EASA
European Aviation Safety Agency

COMPOSITE MATERIALS SAFETY:

- Materials and Processes

Dr. Simon Waite
Senior Expert – Materials

Certification Directorate

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Materials and Processes: Agenda

Simon Waite: **EASA**: Senior Expert – Materials

- Introduction

CS23 – working in an increasingly 'performance based' regulatory environment

Aiko Duehne: EASA: Structures Expert

- Metallic Materials strength properties and design values

- EASA Composite Materials Safety Strategy (draft)
- EASA Certification Memos (CMs): Shared Databases, Bonded Repairs, Additive Manufacturing

Dipl.-Ing. Marcus J. Basien: **Aircraft Design & Certification Ltd.,** Technical Director & Head of Design

Arbietsreis Faserverbund Flugzeuge (Industrial working group fiber composite airplanes), Vorsitzender (ex-President)

- 'Use of AFF shared database (Seiteneinsteigerprogram)'

Philipp Steinbach: Game Composites: Head of Design Organisation, CEO

- 'GB1 GameBird'

EASA MATERIALS SAFETY

- 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.

egulatory Framework (moving towards **performance based regulations**)

Basic Regulation

(EC) No 216/2008

EU Parliament
EU Council

Implementing rules

Regulation No 1702/2003

For the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations.

- **21A.31 Type design … shall consist of:**
  - 2. Information on **materials and processes** and on methods of manufacture and assembly of the product necessary to ensure the conformity of the product

EU Commission

Regulatory framework applies to baseline structure and repairs - metallic and composite

CS23 more generic than other codes … now more 'performance based'

However, the intent and many engineering points remain the same

ss Codes,
e.g. CS 23, 25, 27, 29 etc

PART 145 – Maintenance organisation approvals

Certifying staff

Training organisations

EASA

Binding

Non-Binding

- **e.g. CS25 Certification Specifications: Limited 'Material and Process'**

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

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Metallic Material strength properties and design values

Aiko Dühne
Structures Expert

General Aviation Structures Workshop
16-17 October 2017

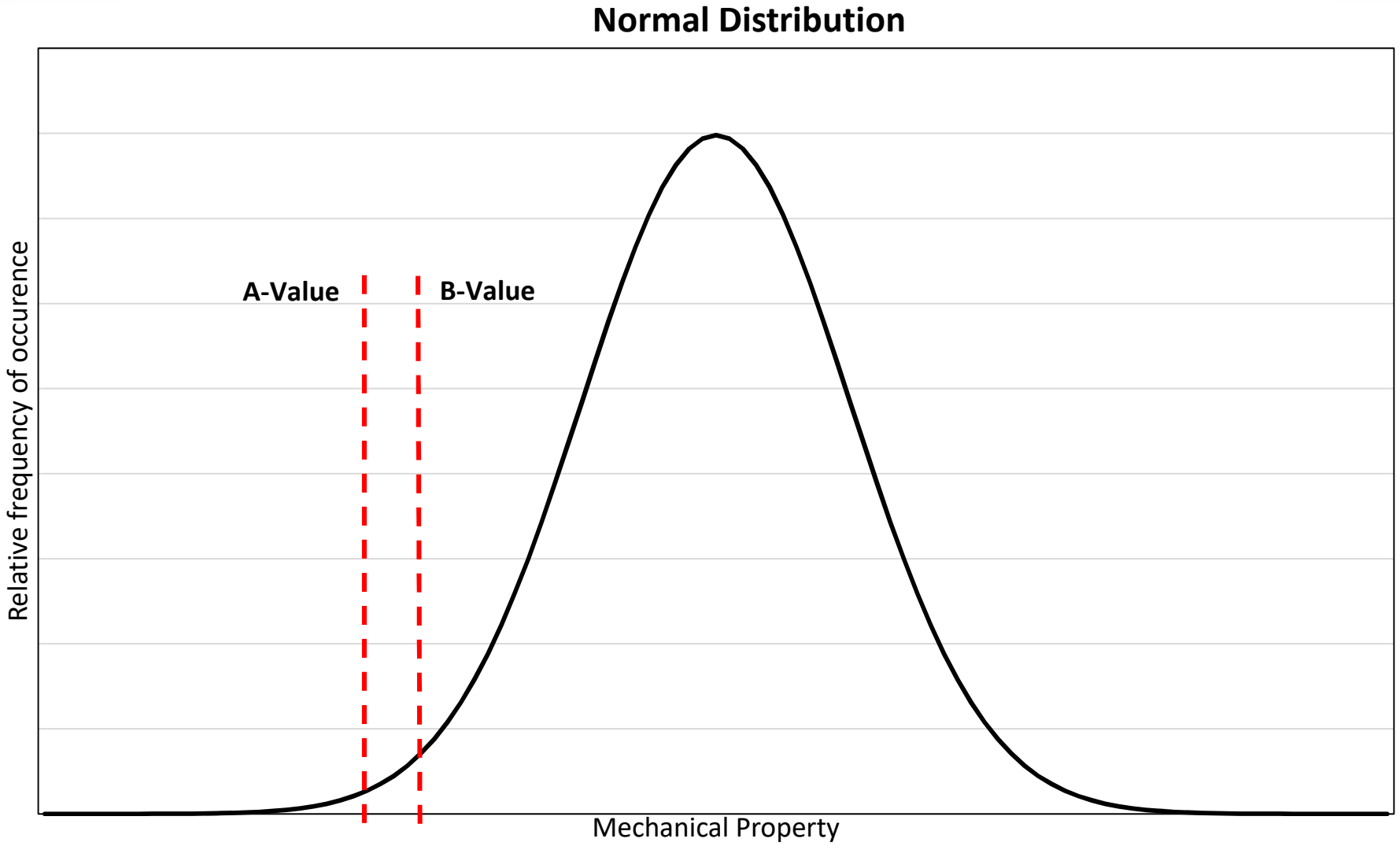
CS 23.613: Material strength properties and design values

