EASA COMPOSITE MATERIALS SAFETY STRATEGY:

SAE CACRC Meeting – Koeln

Theme: Composite Training

Simon Waite
Senior Expert – Materials
September 2016

Your safety is our mission.

An agency of the European Union

SAE CACRC Main Meeting

Koeln – 21-22nd September 2016

EASA welcomes the opportunity to host….

SAE CACRC, FAA, and Industry

Theme: Training (emphasis on bonded structures)

SAE CACRC Main Meeting

Koeln – 21-22nd September 2016

Attendees: 75+

Organisations represented: 35+

- DOAs (TCH and non-TCH)
- Maintenance Organisations
- Operators
- Regulators
- R&D
- Suppliers

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Main Meeting Agenda

+ Monday, Tuesday, Friday:

- CACRC Task Groups
- Max Davis Bonded Structure Tutorial x2

Wednesday 21st September

Organization	Presenter	Subject	Time	Meeting Room
EASA	Simon Waite	EASA Welcome and Introduction	9.00 am	Airbus 1,2,3,4
CACRC	Francois Museux	CACRC – Repair Techniques Task Group	9.20 am	
CACRC	Eric Chesmar/ Jeff Berner	CACRC – Procedures Task Group	9.40 am	
Break			10.00 am	
Toulouse University	Francis Collombet	Advanced Methodology to Evaluate Design of Large Bonded Composite Repair	10.30 am	
Lufthansa	Tobias Adugna	Automated Machining	11.00 am	
KLM	Gerrit Kunst	Training is an issue	11.30 am	
Lunch			12.00 pm	
EASA	Simon Waite	Bonded Repair Size Limits (BRSL)	1.00 pm	
EASA	Jean-Pierre Arnaud	Next Part 66 Amendment and Composites	1:20 pm	
EASA	Markus Janischowsky	MDM.056 (RMT.0252), Instructions for Continuing Airworthiness (ICA) – Overall Status	1:40 pm	
EASA	Guido Margiotta	OSD – MCS Overview and Update	2:00 pm	
EASA	Cecile Ben Mami	Development of Structural scheduled maintenance requirements - MRB process and Interfaces with Type Certification	2:20 pm	
Break			2:40 pm	
FAA	Allen Rauschendorfer	Regulatory Updates AC 65-33	3:00 pm	
FAA	Allen Rauschendorfer	FAA Initiatives Relative to CACRC	3:30 pm	
AAWG	Thorsten Koch	ATA Spec 120	4:00 pm	
HAECO	WN Chung	Structured Training For Composite	4:30 pm	
HAECO	TS Chin and Mikka Antila	Repair Process	5:00 pm	
HAECO	Dr. Alan Lau	Reliability and Repair on Composite	5:30 pm	
Adjourn			6:00 pm	

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Thursday 22nd September

Organization	Presenter	Subject	Time	Meeting Room
CACRC	Ray Kaiser	CACRC – Training Task Group	9.00 am	Airbus 1,2,3,4
CACRC	Ana Rodriguez	CACRC – Material Task Group	9.20 am	
Vibrant	Thomas Kohler	NDT Technology Readiness A P&WC Case Study	9.40 am	
Break			10.00 am	
Boeing	Kirsten Bossenbroek	Boeing Composites Repair Certification	10.30 am	
Adhesive Associates	Max Davis	Repair Technology Transfer	11.00 am	
ANZ	Mark Dimond/ Brendon Smith	ANZ Training Overview	11.30 am	
Ministry of Defense	Steve Arrowsmith	Military Training Experience and Issues	12.00 pm	
Abaris	Mike Hoke	Composite Training Overview and Challenges	12.30 pm	
Lunch			1.00 pm	
Airbus	Holger Speckmann	NDI on Composites – Challenges for Training of Inspectors & Engineering	2.00 pm	
EAMTC	Ian Williams	European Aviation Maintenance Training Committee Composites training overview	2.30 pm	
Adhesion Associates	Max Davis	Effect of Training on Repair Outcome	3.00 pm	
Break			3.30 pm	
FAA	Allen Rauschendorfer	A&P Curriculum Updates	4.00 pm	
Boeing	John Gokcen	2015 Technician Outlook	5.00 pm	
CAA	Ted Blacklay	CAA-UK/Airline Experience with Composites	5.30 pm	
Adjourn			6.00 pm	
Executive Committee Meeting			6.00-8.00 pm	Boeing 1, 2

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Why does working with SAE CACRC, and this meeting, matter to the regulators?

