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

Composite Safety Issues

Regulatory / Industry Meeting Atlanta

17-19th. May 2011

S.Waite
Structures Specialist
Certification Directorate

Your safety is our mission.

Agenda

- AMC 20-29/AC 20-107B – European Process Summary
- EASA - Safety Initiatives
  - Rulemaking
    - MDM-028 'Impact Threats – Engine, Tyre, Runway Debris Requirements Review'
    - Operational Suitablility Data (OSD)
  - R&D
    - Hail Threat (OP25 EASA R&D 2008/05 – Harmonised Task)
    - Significance of Preload to Impact Behaviour (OP24 EASA R&D LIBCOS)
    - Blunt Impact (OP06 EASA R&D CODAMEIN)
  - Certification Memos
    - Bonded Structure
      - bonded Repairs, design assumptions, e.g.stringer failed assumption
  - Other:
    - Shared Databases

Composite Safety Issues - Introduction

AC20-107A/AMC CS25.603 et al History:

- Revision A was 1984 etc
- AC20-107 rewritten by joint USA/Europe 1982-1984
- ACJ25.603 created with “same”text

Meeting held in Gatwick 2003 to consider new revision

Suggested areas for consideration - Gatwick

- JAA to recognise QA and repair doc
- Ensure generic doc covers helicopters
- Define environmental conditioning
- Create a max impact envelope
- Tidy up part 2
- Cross reference between design, QA and repair docs
- Bonding
- Update chemical characterisation

Composite Safety Issues – AMC 20-29 Process

Harmonised Process with FAA and TCCA

Further to the history given by FAA:

Draft AC and AMC texts developed (meetings, workshops etc Jan 2008-June 2009)

- European Industry meeting (January 2009)
(comments noted plus EASA responses given – see AMC NPA document)

- FAA releases AC for comment (June 2009, 1 month - closes July)
(European organisations encouraged to provide comments to AC)

- EASA releases AMC NPA for comment (July 2009, 3 months - closes Oct)

- EASA included in FAA comments review process

- FAA releases AC-20-107B (Sept 2009)

- NPA closes for comment (Oct 2009)

- EASA reviews comments

- FAA included in EASA comments review process

- EASA/FAA Harmonisation meeting (December 2009)

European opportunity to:
- review proposed changes
- identify any European conflicts

Composite Safety Issues – AMC 20-29 Process

continued…

- EASA releases comments response document (Feb 2010 - 2 months)
- EASA/FAA/CACRC Hamburg meeting (26-30th April 2010)
- Comments Response Document (CRD) (second round) closed (2nd May 2010)
- EASA reviews any responses, amends text (icw FAA – any significant issues)
- EASA releases AMC (Summer 2010)

active 26th July 2010

Note: second CRD cycle

http://easa.europa.eu/agency-measures/docs/agency-decisions/2010/2010-003-R/Annex%20II%20-%20AMC%2020-29.pdf

only a few minor differences

Further European Industry/EASA/FAA interaction meetings?

- Develop further Rulemaking, R&D, guidance with industry,
e.g. Bonded Structure

Composite Safety Issues – AMC 20-29 Process

Comments input to European Process (1st round)

USA Process	FAA AC 20-107B	EASA AMC 20-29
Airbus	x	x
Boeing	x	x
D. Ostrodka	x	
Embraer	x	
GAMA	x	
Gulfstream	x	x
J. Soderquist	x	
Lockheed	x	
Rocky Mtn Composites	x	
Sikorsky	x	
Stork	x	
TCCA	x	

European Process	
Austro Control	x
Bombardier	x
CAA NL	x
Dassault	x
Diamond	x
Eurocopter	x
European Sailplane Manufacturers	x
Extra	x
KLM	x
LAMA	x
LBA	x
Lufthansa Tech	x
Pilatus	x
Sell	x
Swedish CAA	x
Swiss Airlines	x
UK CAA	x

EASA/FAA plus European/USA industry opportunity to be involved in both EASA/FAA processes.

Composite Safety Issues – Rulemaking

Impact Threats:– Review of Impact Threat Related Requirements

Engine/Tyre/Runway Debris* & Hail (* EASA/FAA/TCCA - Rulemaking Task 25.028)

Issues:

- Differences between composite and metallic material properties change 'design drivers' and configurations, e.g. skin thickness, rib spacing etc, e.g. composite design generally more 'impact threat' driven than metal structure

- Changes validity of 'service experience' which has partly defined '**acceptable level of safety**' e.g. for metallic wing structure generally provided by other design drivers, e.g. fatigue not impact.

Will change to composite structure reduce existing 'acceptable' level of safety?

- Possible safety and economic benefits from review and standardisation of 'impact threat' related requirements

- Also, existing requirements have not been reviewed for sometime

Impact Threats:– Review of Impact Threat Related Requirements

Engine/Tyre/Runway* Debris & Hail (*Engine/Tyre/Runway – EASA/FAA/TCCA Rulemaking Task 25.028)

Residual Strength – Discrete Source Threats: AMC 20-29 Para. 8(a)(1)(c):

‘Some examples of Category 4 damage include rotor burst, bird strikes (as specified in the regulations), tyre bursts*, and severe in-flight hail.

(* not all tyre debris or bird strikes are obvious events. Not all blunt impacts visible)

Broader F&DT impact threats: AMC 20-29 Para. 8(a)(1)(b):

‘including runway or ground debris, hail, tool drops, and vehicle collisions.’