- Material strength properties must be based on enough tests of material **meeting specifications** to establish **design values** on a **statistical basis**.
- The design values must be chosen to **minimise** the probability of **structural failure** due to **material variability**
- The **design** of structure must **minimise** the probability of **catastrophic fatigue failure**
- **Thermal effects** must be considered where **significant**

Values to be used

- Compliance must be shown by selecting design values that assure material strength with the following probability:
  - "**A-values**": Single load path (lugs):
    At least **99 percent** of the population of values are expected to equal or exceed the A-Value, with a confidence of **95 percent**.
  - "**B-values**": Multiple load path (skin-stringer-comb.):
    At least **90 percent** of the population of values are expected to equal or exceed the B-Value mechanical property allowable with a confidence of **95 percent**.

Values to be used



Values to be used

- **S-Values**
  - The S-value is based on the minimum property value
  - Statistical assurance associated with S-Basis values are only established since 1975 within limitations
  - Within these limitations values since 1975 can be considered as estimated A-values
  - The use of S-Value should be done **carefully** and needs to be **agreed with EASA**

Premium Selection

- Premium selection allows using design values greater than the guaranteed minimum
- A specimen of **each individual** item to be installed on the aircraft has to be tested to determine the **actual strength properties**
- Part has to have areas to obtain test specimen without destroying the part
- **Test procedures** and **acceptance** criteria must be specified on the design drawing

Typical Sources (Examples)

- **MMPDS**
  Metallic Materials Properties Development and Standardization
- **ESDU 00932**
  Metallic Materials Data Handbook
- **Handbuch Strukturberechnung (HSB)**
  (Fundamentals and Methods for Aeronautical Design and Analyses)
  The use handbook is restricted to the members of the industry working group IASB.

Fatigue data

- Fatigue data plotted in e.g. MMPDS may not apply directly to the design of structures
  - Fatigue data is based on smooth specimen
  - Fatigue data may not take into account specific stress concentrations unique to any given structural design.
  - Localized high stresses may be induced during the fabrication
  - All fatigue data require modification into allowables for design use.

Composites

EASA COMPOSITE MATERIALS SAFETY

aviation started with composite structures

EVOLUTION: Composite use in aviation

wood and fabric
Lilienthal

wood and fabric
Wright Flyer

metals (Duralumin) 1917, –
Junker J1

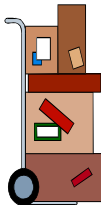
GA Aircraft and Rotorcraft Certification

- use in primary, PSE, and other critical applications well established (long before CS25)

EASA COMPOSITE MATERIALS SAFETY

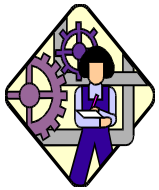
Safety relies upon substantiated 'materials and processes'

Manufacturing Processes



Material Purchased

+



Internal Manufacturing Processes Controlled by site specific Process Documents

=

Production Certification (PC)

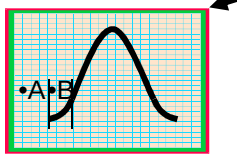
Material & Processing Standards

'engineering properties'

- defined by **'materials and process'**
- **built into the part or repair**
- elements of certification process similar for part or repair

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

Engineering Processes



Prediction of Material Behavior

(Design Values)

+

Prediction of Structural Behavior

(Design Analysis)

+

Verification & Certification Tests

=

Note: slide from a CMH-17 composite tutorial

The Regulations – EASA priorities and resources:

- priority is safety… 'do not reduce the existing level of safety'
- **limited regulatory resource available**… prioritise activities with respect to criticality/risk

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…

EASA Composite Materials Safety Strategy (draft):

EASA Composite Safety Strategy (draft):

CS22, 23, 25, 27,29, CS-P, CS-E, and ETSOs

1/ For the purposes of efficiency, 'when appropriate to EASA objectives and European Industry interests*', work with:

- other regulators**, e.g. FAA, TCCA, etc
- standardisation bodies, e.g. SAE, ASTM etc
- guidance development organisations, e.g. CMH-17

* all aspects, e.g. rulemaking, R&D, Certification (design, production, CAW), etc

recent priority has been CS25, with introduction of B787, A350…

- significant increase in numbers of engineers exposed to composites…

** Note: Industry\Regulator Composite WG

EXAMPLE: CS25 Industry/Regulator Composite WG Charter

(Airbus, Boeing, Bombardier, FAA, TCCA, EASA):

- **Openly share knowledge** from past and current composite applications to transport airframe structure to **support safety and certification efficiency**, **without divulging competitive info (per equal-sharing principles),** in the longer-term pursuit of composite standards

- **Primary advantage** comes from industry **members with experience & knowledge** having a forum that **promotes a more efficient path to composite standards** that meet safety needs and promote certification efficiency