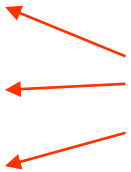
Background:

- rapid increased use of composites

- increasingly globalised and segmented industry (need for 'level playing field')

- 'engineering properties' depend upon 'material and process'
  - built into part or repair (anisotropic, variability etc)

- need for production/design knowledge has moved more towards maintenance
  - potential for non-visible damage/flaws (find damage bounds, visual inspection and NDI)
  - processes different to metal, some sensitive, e.g. bonding
  - majority of workforce experienced with metals, not composites



Training issues

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Regulators: Maintain safety via **high level rules and specifications**… (not detailed)

Basic regulations:

EC No.216/2008 Annex 1**:**

baseline structures **and repairs**

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.

21A.31 Type design … shall consist of:

Composite/Bonded Repairs – can be production processes completed in more challenging service environments

2. Information on materials and processes and on methods of manufacture and assembly of the product necessary to ensure the conformity of the product;

EASA COMPOSITE MATERIALS SAFETY STRATEGY

baseline structures **and repairs**

Example: Key Specification applicable to baseline structure **and repairs**….

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…'

Note: to be changed to Environmental Damage - ED

'(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,
…or an inspection
Note: 80-90% of inspections are visual
ref. also CS25.611

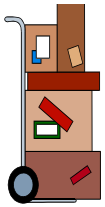
need to find, define, and bound damage…

EASA COMPOSITE MATERIALS SAFETY STRATEGY

baseline structures <u>and repairs</u>

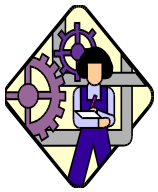
- elements of certification process similar for part or repair

Manufacturing Processes



Material Purchased

+



Internal Manufacturing Processes Controlled by site specific Process Documents

=

Production Certification (PC)

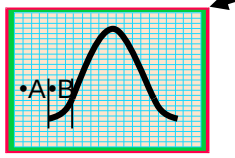
Material & Processing Standards

Material Specification

Process Specification

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

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

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Why does working with SAE CACRC, and this meeting, matter to the regulators?

Regulators: Maintain safety via **high level rules and specifications**… (not detailed)

- only possible if realistic means available to achieve this….
  - **industry** is best placed to develop this detail, icw the regulators, based upon experience, R&D, 'engineering judgement' etc
  - **standardisation bodies** provide a means for **industry** to define **collective good practice** without compromising IP

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Examples SAE*- CACRC – includes long established guidance:

. AIR4844 Composites and Metal Bonding Glossary
- ARP4916 Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials
- AIR4938 Composite and Bonded Structure Technician/Specialist: Training Document
- ARP4977 Drying of Thermosetting Composite Materials
- ARP4991 Core Restoration of Thermosetting Composite Components
- ARP5089 Composite Repair NDT/NDI Handbook
- ARP5143 Vacuum Bagging of Thermosetting Composite Repairs
- ARP5144 Heat Application for Thermosetting Resin Curing
- ARP5256 Mixing Resins, Adhesives and Potting Compounds
- AIR5278 Composite and Bonded Structure Engineers: Training Document
- AIR5279 Composite and Bonded Structure Inspector: Training Document
- ARP5319 Impregnation of Dry Fabric and Ply Lay-Up
- AIR5431 Repair Tooling
- ARP5701 Lay-up of Pre Pre-preg Composite Materials
- AIR5367 Machining of Epoxy and Polyester Matrix Thermosetting Composite Structures
- AE-27 Design of Durable, Repairable, and Maintainable Aircraft Composites
- R-336 Care and Repair of Advanced Composites, 2nd Ed.

