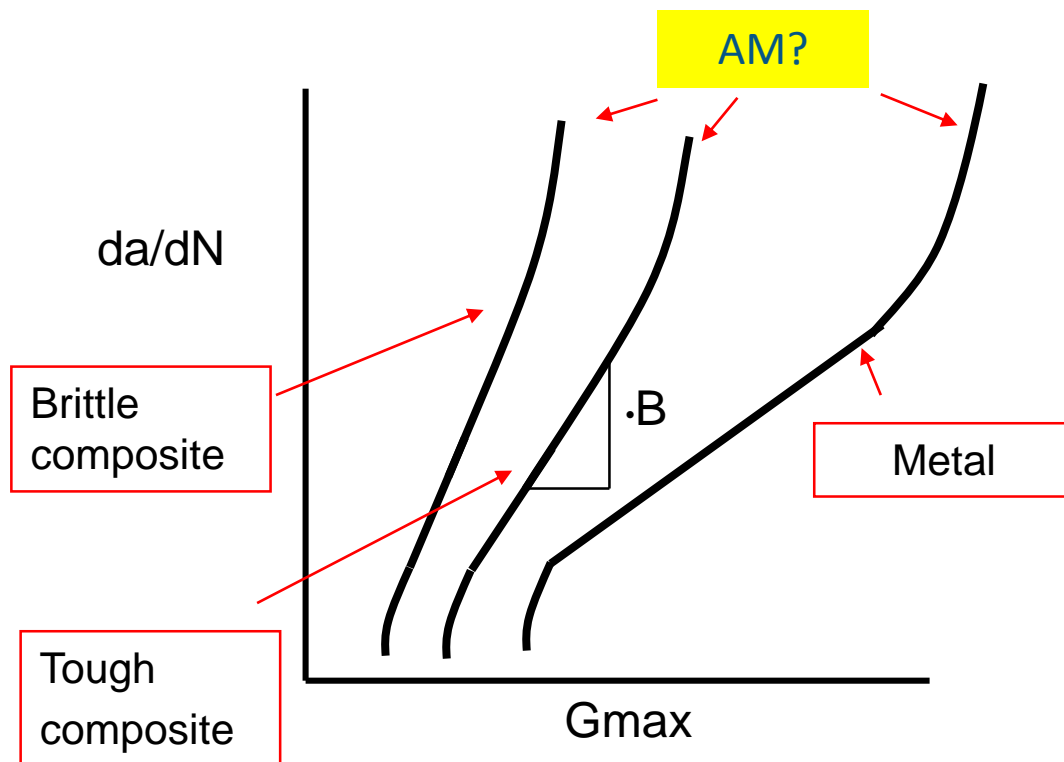
- show 'equivalence' to existing technologies
- result of: experience, R&D, 'engineering judgement', reaction to incidents and accidents, and regulations existing at the time of certification, Type Certificate Holder in-house design practice

Maintain robust 'aircraft level' design concept

- address all identified threats, e.g. manufacture, in-service
- similar to established metallic structure, e.g. T. Swift philosophy etc
- local damage may be different, but structural level failure may be driven by the similar failure mode, e.g. buckling



Damage – Inspection and Damage Tolerance:



$$\frac{da}{dN} = AG^B \quad G \propto P^2$$

$$\Rightarrow \frac{da}{dN} \propto P^{2B}$$

| Material | B |
|----------------------|------|
| Steel | 1.6 |
| Aluminium | 2.2 |
| Carbon/Thermoplastic | 6.1 |
| Carbon/Epoxy | 12.2 |

Solution :- ensure that when damage is present, G is below a threshold value for crack growth

AM – potential for a broad range of Fatigue and Damage Tolerance philosophies
- safe life, flaw tolerant safe life, fail-safe, damage tolerant?



Composite Safety Issues

AMC 20-29 - Composites:

3. APPLICABILITY

This AMC provides Acceptable Means of Compliance with the provisions of CS-23, CS-25, CS- 27 and CS-29. Many of the concepts included in this AMC may also be applicable in part or in full to other CSs. However, when using this AMC as an Acceptable Means of Compliance for these other CSs, appropriate engineering judgement should be exercised and early agreement with the Agency sought.

This AMC applies to: applicants for a type-certificate, restricted type-certificate or supplemental type-certificate; certificate/approval holders; parts manufacturers; material suppliers; and maintenance and repair organisations.