Could this model benefit CS23? …

- 'level playing field' for established organisation
- useful disseminated guidance and 'level playing field' for new organisations

EASA Composite Safety Strategy (draft):

2/ Identify European specific themes which may be different (CS25), or justify different priority, wrt the broader common interests. This may result in new themes, or complementary themes wrt the common interest:

Example 1 - **sandwich structures** (following various incidents across a range of products):

- R&D support for existing CMH-17/Airbus control surface Ground-Air-Ground (GAG)
  - following 'Transat' Rudder separation
- draft EASA Sandwich CM

Example 2 – **training** (prioritise maintenance, **small CS25 MRO DOAs not supported by TCHs**, internal EASA and NAAs)…

- **standardise knowledge base/training at 'Level 2*' for those making composite airworthiness level decisions**

* see support slides

EASA Composite Safety Strategy (draft):

3/ Identify European specific themes (other than CS25!):

Example 1 – **sandwich structures** (following various incidents across a range of products):
Expand scope of existing work to engage **European Rotorcraft and GA Industry**

This is a draft strategy: it needs your input…

- develop R&D support using existing CMH-17/Airbus control surface GAG team

- **draft Sandwich EASA CM – monocoque applications (used more often outside CS25 applications)**

Example 2 – develop regional CMH-17 activities in Europe for GA and Rotorcraft?
(recognising budget limitations for small and/or new organisations, and improved communications technology)
- develop upon a continental basis, e.g. European GA CMH-17, USA GA CMH-17?

EASA Composite Safety Strategy (draft):

3/ Identify European specific themes (other than CS25!):

Example 3 – develop European GA shared database activities?:

- **support existing German AFF/HFF shared database** (base pyramid + details, wet lay-up) expansion to broader European community (introduced 'equivalence' process, Standard Operating Procedures etc), e.g. first example, new product, and new organisation Game Composites 'Gamebird' (aerobatic)

Example 4 – training:

- training (prioritise GA/Rotorcraft DOAs (**particularly new small organisations**))
- CVE knowledge expectations (for new organisations in particular)?

How does the European GA Composite Community wish to work with EASA?

Please contact me with any input regarding the proposed strategy themes in this presentation or new proposals…
simon.waite@easa.europa.eu

Recent CS23 amendment and composite structures:

- CS23 moving from 'prescriptive based' to 'performance based' requirements*
  - potentially offers benefits to industry, and safety, due to rapid adaptation to some new technologies e.g. regarding flight, operations, navigation etc
    …benefits from structures perspective not so clear…
- 'prescriptive' CS23 means of compliance content moved to standardisation body
- potentially more open to interpretation
- maintaining a 'level playing field' with this flexibility may be a challenge

* in conjunction with increasing movement of responsibility towards DOAs, changes the knowledge distribution in the industry

Recent CS23 Amendment and composite structures:

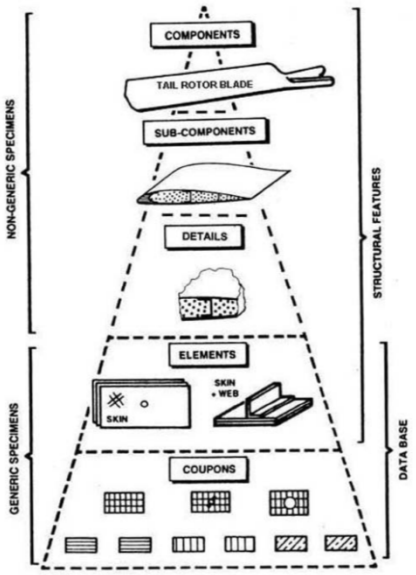
- existing success has been established based upon established organisation histories regarding materials, processes, configurations and design concepts
- based upon 'tribal knowledge' and conservative internal design practices, e.g. bonded joint length - static theory v reality – additional provision for damage tolerance is a good idea, even if not explicitly required in the CSs…
  (also limited standardisation of approach to quantitative design allowable determination etc)
- less prescriptive rules – potential disadvantage for new organisations
- useful to retain conservative 'prescriptive' means of compliance options…
- potential benefits from access to shared databases and standardisation activities…

Note: new/small organisation challenge - need to contribute to shared database activities if they are to benefit from the existing knowledge

Shared Databases:

Composite Shared Database - Options:

- limited established sharing of composite specs and compositions – unlike metals (proprietary data etc)
- complete test pyramid necessary …even if the same material is used by different organisations
- 'engineering properties' result from material, process, and 'configuration detail'
- potentially value in sharing base pyramid work, if the same material is used…



Regulators unlikely to be confident in higher pyramid design data if simple base pyramid properties cannot be consistently produced following standard procedures and test methods

Potentially more important for GA, noting typically limited mid-pyramid test data available, e.g. due to component definition/boundary condition validity, limited high pyramid load case testing….. and COST!

Composite Shared Database Options: History – Not New

AFF/HFF*: (to be discussed by Marcus Basien)

- long established closed group of organisations (until recently**)
- functions and data sharing not limited to composites
- composites - shared base pyramid data + some higher level details
- wet lay-up and bonded joints

AFF
Arbeitskreis
Faserverbund Flugzeuge

* AFF - Arbeitskreis Faserverbund Flugzeugbau, publishes a manual for composite aircraft called HFF Handbuch Faserverbund Flugzeuge.