Review of requirements considers:

- threat definition
- integration into the design
- appropriate simulation

Composite Safety Issues – Rulemaking

Impact Threats: Engine Debris EASA/FAA/TCCA Rulemaking Task 25.028 in progress – Publish 2013

- New data since 1985 Manchester, e.g. FAA/DOT/AR-99/11, & 04/16, AIA 2010 Vols.1&2

- Large/Intermediate Debris - retain per AC 20-128

- Small Debris Fragment
  - AMC 20-128 (para.9(d)1/2 tip blade foil)

    Note: No exact 'small/low energy' definition (mass, speed etc?)
  - CS25.963 (EASA)
  - 3/8in 700 ft/sec steel cube for access covers (not in FAR)
    - unclear how this criteria was selected
    - considers all debris, **not just rotating parts** (review of 'China Lake' data* to be completed)
    - used 3/8in cube as reference impactor to size (1.1in cube per AMC 20-128 ½ tip blade foil definition) for equivalent composite skin in MoC IPs/CRIs

* DOT/FAA/AR-99/11 Large Engine Uncontained Debris Analysis

Impact Threats: Engine Debris

Possible Outcomes (amend harmonised rule/AMC):

- Retain 3/8in 700ft/sec (due to improved confidence that it has some value)
  - must not penetrate any fuel tank skin or access cover
  (to address generic small debris minimum – not just rotating parts)

- Add AMC for composite fuel tank skin sizing by equivalence to metallic penetration iaw CRI/IP MoC* (using 3/8 in cube and max AC 20-128A debris cube e.g. 1.1 in cube)

- Consider larger debris trajectory spread (per recommendations in ref. reports - details TBD)

* Note: approach may not be useful to manufacturers without previous metallic reference

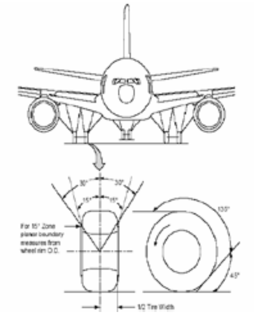
Composite Safety Issues – Rulemaking

Impact Threats: Tyre Debris*

*unlike an engine failure, tyre failure is not always immediately obvious

Consider standardisation:

- different Structures and Systems models exist, i.e. debris size, spread, etc
- same tyre failure, same debris
- different significance to Structures and Systems
- usually causes cross-discipline 'discussion' - managed via CRI



Further discussion points:

Inspection following event:

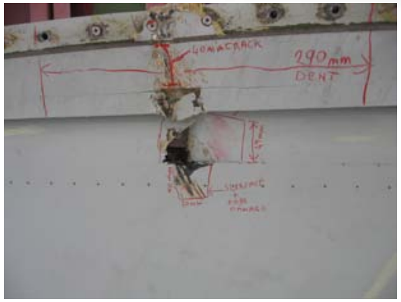
- damage correlation with witness marks/extent of inspection (relatively blunt soft impactor – non-visible damage more likely?)


Carcass Rupture from FOD

Large debris/shockwave (ref. CRIs):

- what debris size should be considered, e.g. 25.963, larger?
- what is the acceptable MoC, e.g. direct test, analysis supported by test, etc

Impact Threats: Runway Debris



- Limited data available
- Large debris
    - rare event
    - difficult to define debris, e.g. large segment of runway surface etc
    - usually known event before take-off
    - no specific threat definition planned – address with generic Residual Strength capability (and specific threat, e.g. bird strike)
- Small debris
    - accept generic use Airbus/Boeing agreed threat/simulation, CMH-17 Rev.G

      i.e. hemispherical steel impactors with tip diameters of 0.5 - 1.0 in (13 - 25mm)….
      cut off values range from 15 to 105 ft-lbs (20 to 140 J)?
    - generally addressed by other considerations,
      e.g. BVID, and higher energy threats via the normal inspection schedule process but may identify structure requiring consideration not otherwise identified
    - What credit can we give to runway debris monitoring initiatives?

Training: Operational Suitability Data (OSD)

(NPA 2009/01 – CRD due February/March 2011, publish 2012)

Proposed regulation providing Part 21 link between Type Certificate (TC) and training for operating staff, e.g. pilots, cabin crew, maintenance certifying staff etc (not specifically a composite regulation)

- manufacturer, the applicant for the TC (or STC), shall produce OSD
(similar to requirement to produce Instructions for Continued Airworthiness (ICA))

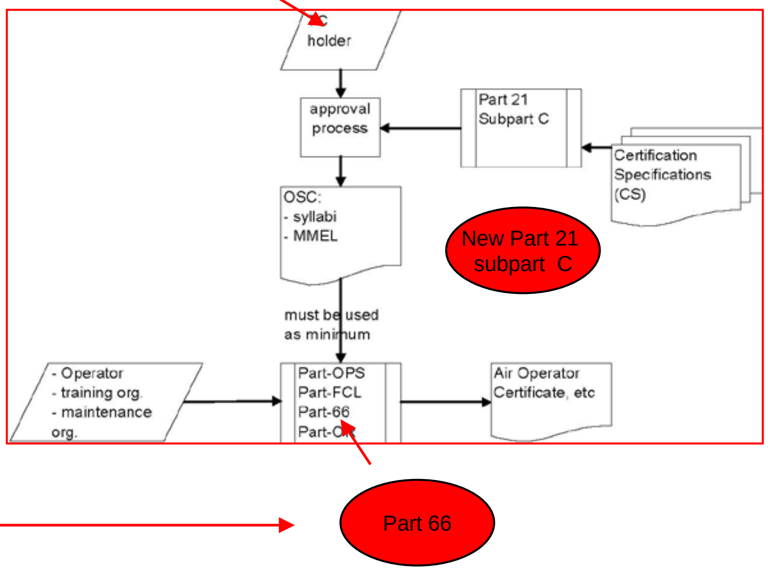
- must be used by the operators of the particular aircraft type

Composites structure training aspect:

- TCH to define minimum training syllabus icw Part 66 Appendix III for product, wrt baseline knowledge of Part 66 Appendix I.