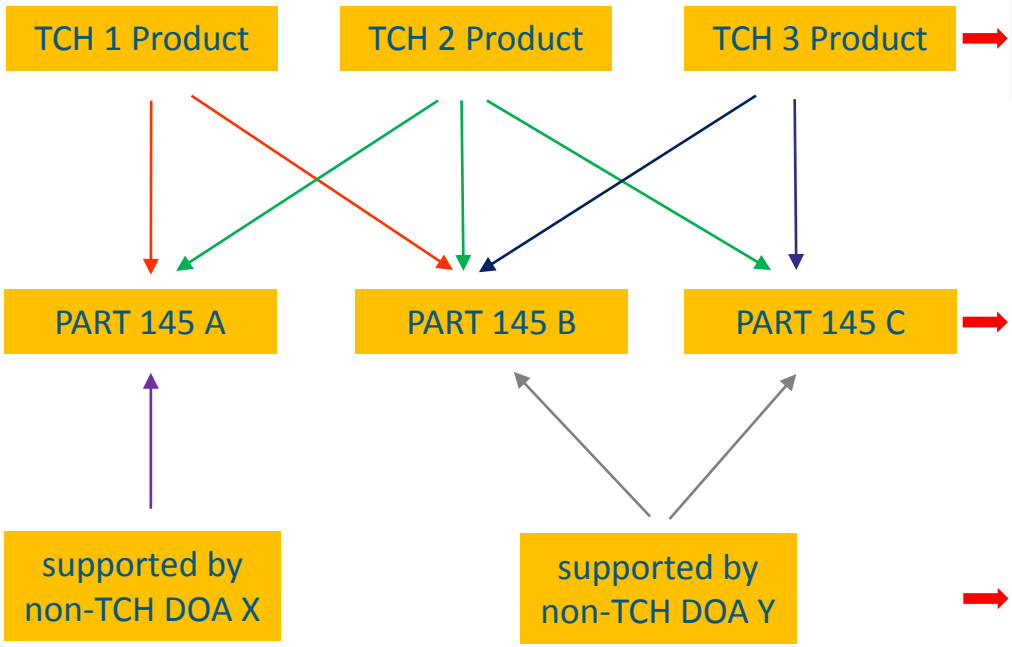
SAE CACRC
– provides useful building blocks
which support certification
- design and maintenance

Training/Approvals – recent developing/developed documents:

.AIR4938A COMPOSITE AND BONDED STRUCTURE TECHNICIAN/SPECIALIST TRAINING DOCUMENT
.AIR 6262 Basic Composite Repair Technician Certification Std
.AIR 5719 Teaching Points for an Awareness Class on "Critical Issues in Composite Maintenance and Repair
.AIR 6291 Guidelines for Repair Process Evaluation of Aluminum Bonded Structure

* Supporting activities in CMH-17 Composite Material Handbook 17

Maintenance Training Standardisation Challenge:



Different TCH design concepts, materials, processes:

- consistent level of information required by PART 145s to maintain AC – documents, type courses etc?

- consistent level of competence across PART 145s ?
  - basic knowledge – find/bound damage, execute repairs
  - maintain currency – existing technologies*
  - new technologies

- scope of non-TCH DOA?
- Certifying Staff capability, e.g. EASA CVEs?

Maintenance Training Standardisation Challenge

CVE – Certification Verification Engineer

DOA - Design Organisation Approval

TCH – Type Certification Holder

* Including priority themes, e.g. Bonded Structures

EASA COMPOSITE MATERIALS SAFETY STRATEGY

EASA COMPOSITE MATERIALS SAFETY STRATEGY:

- training need is part of developing **EASA Composite Materials Safety Strategy**
- harmonise activities, when appropriate, e.g. FAA AVS process, AC 65-33 etc
- supported by broader EASA rulemaking tasks and continued airworthiness activities with composite repair implications…

EASA COMPOSITE MATERIALS SAFETY STRATEGY:

Discussing this meeting*:

EASA MDM.059 RMT.0255 'Miscellaneous of Part-66'

(Jean-Pierre Arnaud – Regs Officer – Continued Airworthiness Maintenance)

- includes revision to PART 66 'Certifying Staff', possible training appendix, ref. SAE AIR 5719 content

Note: Existing Part 66 very limited wrt Composites:

PART 66 'Certifying Staff': 66.A.45 Type/task training and ratings

'6.3 Aircraft Materials — Composite and Non-Metallic
6.3.1 Composite and non-metallic other than wood and fabric'

no further information!