** recent project development with AFF/HFF beyond Germany to be presented by Philipp Steinbach (Game Composites)

Composite Shared Database Options:

National Center for Advanced Materials Performance (NCAMP)*:

- open group of global organisations (industry/regulators)
  - following Standard Operating Procedures (SOPs)
- base pyramid composite specific data sharing (simple flat coupons etc)
- **two main levels of activity**:
  - **users of data for materials in the existing NCAMP database** (show equivalence using a reduced dataset and following SOPs)
  - **new material contributors**
- independent checking of data (panels tested etc)
  - **need for independent 'test houses' in Europe (FAA v EASA conformity requirements)?**

Note: CMH-17 NCAMP Tutorial planned

* Note: Originally Advanced General Aviation Transport Experiments (AGATE), formed in 1990s intended to support GA. However, evolved into NCAMP, currently populated by prepregs and CS25 supplier organisations. However, may become more relevant to GA again as more prepreg is used.

Composite Shared Database Options:

NCAMP: EASA CM – S – 004 Issue 01 'Composite Materials – Shared Databases, Acceptance of Composite Specifications and Design Values Developed using the NCAMP Process'

'EASA accepts the processes and data generated, as described in para. 3.1.1, as appropriate and subject to review in accordance with standard project Certification and Validation processes, for:

- project Validations, e.g. for EASA Validation of FAA products
- EASA product Certification, **when applicant has fully engaged with the NCAMP SOPs***

small organisation issues recognised… limited resource, but need to maintain independence and satisfy 21A.239(b) and CVE functions: https://www.easa.europa.eu/faq/20110

*acceptable to NCAMP and EASA

Composite Shared Database Options:

NCAMP SOPs and European Functionaries:

Authorised Engineering Representative (AER):

2.5.2 Authorized Engineering Representative (NCAMP AER)

The NCAMP AER is an individual qualified to conduct independent/un-bias engineering functions. The NCAMP AER is typically responsible for (1) reviewing and recommending acceptance of documents such as test plans and specifications, (2) witnessing specimen testing, and (3) accepting test data. Individuals desiring to hold this position must meet the requirements of NCAMP Authorized Engineering Representative (AER) Qualification Plan (NCAMP Document No. NQP 200) and be approved by the NCAMP Manufacturers Advisory Board members participating in a given program. An AER may be an independent/self-employed engineer or may be employed directly by the company that is performing the tasks for NCAMP. In the latter case, the AER must not work for the same engineering department and must be able to provide impartial engineering approval or recommendation for approval.

For document review tasks, the AER is usually paid by the entity that is funding the qualification program. For test witnessing task, the AER is usually paid by the testing lab or the entity that is funding the qualification program.

- independent review*/recommend document acceptance
- witness testing
- accept test data

Proposed: EASA CVE or NAA (with appropriate composites experience identified in capabilities)

- direct AER function

or

- finding appropriate AER

* supported by/or initially EASA/NAA (review, but not recommend)

Composite Shared Database Options:

NCAMP SOPs and European Functionaries:

Authorised Inspection Representative (AIR):

2.5.1 Authorized Inspection Representative (NCAMP AIR)

An NCAMP AIR is an individual qualified to conduct independent/un-bias inspection verifications. This individual's regular job function includes inspection verification of test panels and specimens. Companies and testing laboratories that participate in NCAMP activities typically have internal quality procedures and conduct internal inspection on test articles. In such cases, the NCAMP AIR may elect to conduct inspection verification on representative samples of test articles to ensure that the internal quality procedures and inspections are adequate. The NCAMP AIR may conduct more rigorous inspection verification frequency, at the sole discretion of the NCAMP AIR, if the internal quality procedures and inspections are deemed inadequate. Individuals desiring to hold this position must meet the requirements of NCAMP Authorized Inspection Representative (AIR) Qualification Plan (NCAMP Document No. NQP 100) and be approved by the NCAMP Manufacturers Advisory Board members participating in a given program. An AIR may be an independent/self-employed inspector or may be employed directly by the company that is performing the tasks for NCAMP. In the latter case, the AIR must not work for the same inspection/quality department and must be able to provide impartial inspection verification.

- independent test article inspection verification
- supports AER*

Proposed: EASA CVE (with appropriate composites experience identified in capabilities)

- direct AIR function

or

- finding appropriate AIR

* CVE not to be both AIR and AER on same project!