- possible direct linkage to Part 145 could be considered via MDM-075 ‘Specialised tasks other than NDT’ NPA TBD.

Also, new CS-MCS (Maintenance Certification Staff) planned via new NPA, target publication date 2014



Training: Operational Suitability Data (OSD)

Part 66:

Current Situation: Very limited composite specific content: e.g. 6.3 Aircraft Materials ‘*Composite and Non-Metallic*’

EASA Intent: - amend Part 66 para. 6.3/7.14.2

- composite certifying staff to have at least <u>minimum level of knowledge</u> per content AIR 5719 (or similar) (Teaching Points for an Awareness Class on ‘Critical Issues in Composite Maintenance and Repair’)

SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT	AIRxxxx	
	Issued Revised	Proposed Draft (Date) (OrigDate)

Teaching Points for an Awareness Class on
“Critical Issues in Composite Maintenance and Repair”

1. SCOPE:

The following document has been generated by the ATA/IATA/SAE Commercial Aircraft Composite Repair Committee (CACRC) and provides the essential curricula for conducting classroom and laboratory sessions for a Critical Issues in Composite Maintenance and Repair class.

1.1 Purpose:

The purpose of this AIR is to provide the terminal course objectives and teaching points necessary for conducting a Critical Issues in Composite Maintenance and Repair class. When an entity offering this type of course teaches each of the subjects of this document according to its Terminal Course Objectives (TCO's) and Teaching Points, then the course shall be deemed to be in compliance with this document.

2. REFERENCES:

<u>AIR4844B : Composites and Metal Bonding Glossary</u>
<u>AIR4938 : Composite and Bonded Structure Technician/Specialist: Training Document</u>
<u>AIR5278 : Composite and Bonded Structure Engineers: Training Document</u>
<u>AIR5279 : Composite and Bonded Structure Inspector: Training Document</u>
<u>R-336 Care and Repair of Advanced Composites, 2nd Ed.</u>
<u>ARP5089 : Composite Repair Ndt/Ndi Handbook</u>
<u>AE-27 : Design of Durable, Repairable, and Maintainable Aircraft Composites</u>

3. Base Knowledge

This base knowledge subject is provided to those students having limited exposure and/or understanding of materials science. Prior to the exposure to critical issues involved with the maintenance and repair of composite materials in commercial aerospace applications (Part II below), the student must understand the fundamentals of the technology to enhance learning. This subject will provide an overview of maintenance and repair, to be later reinforced in Part II below in detail. Included in this topic is: 1) a description of basic materials technology and terms, 2) an introduction to maintenance and repair, 3) other critical elements, such as coatings and selection criteria for bolted and bonded repairs, and 4) developments in materials research regarding maintenance and repair.

3.1 After completing this unit, the student will *understand the basics of composite materials technology.*

This material is intended to provide fundamental concepts and vernacular to the student with minimal exposure to composites' technology. Terminologies, material applications, processing, and properties are covered at a summary level. For students requiring this level of knowledge, this content is best taught as a first topic in the awareness course.

3.1.1 The student will be able to distinguish among resin, fiber and core applications and uses.

3.1.2 The student will be able to describe various composite processing parameters.

* Many Parts amended

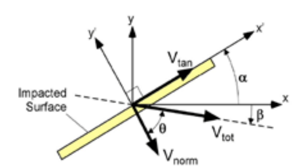
Impact Threats: Hail – Standardise Threat

Identified as threat in AMC 20-29:

- Discrete source and more general DT threats
- Para 8a 'currently few standards' (generally for impact threats)

Suggested approach to standardisation:

- Review existing data and new EASA report:
  http://easa.europa.eu/safety-and-research/research-projects/large-aeroplanes.php#2008op25
- Define threat – consult with industry
- Likely form – 2 levels:
  - small F&DT threat – multi-strike
    (e.g. 50-70 mm, ?? mm apart)
  - large discreet threat (CSF&L)
    e.g. 110mm, 10^{-3} probability if in hail, assume an aircraft will fly in hail
    (can we rely upon aircraft radar to avoid this?)
- Manage threat into design, e.g. per J. Halpin
  - confirm consistent damage modes through energy range up to these levels
- Simulation Method
  (energies, geometries, stiffness (metallic, frozen cotton ball), orientation etc - TBD)



Projectile and surface are both moving. Velocity vector V_{tot} describes the motion of the incoming projectile relative to the surface.

α is angle between surface and horizontal (+ccw w.r.t. x-axis)
β is angle between projectile relative path and horizontal (+ cw w.r.t. x-axis)
$\theta = 90 - \alpha - \beta$ is angle between normal and total velocity components of projectile

Impact Threats: Preloaded Structure

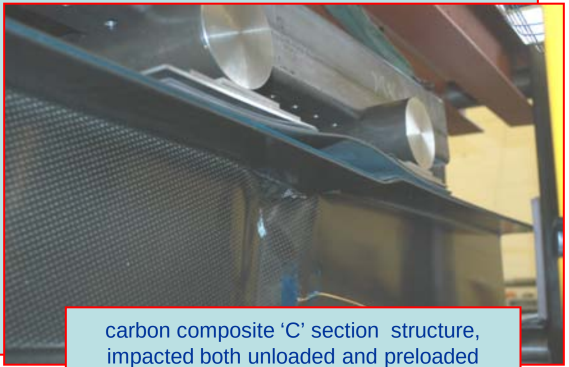
Typically, representative loads are not applied to structure during impact testing

- Is this significant (different dynamic failure behaviour wrt metal)?
- Do other existing MoC already address this adequately?

