



‘Composite Materials’

Revision to CS XX.603 AMC

(CS 23,25,27, & 29)

(Harmonised with Revision to AC20-107A)

European Meeting - Köln 28th. January 2009

(FAA/EASA/TCCA/INDUSTRY)



**EASA Workshop:
Harmonised Revision to Regulatory Guidance
'Composite Aircraft Structures'
28th January 2009, Cologne**

Programmed

- 9:00 Registration
- 9:30 Opening/Introduction/Background
- 10:30 Coffee Break
- 11:00 Outline and discussion
- 12:30 Lunch
- 13:30 Outline and discussion continued
- 15:00 Coffee Break
- 15:30 Outline and discussion continued
- 17:00 Close

Please note: All presentations given will be made available on the Agency's website (http://www.easa.europa.eu/ws_prod/g/g_events.php) after the event.



Welcome to attendees: (Manufacturers, Repair Organisations, Regulators - fixed wing, rotorcraft):

- Aernnova
- Aero-Sport Luxembourg
- Agusta Westland
- Airbus France
- Alenia
- CAA Latvia
- CAA UK
- Dassault Aviation
- EADS Socata
- EADS Socata
- EASA (Certification, Rulemaking, Standardisation Directorates)
- ENAC
- Envirotainer
- Eurocopter
- J2R Consulting
- Lufthansa Technnik A.G.
- Pilatus
- Stork Fokker AESP



Presentation Details:

- 1/ Introduction
- 2/ Background
- 3/ New and Revised Guidance Development
- 4/ Harmonised AMC/AC History
- 5/ Revised AMC/AC Team and Timescale
- 6/ Revised AMC/AC Inputs
- 7/ Revised AMC – Meeting Objectives
- 8/ The Basic Rule and AMC Outline



Recent History: - extensive increase in composite use – particularly CS 25 aircraft

- material advances
e.g. tougher matrix systems

- new material forms
e.g. braided structure

- more exposed PSEs
e.g. pressure hull

- new applications
e.g. fan blades, undercarriage



Transport Aircraft

- Secondary structure
- Control Surfaces
- Empennage
- Wing & fuselage applications for new aircraft
- Some engine (e.g., fan blades)



Small Airplanes and Rotorcraft

- Most structures
 - Pressurized fuselage
 - Wing
- Dynamic components
 - Propellers & rotor blades
- Extensive bonding

need for new and revised guidance



Background Concerns- particularly for older materials and processes:

- **environment** (moisture/temperature – build and service)
- **poor heat and electrical conduction** (lightning strike)
- **fire behaviour** (toxic fumes, fibre release, in-flight, post crash fire strength)
- **low out of plane, compressive, and shear strengths**
- **quasi-brittle** (vulnerable to load peaks, impact damage, strain rate etc)
- **high engineering property data scatter** (static and fatigue)
- **failure loads, modes, and locations difficult to predict**
- **can be difficult to detect damage** (delamination, blind side damage, material relaxation – NVD/BVID – Non Visible/Barely Visible Impact Damage)
- **typical damage** (delamination/matrix damage) **can adversely affect the existing critical modes** (out of plane, compressive, and shear)
- **high energy blunt impact damage detection**
- difficult to **repair** (drying, cleanliness etc)

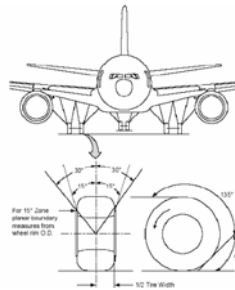


- concerns have driven need for Special Conditions, CRIs etc for new projects (not explicitly addressed in rules for composites)

lightning



tyre debris



fire



crashworthiness



engine debris

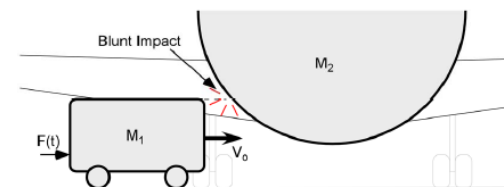


- composite utilisation not to reduce safety level relative to that provided by metallic structure – can be difficult to define and quantify!



Fatigue and Damage Tolerance of particular interest:
e.g. concern large blunt impacts?