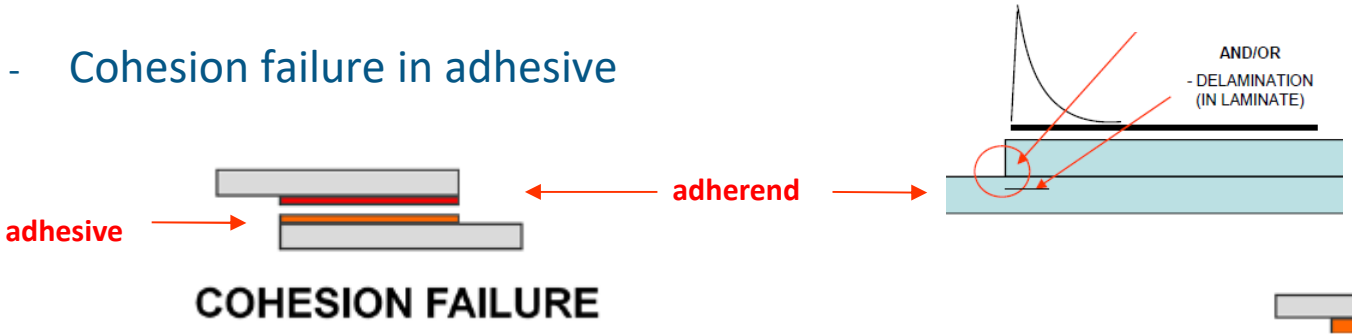
Bonded Structures and Repairs

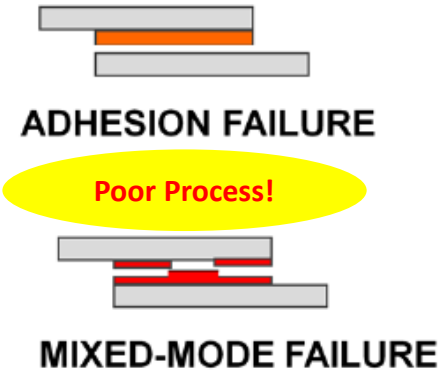
AMC 20-29 Para.6. **MATERIAL AND FABRICATION DEVELOPMENT**

C. STRUCTURAL BONDING

Acceptable failure modes (one dominant repeatable mode preferred):

- Adherend failure (preferred)
- Cohesion failure in adhesive





- ADHESION FAILURE – UNACCEPTABLE (disbond*)
(at interface between adhesive and adherend)
  - contamination, compatibility etc

*'disbond' and 'debond' used interchangeably in lit.
However, 'disbond' – accidental, 'debond' – intended (access, repair)

ADHESION ASSOCIATES

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Many years of successful bonded repair to critical structures: GA and Gliders

CS22 – many years bonding back failed empennage:

- appropriate material
- established process
- experienced people etc

EASA COMPOSITE MATERIALS SAFETY STRATEGY

EASA - Bonded Structures and Repairs:

Disbond or delamination:

- **a disbond/weak bond/delamination exists**
- **< UL capability** (large damage/disbond, critical location)
- **damage/defect remains undetected**
- **load event > Residual Strength capability** (>LL)

- all of these can occur, but typically not together…..

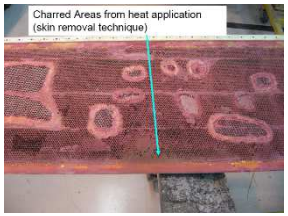
- most events not significant safety issue*
  applications have not been significant

*variable quality data

- unclear if disbond is cause or witness
  (either suggests poor process)
- **need to improve forensics and taxonomy***
  *** training?**

1 incident 10^6 hrs
1 serious incident 10^8 /10^9 hrs
No fatal accidents
(CAA-UK MOR & fleet data only)

1 serious incident/accident
>10^8 hrs
- EASA database



EASA COMPOSITE MATERIALS SAFETY STRATEGY

EASA CM No.: CM-S-005 Issue 01*: Bonded Repair Size Limits in accordance with CS-23, CS-25, CS-27, CS-29 and AMC 20-29**

- restrict bonded repair size to that which allows the structure to carry LL (min.), when repair is failed…

  - simply restates intent and scope of CS23.573(a)(5) and provides a reminder that it applies to baseline structure and repair…

- CM 'Scope' allows credit for established previous successful practice

'…This CM applies to those projects with an application date that is on or after the effective date of the policy. If the date of application precedes the effective date of the policy and the methods of compliance have already been coordinated with and approved by the EASA, the applicant may choose to either follow the previously acceptable methods of compliance or follow the guidance contained in this policy.'

- new organisations and/or new materials, processes, configurations - no history/database to justify otherwise…

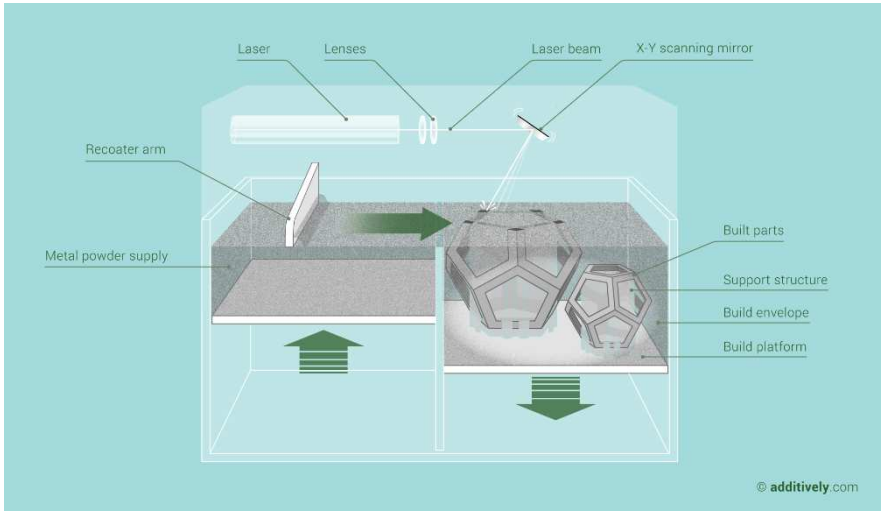
*https://www.easa.europa.eu/system/files/dfu/%27final%27%20CM005%20Issue%2001_Bonded%20Repair%20Size%20Limits_PUBL.pdf