Example: Bird Strike* - operational structure is impacted when loaded

- **metal experience, plus test** (e.g. Vc, 4lb bird), **without load provides 'acceptable level of safety**'
- **composite** material **behaviour** (typically quasi-brittle) **differs to that of metal**
- **Does passing the same test, without load, provide the same level of safety for composites?**
- **Preliminary CAA UK R&D suggests impact of loaded structure:**
    - **reduces (visible) damage area**
    - **reduces residual strength**

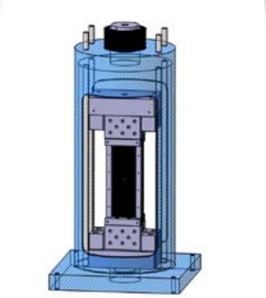
*** Bird strike not always a known event**



carbon composite 'C' section structure, impacted both unloaded and preloaded with 0.25kg birds at 70-80 m/s

Composite Safety Issues – R&D

Impact Threats: Preloaded Structure – are we addressing this?



Recent EASA R&D (OP24 LIBCOS – publish soon)

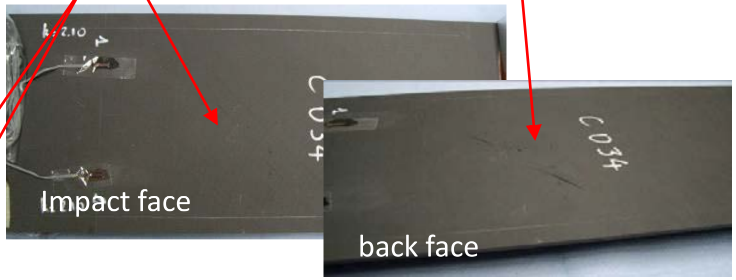
- hard/sharp (3/8in metallic cube) and blunt/soft (1in glass ball) impactors
- simple 'representative' material & lay-up small panels (500mmx200mmx2.125-3.125mm)
- loaded (zero, tension, and compression)
- V = up to 200 m/s (60mm gas gun)
- Residual Strength tested (RSF wrt no impact/no load)

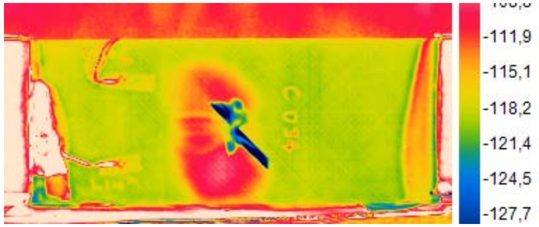
R&D again suggests impact of loaded structure :
- **reduces residual strength**
- **damage not visible (limited visibility back face)**

	Loading	Preload	RSF: Notch impact damage	RSF: Delamination/ indent damage
Composite	Tension	0 0.25 % strain	0.37 0.48 – 0.53	TBD 0.66 – 0.75
	Compression	0 0.95Pb - 1.4Pb	1.0 0.96 – 1.02	0.84 0.67
Aluminium	Tension	0 0.25 % strain	TBD 0.76	TBD TBD
	Compression	0 1.5 Pb	TBD 0.93	TBD TBD

Pb = buckling load

generally visible





Thermographic image

Impact Threats:– High Energy Low Velocity Blunt Impact

EASA Project CODAMEIN (Composite Damage Metrics and Inspection)

Experimental identification of key phenomena and parameters governing high energy blunt impact damage formation, particularly focusing on what conditions relate to the development of massive damage occurring with minimal or no visual detectability on the impact side

EASA Priorities (further to Hyonny Kim work): :

Boundary Conditions:

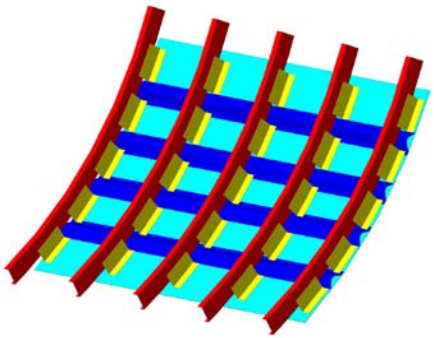
- Aircraft level boundary conditions and impact dynamics
(later programme – needs large budget and appropriate manufacturer)

Hybrid structure:

EASA to complement existing Hyonny Kim work with impacted hybrid structure (with approximate extreme boundary conditions)