– similar for AM



Composite Safety Issues

Standardisation of Certification Requirements for Composites

Composite Certification - existing rules and guidance

EASA AMC 20-29/FAA AC20-107B – ‘COMPOSITE AIRFRAME STRUCTURE’

CONTENTS (expanded 12 to 36 pages, new sections – red)

1. PURPOSE
 2. CANCELLATION
 3. **TO WHOM THIS AMC APPLIES**
 4. RELATED REGULATIONS AND GUIDANCE
 5. GENERAL
 6. **MATERIAL AND FABRICATION DEVELOPMENT**
 7. PROOF OF STRUCTURE – STATIC
 8. **PROOF OF STRUCTURE – FATIGUE AND DAMAGE TOLERANCE**
 9. PROOF OF STRUCTURE – FLUTTER
 10. **CONTINUED AIRWORTHINESS**
 11. ADDITIONAL CONSIDERATIONS (crashworthiness, fire/flammability, lightning)
- APPENDIX 1 Requirement Table
- APPENDIX 2 Definitions
- APPENDIX 3 **Material Change**

1984
document

applicable
to PMC
composite fan
blade



– similar for AM



Composite Safety Issues

Safety
Management
System

Standardisation of Certification Requirements for Composites:

AMC 20-29 includes clear linkage between design requirements and many material, production, and continued airworthiness related requirements...

| Regulations: | CS23 | CS25 | CS27* | CS29* |
|-----------------------------|-------------------|-------------------|-------------------|-------------------|
| Material and Fabrication | 603 613 619 | 603 613 619 | 603 613 619 | 603 613 619 |
| Proof of Structure – Static | 305 307(a) | 305 307(a) | 305 307(a) | 305 307(a) |
| Proof of Structure – F&DT | 573** | 571 | 573 | 573 |
| Proof of Structure – Flight | 629 | 629 | 629 | 629 |
| Additional Considerations | | | | |
| Impact Dynamics | 561 | 561 | 561 | 561 |

Works for
CS-P
CS-E

table continues with other requirements linked to flammability, lightning strike, production specifications, continued airworthiness etc.

* Rotorcraft

** Many similar code numbers, but some differences in content

– similar for AM



Production Organisation Approval PART 21, Sub. G:

21.A.147 Changes to the approved production organisation

(a)each **change** to the approved production organisation ... significant to the **showing of conformity or to the airworthiness** ... particularly changes to the quality system, shall be approved by the competent authority

GM 21.A.147(a) Changes to the approved production organisation – Significant changes

1 Changes to be approved by the competent authority include:

- **significant changes to production** capacity or **methods**...
- **changes in the production or quality systems** ...important impact on the conformity/airworthiness of each product, part or appliance.

2 ...ensure that **changes do not result in non-compliance** ... competent authority and approval holder to establish a relationship ... will permit the necessary evaluation work to be conducted before the implementation of a change



Conclusions: AM is rapidly evolving:

Rules: limited/possibly no rule change expected by EASA...

Guidance: some guidance change expected (level of content/detail unclear), a function of:

- criticality of applications
- identification of any common underlying philosophy development* associated with maturing technologies e.g. icw international standards bodies etc, e.g. SAE, ASTM.
- would an AM equivalent to AMC 20-29 'Composite Structures' potentially useful?

R&D: EASA increasingly working with EU funded projects

Workforce knowledge base and training: Need

* it is understood that IP will not be shared. However, applicants are required to meet the requirements, e.g. show stable process, repeatable 'engineering properties' etc



Conclusions:

POA/DOA/Maintenance:

- need to increase awareness of closer relationship between design, production, continued airworthiness (CAW), more integrated than many typical metallic processes (some similarities wrt composites)
- need to increase awareness of existing rules, particularly at interfaces between design, production, and maintenance, e.g. link between non-TCH DOA, PART 145 (AMC 145.A.42 para.7), and the need for TCH data for extensive repair and 'replacement' (also similarities wrt composites)

R&D:

EASA strategy to work with EU funded projects and industry to ensure regulatory resource is efficiently focused upon maturing methods and applications

- Test/analysis pyramid statistical credibility issue within scope of next EU FP - TBD



EASA AM Workshop

September 2017

CLOSE

Next EASA AM Workshop
...date TBD

Thank you for your interest and support

Particular **thanks to: The Presenters**
and

Lily Kamburova and **Wolfgang Hoffmann** for
organising the agenda and managing this
Workshop