** recent impact of changes to CS23 and ASTM to be assessed when complete. However, intent of CS23.573(a)(5) is planned to be carried into revision of AMC 20-29/AC20-107B, and into CMH-17

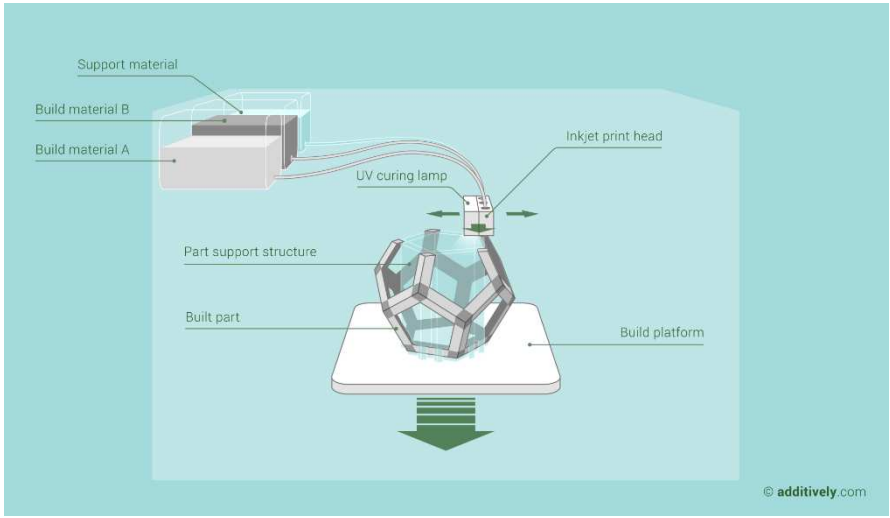
Additive Manufacturing:

Additive Manufacturing – many methods: '… make objects…layer upon layer…'

- Laser-melting



- Photopolymer-jetting



- metallic/non-metallic
- single material, multi-material, + fillers,
- hybrid processes, e.g. icw convention methods

Illustrations courtesy of additively
your access to 3D printing

- significant potential commercial benefits, e.g. rapid prototype evolution, reduced part count, weight reduction etc

many similarities to composites

AM – EASA Perspective

- rapidly increasing number of applications, i.e. baseline structure applications and repair
- increasingly globalised supply chains
- potential safety considerations
  - 'engineering properties', e.g. anisotropic, competing damage modes, repeatability etc
  - changes in relationship between design, production, continued airworthiness (CAW), more integrated than many typical metallic processes
    - 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?

EASA - AM

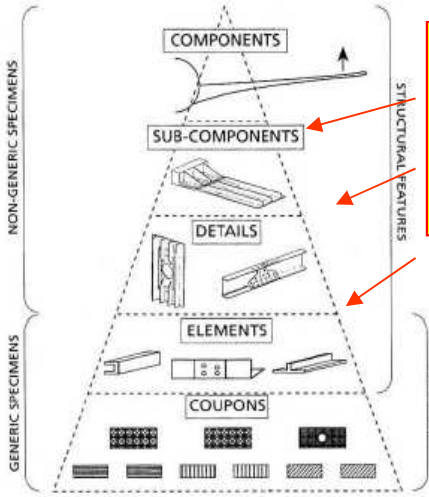
AM ‘Engineering Properties’ are:

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

a challenge:

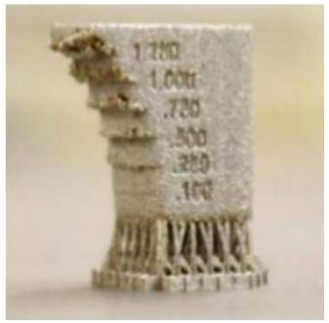
- ‘complex parts’ – base pyramid coupon data may not represent the complex part properties (although stable simple base pyramid data is essential…otherwise, how can the higher pyramid work be trusted?)
- ‘sensitive processes’ – a major challenge if completing production activities in a more challenging maintenance environment

e.g. AM, composites, (particularly bonded structures.)



representative ‘engineering properties’ developed here?

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



Free Edge – fatigue issue?

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

Additive Manufacturing: What is new to manufacturing regarding AM?

raw materials	e.g. handling, transport, storage, preparation etc	many existing standards and practices apply
build process	e.g. preparation, processing, process monitoring etc	many (TCH) methods… few existing standards
post build processing	e.g. removal from equipment, heat treatment, machining etc	many existing standards and practices apply
inspection & testing	e.g. chemical, physical, NDI, visual etc	many existing standards and practices apply

Develop and maintain Design Allowables?

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

monthly WG
co-ordination meetings

Additive Manufacturing (AM):

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)

EASA Cert. Policy and Guidance - DOA and POA Holders to demonstrate: simple messages

- compliance with appropriate CS's
- DOA advised to inform EASA early of intent to use AM**
- POA advised to inform competent authority of intent to use AM**
- PART145…limitations reminder associated with AMC 145.A.42(c)
- repair design normally classified Major, applicants are advised to consult EASA when introducing AM in repairs including cases where they hold a privilege for repair approval.