- provide comparison with all carbon structure behaviour

- provide some idea of boundary condition sensitivity



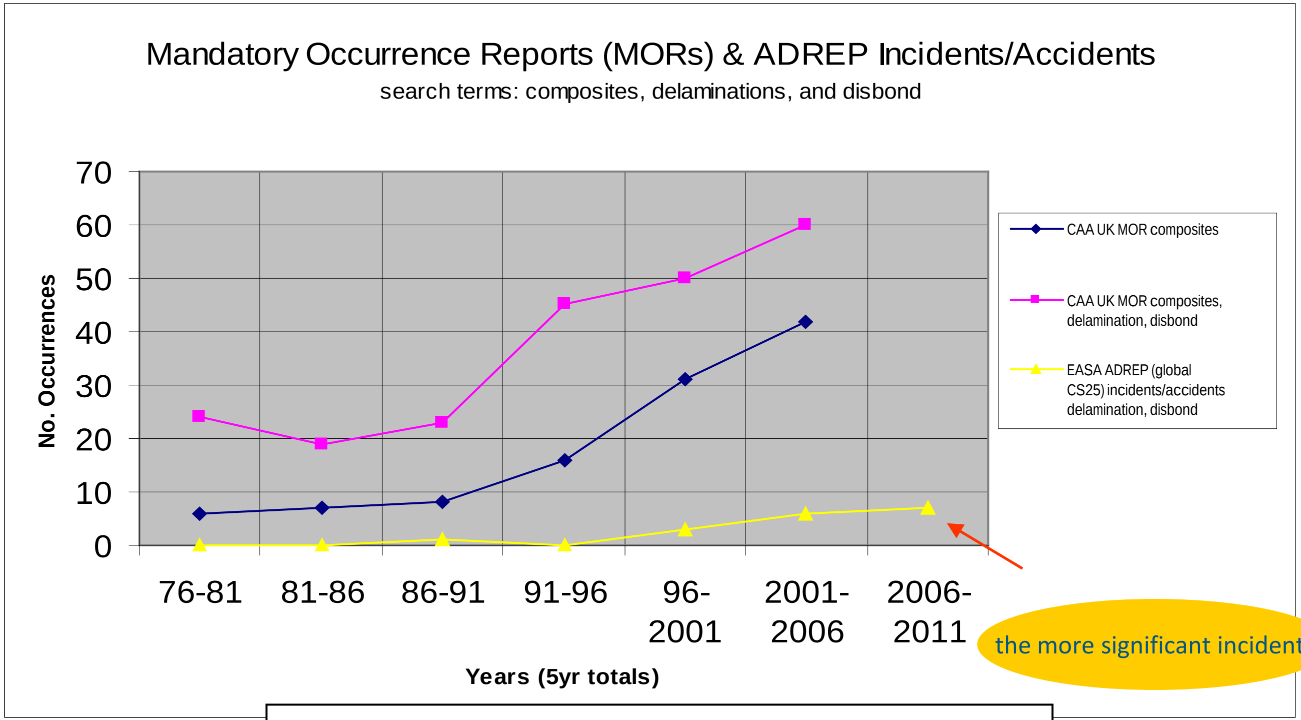
carbon skin/stringer - aluminium frame

project starting

Bonded Structure: Growing Concern

Plus many more recent Primary/PSE/Critical Structure examples: Production and in service issues: e.g.

- Primary Structure failure following failure to inspect /find damage in impacted structure which was already subject to an AD addressing disbond.
- Repairs – various control surface and repair failures



the more significant incidents

FYI: EASA Occurrence reporting system now under development

MOR reporting scheme objective (UK CAA CAP382) : prevent accidents/incidents… not to attribute blame/ liability.

Example: AD2010-26-53 ….This emergency AD addessed significant structural failure in the wing during a production acceptance flight test. The wing skin disbonded from the upper forward wing spar. The length of the disbond was approximately 7 feet.

Bonded Structure: Growing Concern - Repair

Existing AMC 20-29/AC20-107B, via ref. to CS23.573(a)(5), allows failure of bonded structure, provided that LL is maintained, e.g. using back-up design features. This does not permit poor process.

- this approach may be acceptable if the failure is obvious, such that failure does not exist with structure capability below UL for any significant period in service

- this does not account for ‘weak bond’
(due to in installation process error or in service degradation)

- recognising the greater process variability in the service environment, do we amend the AMC/AC* to require

- only mechanically fastened repair to Primary/PSE structure

or

- do we have enough understanding/confidence regarding ‘weak bond’ residual strength capability to permit a factored repair design, e.g. bonded repair damage sizing to ensure 1.2 -1.3LL capability if failed, offsetting the probability of such a condition.

* Note: Harmonised Policies regarding bonded structure are under consideration

Bonded Structure: Growing Concern – Design/Production

1/ The single disbonded stringer assumption:

- inconsistent use/interpretation regarding what it represents, i.e. between design codes, manufacturers etc

  - does it represent a 'typical' production error?

    (is a single stringer disbond a likely production process error?)

  - does it represent a service damage scenario?

    (is blunt impact more likely to disbond more than 1 stringer? If so, should such a case be considered in F&DT, Cat.2/3, Cat. B etc)

    - metallics - 2 frame bay and frame crack - equivalent to composite large notch work?
    - composites – more failure modes, e.g. disbond, what is the equivalent 'robust' criteria?

  - what is industry experience?

  - considering the growing number of production and repair issues, do we need a more conservative and robust criteria e.g. exposed fuselage

Bonded Structure: Growing Concern – Design/Production

2/ Is ranking of bonded joint design/production methods wrt expected approach MoC, required*?
e.g. secondary bond v co-bond v co-cure etc:

- any processes involving preparation, storage, etc of an existing cured surface are probably the most vulnerable processes.

- is 'co-bond' a less reliable design concept/process than 'co-cure' etc?
  - if so, how do we account for any differences in substantiation?

- are there generic sub-component stiffness ratios which can be used to provide guidance regarding expectation of likely problems with such structure?

- is more R&D, standardised guidance necessary/possible?

* i.e., next level of information to that provided in '*Bonded Joints and Structures - Technical Issues and Certification Considerations* [PS-ACE100-2005-10038, September]'

Composite Safety Issues – Shared Databases

Shared Databases (production and repair materials data) – EASA Update:

- NCAMP - No direct European approval mechanism available, e.g. no independent 'Test House' etc. - possible interpretation of existing sub-contract control?
- Need more explicit approval process

Short term EASA position:

- NCAMP procedures considered acceptable for Validation of products (appropriately supported) – No EASA equivalent available to FAA for EASA product (note: LBA Handbook?)

- EASA Structures Policy in development to confirm the point above

Long term - EASA anticipates some future more permanent action:

- What is the industry perspective/need?