EASA MDM.056 RMT.0252 'Instructions for Continued Airworthiness'

(Markus Janischowsky– Senior Expert – Instructions for Continued Airworthiness)

- review types and levels of information needed/shared between TCH and MROs, information flow and approvals, relationship with Maintenance Review Board activities etc

* some themes previously addressed in EASA RMT.275 Specialised Tasks Proposal - composite repairs (not completed)

EASA COMPOSITE MATERIALS SAFETY STRATEGY:

Discussing this meeting:

- **Operational Suitability Data (OSD):**
  Includes EASA CM-MCSD-001 Issue 1 'Development of **OSD** for Maintenance Certifying Staff' – link to AC20-107B/AMC 20-29/SAE AIR 5719
  (Guido Margiotta – Regulations Officer Senior Expert Maintenance)

- **Maintenance Review Board/Airworthiness Limitations Section***
  (Cecile Ben Mami - Maintenance Review Board Expert, FS.1.5 - Maintenance & Production Dept.)

  - review of relationship between MRB and Certification, ref. also MDM.056

  - inspection assumptions (fatigue, environmental damage, accidental damage) relative to ability to detect damage modes and bound damage (visual, NDI etc), mandated status of inspections and airworthiness credit ('fleet leader' programmes, sampling, ageing composites?)

  - new inspection methods (ramp damage checkers, NDT training?, SHM)

* subject also forms important part of ongoing ARAC task discussions wrt 25.571

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

Conclusion:

- composite material and process is often product specific - standardisation difficult
- industry experience limited/ rapid expansion in use – standardisation beneficial
- bonding processes requires particular attention – challenging in-service environment
- new inspection methods, new materials and processes, and new repair methods
- training is a key element of standardisation (training courses important, but alone not adequate - On The Job training and appropriate TCH data also essential)
- Regulators and Industry are developing regulation and guidance material to support this expansion in use and the more integrated link between Design and Maintenance… this needs to continue

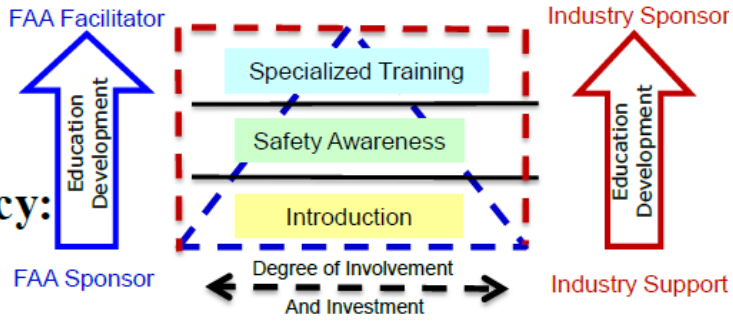
QUESTIONS?