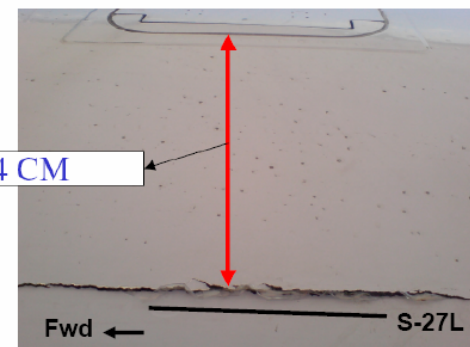
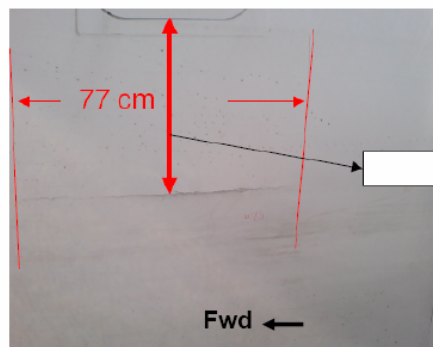
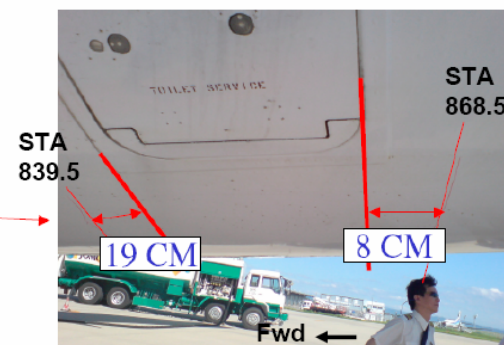
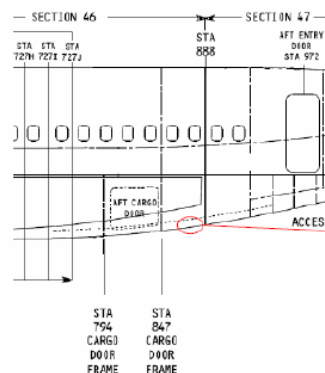
metal and composite responses to impact differ....



ground
impact



in-flight impact – incorrect initial
inspection and repair procedure





European Aviation Safety Agency



BACKGROUND



Other impact threats...

- need to define/standardise threats and then manage into design...

Ref. John Halpin

Threat	Test Protocol	Simulation Models	Threat Allowable	Self Evident Event	Impact Location(s); Zones 1 & 2
Bird Strike	Gel-pack	Yes	"B" FAR's (Wt. & Vel.)	Yes	YES
Hail	Simulated Hail Ice, SHI?	Yes Maturing	"B" Up-date MIL HDBK 310	Yes	YES
Runway Debris	Lead Ball ? Drop-tower?	?	"B" Up-date JSSG-2006 ?	Sometimes	Usually
Tire Rupture	Rubber Puck	?	AC25.963-1	Yes	YES
Panels Lost In-flight	?	?	?	Yes	Sometimes
Tool-drop	Steel or Aluminum Hemisphere Drop-tower	?	JSSG-2006 Structures	Sometimes	Yes
Incidental Contact With Ground Vehicles	TBD	TBD	TBD	Sometimes ?	Yes
Others? Lighting Strike	----	-----	-----	-----	-----



- common practice: e.g. CS23.573 (a)(5) (bonded structure) principle applied to other CS's

CS 23.573(a)(5): ‘for any bonded structure, the failure of which would result in catastrophic loss of the airplane, the limit load capacity must be substantiated by one of the following methods.

(i) ..*disbonds ...must be prevented by design features*
(note: not an excuse for poor process)

(ii) ..*proof testing...each production article...(not practical for many designs), or*

(iii) ..*repeatable and reliable NDI... not yet considered adequately reliable'*

***Note 'secondary bond' - the joining together, by the process of adhesive bonding, of one or more already-cured composite parts (referred to as adherends - V3C3)**

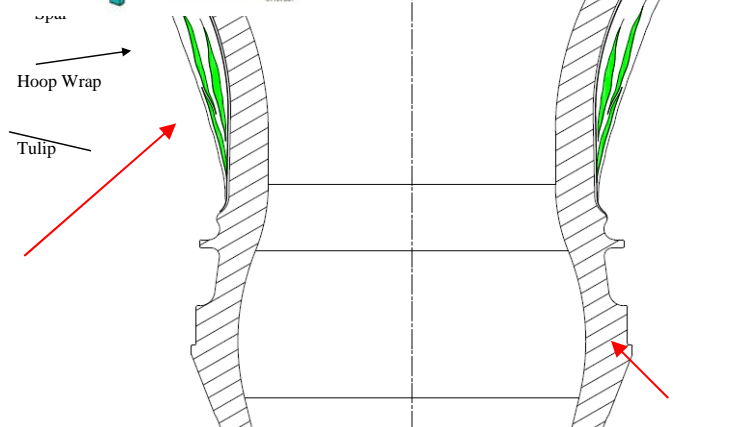
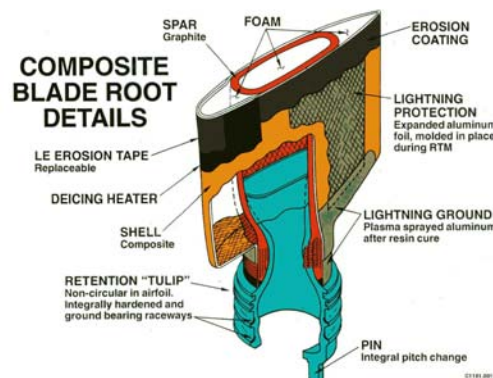


- Example: e.g. use of CS23.573 (a)(5)

CS-P 160: *'(a) critical parts to be withdrawn from service at a life before hazardous failure ($> 10^{-7}$ hr)'*

CS-P 150: Safety Analysis Hazardous Propeller effects include..

'(g) (iii) release of the propeller, or any major part of the propeller'



metallic
root

Strap - good design practice

– design safety feature

(weak bond, tight disbond
cannot reliably be detected)

- has worked in service!