FYI: NPA 2010-01 'Other Party Supplier Control' IR 21.139 - formally identifies third party/industry run organisations (beyond simple direct Production Organisation subcontract control), e.g. NADCAP – similarly could be discussed within DOA WG. Also note, could be within scope of MDM-075 Maintenance – 'Specialised tasks other than NDT'

- FAA acceptance required for 'NCAMP' type activities run in Europe
e.g. independent test facilities, EASA involvement, European run processes etc

- within scope of EASA/FAA Bi-lateral? (TBD)

http://easa.europa.eu/rulemaking/international-cooperation-bilateral-agreements.php

Back-up Slides

Composite Safety Issues – AMC 20-29/AC20-107B LEF

- LEF: developing CMH-17 V3C12 work very useful (WSU, Waruna etc), providing good discussion of issues, e.g. individual Weibull, joint/modified Weibull, Sendeckyj etc

Is there need to further reduce this to brief and clear regulatory guidance regarding 'key points' relating to how the factor is expected to be developed and used?, e.g. AMC could include content for:

Example: CMH-17 Rev.G V3C12.6.3.3 guidance – Test matrix for Life/Load Factor development could be reduced/defined as minimum:

- • Critical design details, loading modes, and stress ratios must be represented in coupon and element level.
- • Specimens must be fabricated from a minimum of three distinctive material batches, unless otherwise proven that a significant batch variability does not exists through lamina-level statistics (i.e., alpha = 0.01 significance level using the Anderson-Darling test).
- • Excluding the static stress level, a minimum of three fatigue stress levels must be included in the test matrix for each S-N curve. At least two stress levels must show fatigue failures for analysis techniques that utilize residual strength of runouts, or else, all stress levels must have a minimum of six fatigue failures.
- • Based on the fatigue analysis technique (i.e., analysis of individual stress levels or pooling fatigue data across stress levels using either joint Weibull or Sendeckyj analysis), the minimum recommended number of specimens as shown in Figure 12.6.3.3(f) must be included.
- • Minimum of 6 datasets for static are included (at least 6 Weibull shape parameters) in the staticstrength scatter analysis for generating strength shape parameter.
- • Minimum of 6 datasets for fatigue are included (at least 6 Weibull shape parameters) in the fatigue-life scatter analysis for generating life shape parameter.

- LEF: Further potential subjects requiring summary/further development at AMC level:

1/ Different Material Forms:

- '1.15' initially accepted for current prepreg as conservative because material and process improvements (subject to later substantiation *):

- Is this good practice, even for prepreg (improved materials and processes)?

- Is this acceptable for other material forms? no, e.g. VARTM-1.20-1.25, RTI-1.85 etc

Therefore, clear requirement/AMC expressing need to establish appropriate Factor for material form may be required. e.g.

- CMH-17 Rev.G V3C12.6.3:' ...At a minimum, this requires a fatigue-life scatter analysis of representative coupon/element S-N data obtained for one fatigue-critical design detail and a representative stress ratio (i.e., open-hole test with R=-1) as shown in Figure 12.6.3.3(g)....'

* This should only be a business risk, if substantiation indicates a higher number. However, the work and time necessary to address any 'surprise' may result in unnecessary conflict, and possibly a safety issue.
What level of similarity justifies no need for further work?

Composite Safety Issues - AMC 20-29/AC20-107B LEF

- LEF:

  2/ Factored peak load reduction (truncation, clipping):

  - at what level is this acceptable, e.g. above LL after Factor is applied?
  - should additional cycles be added to replace reduced cycle load above this?

  3/ Factor typically applied to peak load.

  - is guidance required regarding the significance and influence of LEF upon other cycle parameters, e.g. min, mean, and amplitude* (R, change of R from +ve to –ve etc)
  - express priority to maintain R when applying LEF?

  4/ Low load level cycles removal from test (omission, truncation).

  - provide a standard approach?
  e.g. data required to establish theshold etc - 60-70% B-basis value etc?

  5/ Factor application to complex structure

  - does selecting the largest factor applicable to a particular part of a complex structure for test of the complete complex structure result in potentially incorrect failure modes for other parts of the structure (recognising the limited number of practical tests possible)?

* ‘Application of LEF’ Waruna 2009 discussions?

- LEF:

6/ Mixed metal/composite Structure

- what confidence is required for proof of a lower LEF, e.g. no. batches etc?
- when is the Factor low enough to allow both metal and composite to be tested in the same test, e.g. considering metal crack retardation/acceleration issues etc

7/ What features are not addressed? How should they be addressed?

- ply drop-offs
- stringer/stiffener run out,
- post buckled structure,
- bonded/co bonded/co-cured joints
- crack initiation manufacture deviation, BVID damage etc
- extension from in-service damage

8/ How should environmental factor be managed in F&DT testing, e.g.

- high pyramid component static testing with environmental factor between fatigue phases icw lower pyramid (above coupon level) environmental testing

and/or

- include factor in high pyramid fatigue test (possible if low enough total LEF)?

- LEF:

9/ Spectrum sequence

- load spectrum sequence suspected to be of limited concern, e.g. refs give CMH-17 V3C12.6.3.5 (1979 – 1988) regarding low load cycle removal (note Miners rule unconservative for composites) etc.

- is this true for sequencing of the remaining loads, e.g. use of high load blocks etc? If so, is specific guidance required to bound the applicability of this assumption for high loads?

Impact Threats: General Comment

Amend AMC to more explicitly require investigation for range of impactor parameters (not just the defined threat limit) in order to capture any change in failure modes, e.g. consider impactor

- Energies
- Geometries
- Stiffness
- Orientations

Composite Safety Issues – Shared Databases

Shared Databases (production and repair materials data) – EASA Update:

- NCAMP - No direct European approval mechanism available, e.g. no independent 'Test House' etc. - possible interpretation of existing sub-contract control?
- Need more explicit approval process

Short term EASA position:

- NCAMP procedures considered acceptable for Validation of products (appropriately supported) – No EASA equivalent available to FAA for EASA product (note: LBA Handbook?)
- EASA Structures Policy in development to confirm the point above

Long term - EASA anticipates some future more permanent action:

- What is the industry perspective/need?