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

** EASA will work with existing audit schedule, when possible

AM Certification Memo (lessons learned):

- working well with large TCHs, e.g. Airbus, Rolls Royce, Safran (see 2016, 2017 Workshop Slides)
  - evolution towards more critical applications in progress
- need to better identify and understand 'key parameters', e.g. machine parameters, shared databases (e.g. SAE AM-P, NIAR equivalence work in progress) etc
- some challenges to be addressed regarding optimisation of evolving use in maintenance/operator environment
  - less critical interior part applications
- knowledge base and training – TBD

- need to establish statistical expectations for less critical structures and the potential impact upon criticality assessment of damage mode changes…
  e.g. 'insignificant' internal part changed to AM production introduces new damage modes, e.g. carbon fibre exposure resulting in incapacitation of passenger or crew following otherwise survivable accident

Conclusions:

Metals:

- reminder of established process and references

Composites:

- developing draft EASA Strategy…. needs GA industry input!
- CS23 move from 'prescriptive' to 'performance' approach + limited resource:
  - LOI
  - 'level playing field' challenge
  - new organisation challenge
  - shared database options might help… (e.g. AFF/Game Composites)
  - potential for complimentary use of different databases?

Bonded Repair CM:

- business as usual – 23.573a(5) applies to baseline structure and repairs (retain intent in AMC 20-29)
- credit for established materials, processes, databases

AM CM:

- simple message - DOA, POA please inform EASA early in process
- need for robust statistics for simpler/lower criticality structure etc

EASA MATERIALS SAFETY STRATEGY

QUESTIONS?

Please contact me with any input regarding the proposed strategy themes in this presentation or new proposals…
simon.waite@easa.europa.eu

SUPPORT SLIDES

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Game Composites 'Lessons Learned'* working the AFF and EASA:

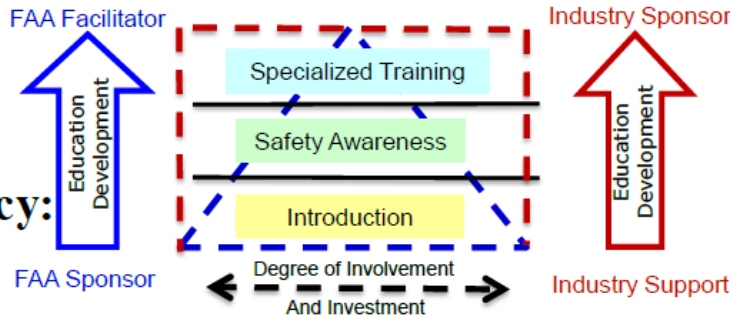
- Being part of the AFF has certainly helped to gain confidence in our processes and design on EASA, FAA and our side.
- Access to the documented experience gathered with those specific materials and related processes by various AFF members over decades provides **huge cost- and time saving benefits for a small airplane project** over the large airplane methods.
- The open communication between the AFF members and EASA, and growing acceptance of the AFF by the FAA, has been a big positive factor in completing the GB1 project in a comparably short timeframe, with a small team.

* e-mail Philipp Steinbach 16/11/17

Composite Educational Initiatives

FAA AVS Composite Training

- **FAA composite training strategy established** [Sept., 2009]
  - Courses to support airframe structural engineering, manufacturing, and maintenance functional disciplines



- **Incl. three levels of competency:**

I) Introduction (common to all functional disciplines)
Self-study intro content for composite basics/terminology
CMH-17 Tutorial for composite certification & compliance [Aug, 2008]

II) Safety Awareness (courses for each functional discipline)
Skills needed for FAA workforce supporting composite applications (including industry focal involved in safety and certification oversight)

III) Specific Skills Building (most courses developed by the industry)
Specialized skills needed in the industry & some FAA experts
Currently dominated by industry on-the-job training/mentoring

EASA COMPOSITE MATERIALS SAFETY STRATEGY

- **Composite Maintenance Technology (CMT)**
  - FAA inspectors and industry focal involved in maintenance oversight and support to continued airworthiness assessments
  - *Course covers maintenance roles and responsibilities, approved data and composite damage, inspection procedures and repair methods*
  - Includes hands-on labs and case studies of field repair experiences
- **Composite Structural Engineering Technology (CSET)**
  - FAA engineers and industry focal involved in structural approvals and engineering support to manufacturing or maintenance
  - *Course covers composite design and fabrication development, proof of structure, manufacturing and maintenance interface and other considerations*
  - Includes hands-on labs and case studies on engineering experiences
- **Composite Manufacturing Technology (CMfgT)**
  - FAA inspectors and industry focal involved in manufacturing oversight and support to product conformity and continued airworthiness
  - *Course covers composite processes, factory flow, quality control, conformity, manufacturing defects/deviations and inspector roles and responsibilities*
  - Includes hands-on labs and case studies of factory experiences

EASA COMPOSITE MATERIALS SAFETY STRATEGY:

Certifying Staff: Level of Knowledge/Training

- Developing EASA intent: All staff making direct decisions involving composites at airworthiness level should be at Level 2* (**minimum**)
  - EASA Internal
  - European NAAs
  - Industry (e.g. Composite CVEs) etc

- All support staff, including management, making decisions involving composites at airworthiness level should be at Level 1* (**minimum**)

Note: inclusion of 'hands-on' training considered beneficial for gaining appreciation of issues associated with this technology

* see support slides

Sandwich Materials/Structures

- many competing damage modes (beyond disbond),
  - some not readily detectable
  - Boundary Conditions important

core crushing...

- some uncertainty wrt damage metrics..