SUPPORT SLIDES

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

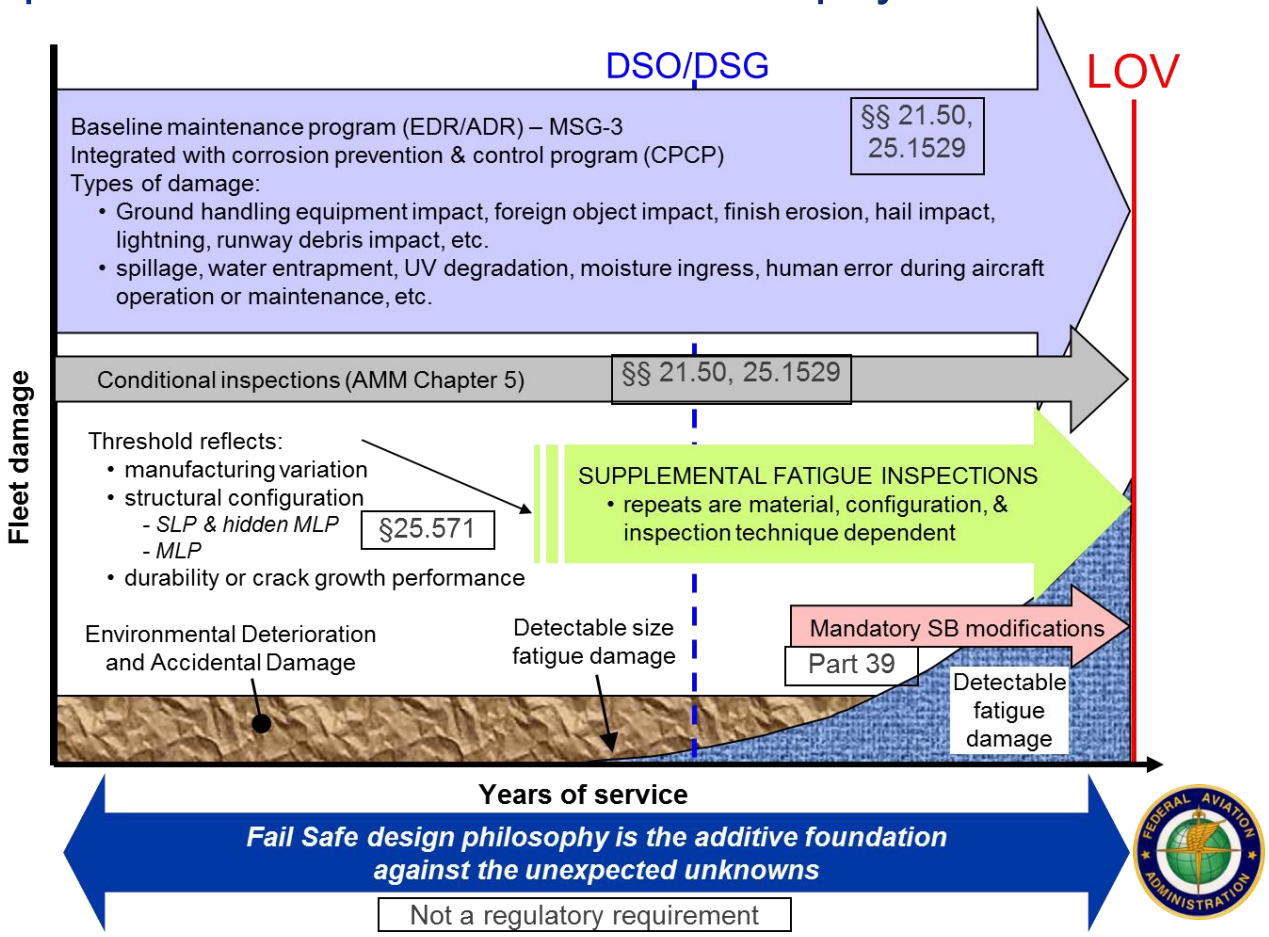
EASA COMPOSITE MATERIALS SAFETY STRATEGY

- **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

- Current certification (ALS) and MRB inspection practice:

Note: need to improve:
- relationship between inspection methods, frequencies, and damage modes
- understanding and formality of relationship between ALS and MRB

(slide - ARAC TG)



Bonded Structure - Bond Repair Size Limits (BRSL)

EASA COMPOSITE MATERIALS SAFETY STRATEGY

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

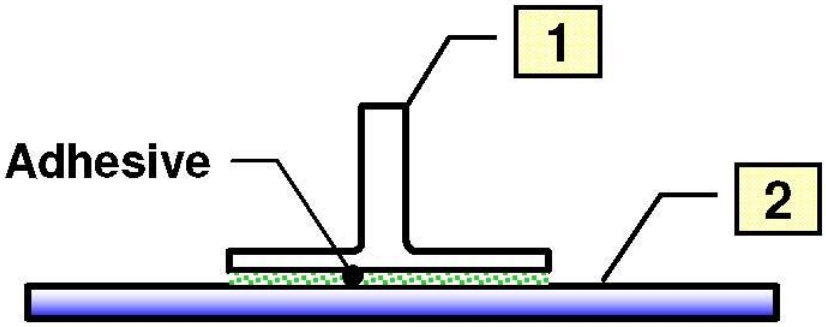
CS22 – many years bonding back failed empennage:

- appropriate material
- established process
- experienced people etc

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

C. STRUCTURAL BONDING

- important existing rule regarding Bonded Structure – 23.573(a)(5)
  - approach used in other specifications, CS25, 27, 29, CS-P etc
    (now broader use formally recognised in AMC 20-29)



Structural Bonding:

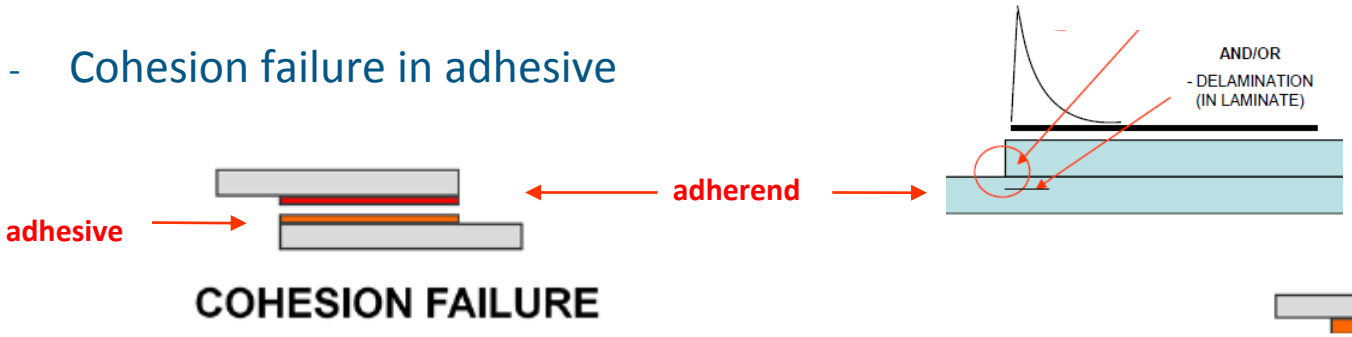
- extremely sensitive to process
- particular caution is required if item 1 and/or 2 is pre-cured or metal, requiring:
- surface protection, cleaning, preparation etc

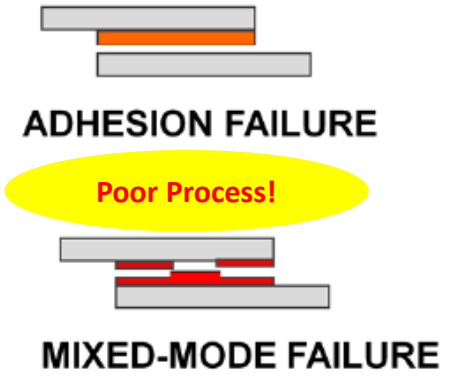
AMC 20-29 Para.6. **MATERIAL AND FABRICATION DEVELOPMENT**

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

EASA - Bonded Structures:

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

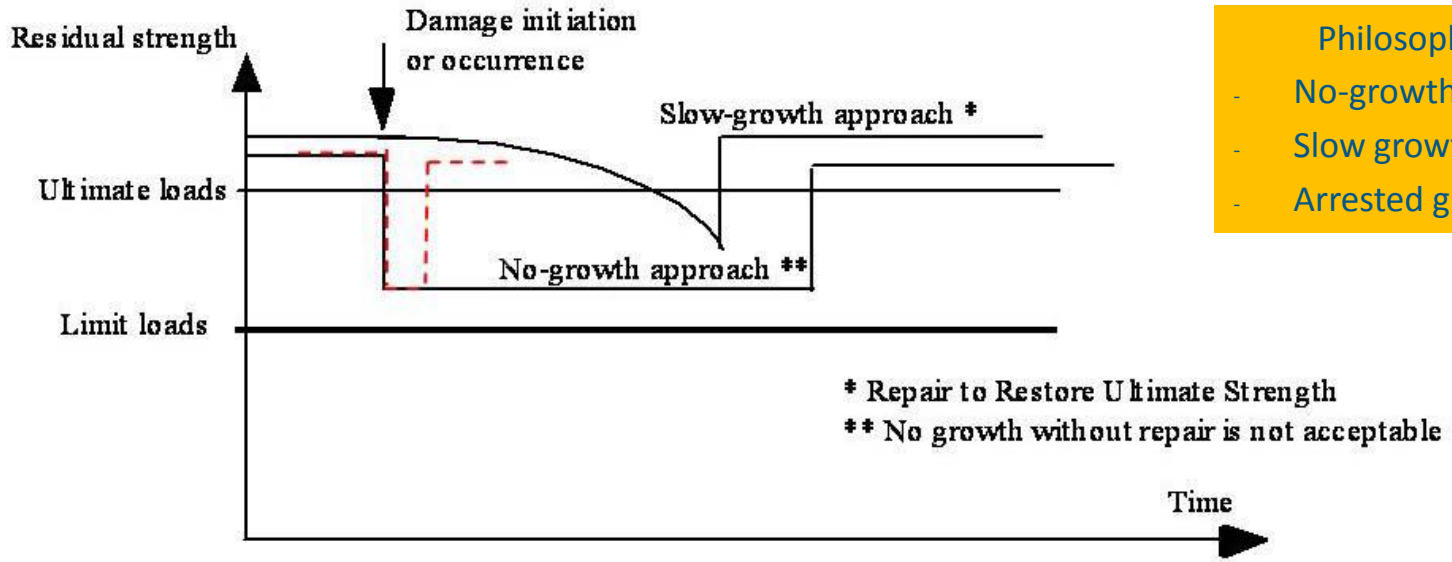
*variable quality data

- 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

AMC 20-29 Para.8. **PROOF OF STRUCTURE - FATIGUE AND DAMAGE TOLERANCE**



Philosophies:
- No-growth (typical)
- Slow growth
- Arrested growth

Figure 4 - Schematic diagram of residual strength illustrating that significant accidental damage with “no-growth” should not be left in the structure without repair for a long time.

Standardisation of Certification Requirements for Composites

23.573(a)(5)*: *'For any bonded joint, the failure of which would result in catastrophic loss of the aeroplane, the limit load capacity must be substantiated by one of the following methods:*

(i) The maximum disbonds of each bonded joint consistent with the capability to withstand the loads in paragraph (a)(3) (i.e. critical limit flight loads considered ultimate) of this section must be determined by analysis, tests, or both. ***Disbonds of each bonded joint greater than this must be prevented by design features;*** *or*

Not to be used to address poor process, poor process is unacceptable, ref. 2x.605

or

(ii) ***Proof testing*** *must be conducted on* ***each production article*** *that will apply the* ***critical limit design load*** *to each critical bonded joint;*

Not practical for large aircraft, does not address degradation, simulated loading process damage

or

(iii) ***Repeatable and reliable non-destructive inspection techniques*** *must be established that ensure the strength of each joint.'*

'Weak Bonds' and 'Tight Disbonds'

- *cannot be reliably detected by Visual Inspection*
- *have not been shown to be reliably detected by NDI at a production scale*

**Note: 23.573 to be removed from CS23/PART23 (NPA 2016-5/NPRM 16-01). Intent to be retained elsewhere, e.g. AMC 20-29/AC20-107B.* https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2016-05

EASA COMPOSITE MATERIALS SAFETY STRATEGY

Conclusion: Bonded Repair Size Limit seems to be appropriate…

EASA Bonded Repair Size Limits (BRSL) Certification Memo (CM)*:

- BRSL to ensure LL residual strength (or higher iaw other TCH design limitations) retained in repair failed condition
- European industry requested visibility of potential to deviate from LL limitation, e.g. when TCH has adequate control/confidence/experience to show that the repair facility can achieve more (approaching production repair capability?)
- Link to PART 145 (145.A.42 para.7) – appropriate PART 145 communication method TBD

http://easa.europa.eu/system/files/dfu/%27final%27%20CM-S-005%20Issue%2001_Bonded%20Repair%20Size%20Limits_PUBL.pdf

* CM published 11/9/15, harmonised with FAA PS

QUESTIONS?

Conclusion: Training (emphasis on bonded structures)

MEETING CLOSE

- composite material and process is often product specific - standardisation difficult
- industry experience limited/ rapid expansion in use – standardisation beneficial
- bonding processes requires particular attention – challenging in-service environment
- new inspection methods, new materials and processes, and new repair methods
- TRAINING is a key element of standardisation (training courses important, but alone not adequate - On The Job training and appropriate. TCH data also essential)
- Regulators and Industry are developing regulation and guidance material to support this expansion in use and the more integrated link between Design and Maintenance… this needs to continue

SAE CACRC Main Meeting

Training (emphasis on bonded structures)

Koeln – 19-23rd. September 2016

MEETING CLOSE

THANK YOU FOR YOUR SUPPORT

PARTICULAR THANKS TO THE PRESENTERS

Thanks for organisational support in the new building:

- Erika Amrhein
- Angela Cojocaru
- Julie Malats
- Security, Reception, Catering, and IT Teams

EASA
European Aviation Safety Agency

End slide

Your safety is our mission.

An agency of the European Union