FYI: NPA 2010-01 'Other Party Supplier Control' IR 21.139 - formally identifies third party/industry run organisations (beyond simple direct Production Organisation subcontract control), e.g. NADCAP – similarly could be discussed within DOA WG. Also note, could be within scope of MDM-075 Maintenance – 'Specialised tasks other than NDT'

- FAA acceptance required for 'NCAMP' type activities run in Europe e.g. independent test facilities, EASA involvement, European run processes etc
- within scope of EASA/FAA Bi-lateral? (TBD – 'diplomatic notes to be exchanged this year')

Composite Safety Issues - Crashworthiness

- Crashworthiness: Developing Situation:
  - new materials and/or application of materials,
    e.g. extensive composite use in large CS25 fuselage
  - new (to aviation) design concepts applied, e.g. active energy management design
  - different configurations, e.g. large CS23/small CS25 jets – low wing etc
  - advances in computer modelling
  - further incidents/experience
  - composite structure referenced to nominal metal comparison

Resulting in:

- Special Conditions, e.g. A350, B787, HBC4000 etc
- evolving Policy, e.g. ditching policy
- cross subject discipline issues, e.g. fuel tanks, fire (post crash) etc

Develop integrated crashworthiness rules?

Need to review Crashworthiness Requirements (metallic and composite)

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective - Survivability
- Defined for fuselage, e.g. in composite comparison in SCs:

Don't forget fuel tanks

- Maintenance of the living space

- Retention of items of mass (seats, overhead bins or other items of mass)

- Maintenance of acceptable accelerations and loads experienced by the occupants

- Maintenance of occupant emergency egress paths

These are addressed at generic and comparative level - should these be considered in requirements at the aircraft level, e.g. recognising improved modelling etc? How?

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

  Maintenance of acceptable accelerations and loads experienced by the occupants:

  Can we assume that the composite (and/or energy management design feature) airframe interface pulse is adequately similar to a conventional aircraft for the defined pulse bounds in 25.562 2(b)(1)(2) to apply?

  Assuming that a 'validated aircraft level model' can be defined:

  probably of more significance to Small CS25/large CS23

  25.562 2(b)(1)&(2) could be amended to add a note:

  'For non-conventional (to be defined) fuselage designs, including significant use of new materials (to be defined) and/or new design concepts, the applicability of using the above stated interface pulse values should be established iaw AMC 25.562(b)(1)&(2), otherwise an acceptable alternative substantiation approach should be established'

  AMC 25.562(b)(1)&(2):

  - define 'non-conventional', 'new materials', 'applicability' criteria, 'validated aircraft level model'

  - also explicitly indentify use of Dynamic Response Index (DRI) as possible MoC?

- Crashworthiness: Objective – Survival

probably of more significance to small CS25/large CS23

Retention of items of mass:

Assuming that a 'validated aircraft level model' can be defined:

25.561(c)(2) (similarly 25.561(d)) could be amended to read:

> 'When such positioning is not practical ...each such item of mass must be restrained under *the greater* of the* loads specified in subparagraph (b)(3) of this paragraph *or as determined by the use of a 'validated aircraft level model' subject to a 'rational crash'*

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

‘Validated aircraft level model’: ‘Test’ and ‘Test supported by Analysis’

- define level of test in pyramid necessary wrt new materials, non-conventional design features
- relevance of Vz comparison with metal structure to be determined (difficult to find representative section, particularly in smaller CS25 configurations)
- use the MOC route per A350, B787, e.g. acceptable model criteria, appropriate test level in pyramid etc
- develop AC/AMC checklist for possible MoC?

e.g.
- content?
- level of detail?

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

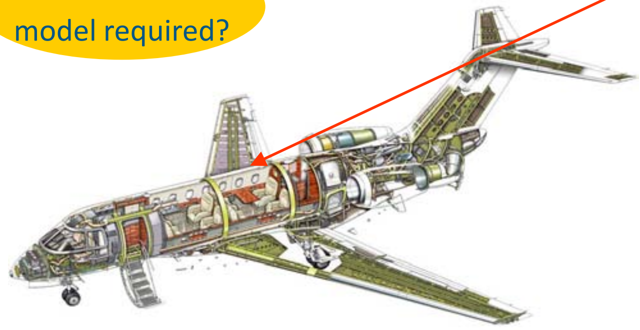
Vz reference and testing required in pyramid:

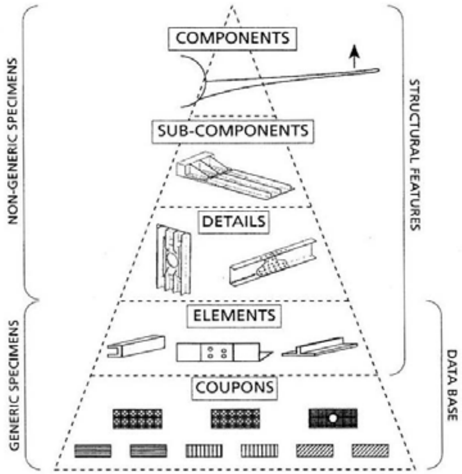
- How can we define appropriate boundary of new material/unconventional structure with conventional material/structure?

- what is a 'representative' section?

(more difficult to define for small CS25/large CS23)

Aircraft level model required?