'...it was concluded that residual indentation depth is not a reliable indicator of impact damage; rather, the planar damage size better reflects the residual strength degradation in sandwich panels.'*

*DOT/FAA/AR-02/121 Guidelines for Analysis, Testing, and Non-destructive Inspection of Impact-Damaged Composite Sandwich Structures

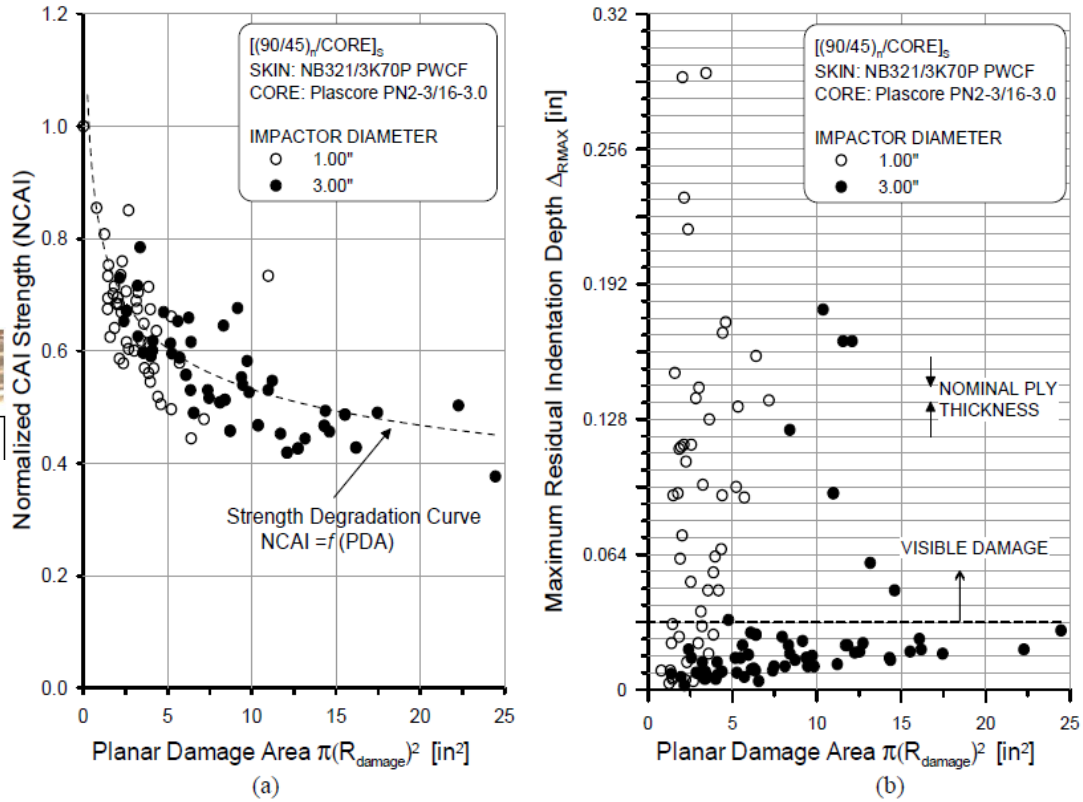


FIGURE 2-10. (a) NORMALIZED RESIDUAL STRENGTH FOR $[(90/45)n/CORE]_s$ (n=1,2,3)* SANDWICH PANELS WITH HONEYCOMB CORE (3/8″ AND 3/4″ THICK) AND (b) VARIATION OF MAXIMUM RESIDUAL INDENTATION DEPTH WITH PLANAR DAMAGE AREA FOR THE SANDWICH PANELS

Example*:

Suggested regulatory approach? *… includes extensive exploration of impact threat…

TASK 1: DAMAGE FORMATION IN SANDWICH STRUCTURES SUBJECTED TO LOW-VELOCITY IMPACT

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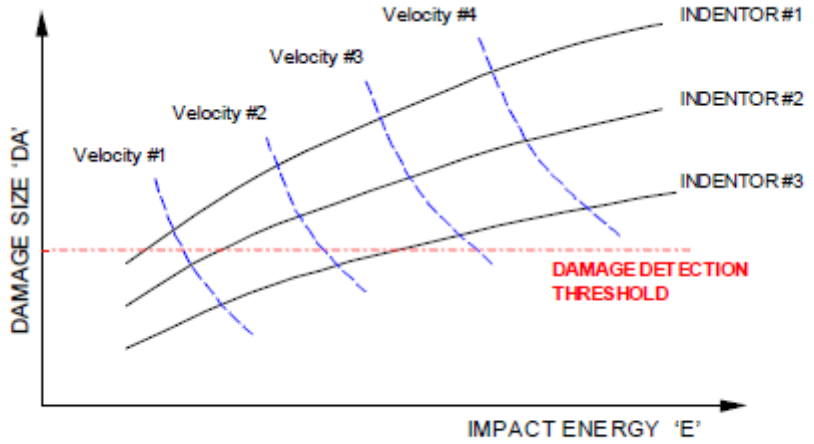

FIGURE 25. TYPICAL PLOTS EXPECTED FROM THE EXPERIMENTAL PROGRAM

* e.g. DOT/FAA/AR-99/49 Review of Damage Tolerance of Composite Sandwich Airframe Structures

EASA
European Aviation Safety Agency

End slide

Your safety is our mission.

An agency of the European Union