Crashworthiness: Objective – Survival

Interiors: ‘warpage’ Floor Rail 10 deg. roll – 25.562

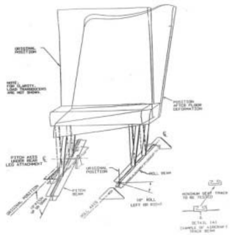


Figure 9-1. Schematic Floor Deformation Fixture—Seat Legs Attached at Floor Level

- applied to larger CS25 metallic aircraft

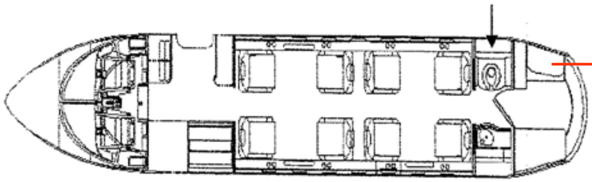
(capable of such deformation, providing a level of robustness etc)

- not practical be practical in small composite CS25 configurations (brittle, stiff, - damage produced before this can be achieved)

- new interior configurations - unconventional

e.g. side facing seat - belt attached direct to airframe etc, not addressed in AC 25.562

- review this?



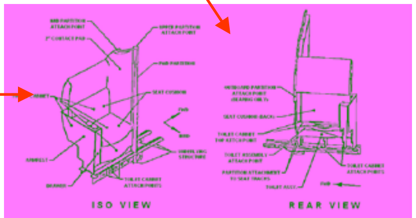


Figure 3.2 – Toilet Seat & Partition Assy

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

Interiors: Composite Seats

- increasing interest in composite seat structure,
e.g. recent ETSO meeting Koeln Dec 2010

- how should composite seat structures be addressed?
  – DT structure?
  – significance of correct selection and location for artificial defects?

- preloading can cause damage
  - repeatable?
  - representative?

- are new test failure criteria required?

- should a post dynamic test static test also be applied to help to find damage, e.g. stiffness check etc?

Composite Safety Issues - Crashworthiness

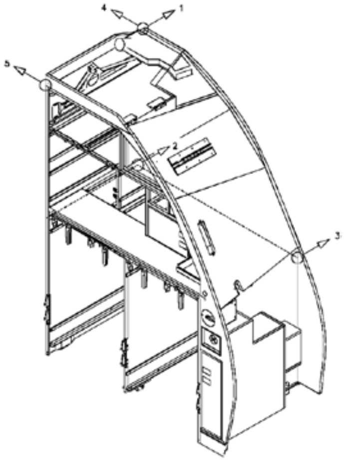
- Crashworthiness: Objective – Survival

Interiors: UL tested monuments used in service:

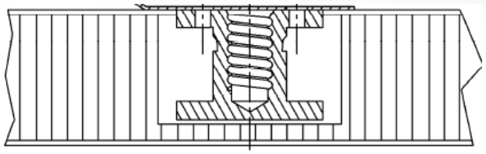
- common practice for VIP, and even large production runs

- can we be confident regarding the finding of damage and completing any repairs? If so, how?

(if so, GAMA Pub.No.13 needs amendment)



Crashworthiness: Objective – Survival



Interiors: Bonded Inserts (blind/non-trapped/no spacer)

- common for non-TCH DOAs to complete modifications, iaw TCH insert process guidance, for items of mass (often with deviations to TCH process)

  - strengthen culture of responsibility for process POA/DOA interface

- is a process witness step necessary in bonded insert instructions? (as for metal bonded structure in operating environment)

- is more explicitly stated policy necessary regarding use of non-trapped inserts, e.g. application and/or process?

  - NDI of limited use
  - no indication of failure until needed, too late (crash, gust)
  - in-service variability for process
  - limited linkage between Part 145 bonded structure audits, and the recent process application

- although a witness is not a perfect solution, having such a step does focus attention on the process

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

Post Crash Fire (policy being developed): Special Condition:

- survivability dependent upon evacuation time for pax. before tank breach – considers wing:

- endure external fuel-fed pool fire > 5mins
(or show equivalence to existing wing - EASA)
- min fuel loads (not less than reserve fuel levels)
- max fuel loads
- other identified critical fuel loads

- do we need rule/AMC to standardise MoC

- reference fire threat definition
- approach to test v analysis
- need to explicitly reference empennage tanks, fuselage etc

Also consider: burn through resistance, auto-ignition threats, rescue crews

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

Fire: More generally:

(considering wing/fuselage – in-flight/post crash)

- current composite materials and configurations appearing to be equivalent to metallic references (strength/stiffness etc)

- will this be the case as materials and configurations evolve?

- is an AMC/standard for strength and toxicity checks necessary as materials evolve
- ‘sanity checks’?

Composite Safety Issues - Crashworthiness

- Crashworthiness: Objective – Survival

Define survivable 'Rational Crash' for aircraft level:

- based upon 25.721?
- 20 deg. yaw, plus appropriate pitch, role, etc
  (in order to consider off-axis crash behaviour)

10fps, 15fps, not 5fps? (>5ft/sec per 25.721 as crash may be result of problem other than known u/c issue - 25.721 and may be associated with less control. Also 10fps/6fps 'limit' decent velocity landing/take off weight – 25.473, & 12ft/sec 25.723 'shock absorber', etc

Note: current SC uses up to 30ft/sec for Vz test ref, partly based upon event analysis – is this correct?

- plus appropriate forward speed
- consider airfield features, e.g. slopes, ditches, obstructions?
- runway surfaces?
- aborted take-off at what stage, aircraft weight etc?
- and ditching scenario 25.563? (developing policy)

Crashworthiness: Objective – Survival

Fuel Tank Boundaries:

- material change allows configuration change

- current requirements
  - 25.561 - inertia
  - 25.963 - hydrostatic

- distinction 'within fuselage boundary'
  - pressure boundary
  - between fuselage and engine

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