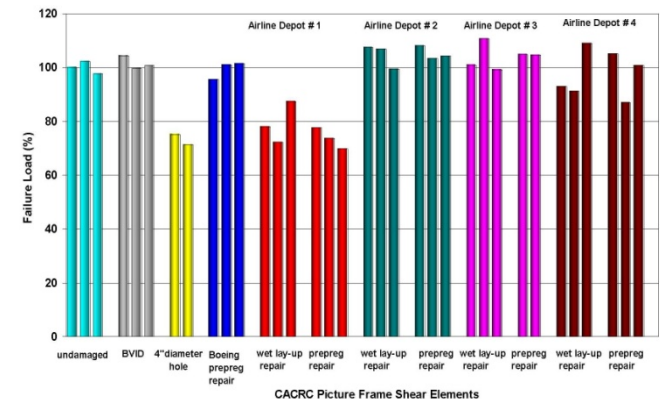
Material properties are built into manufactured/repaired structure:

- strengthen recognition of

integrated Design, Production, and Continued Airworthiness Functions

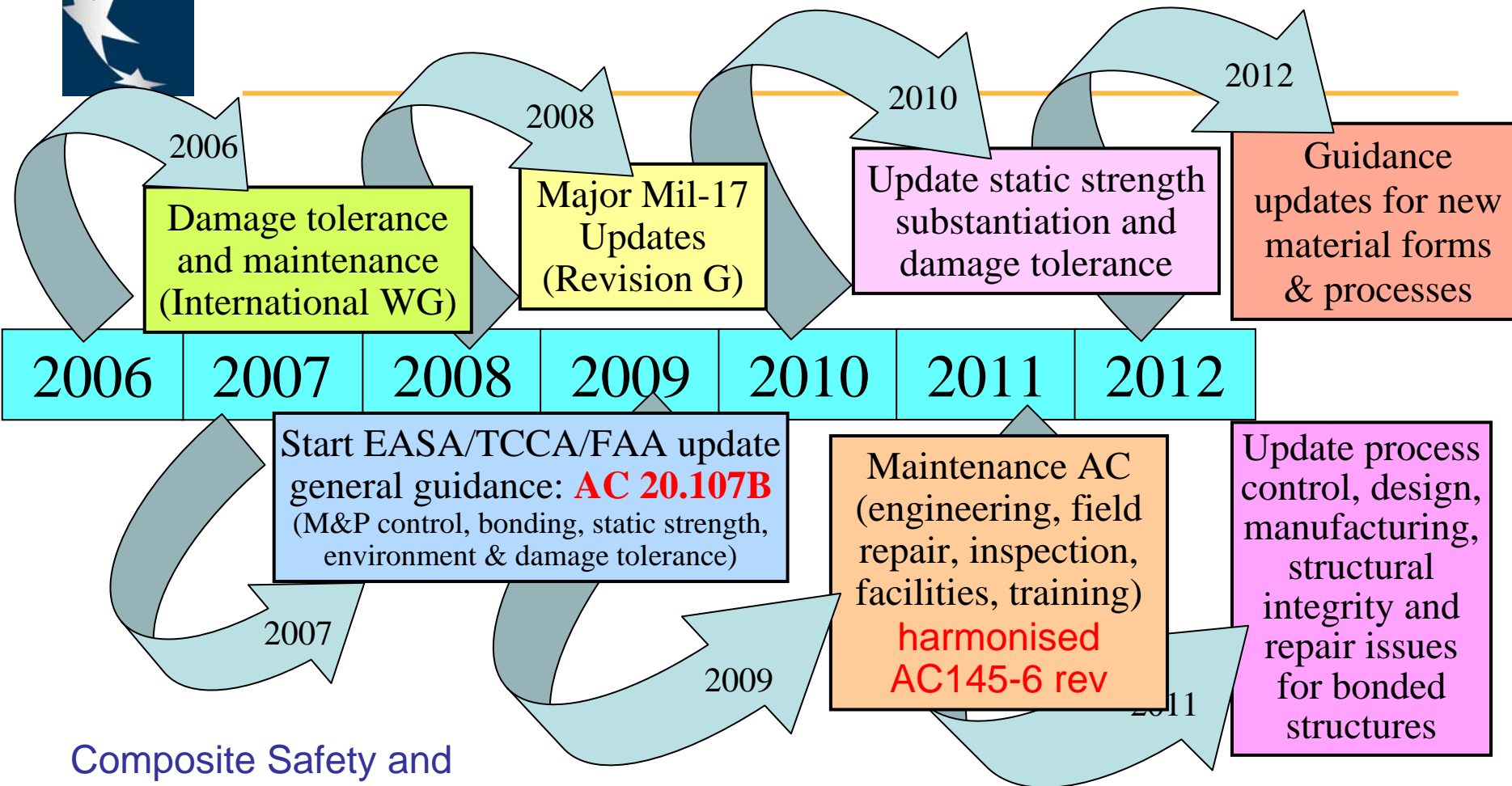


OEM v Field Repair Variability





AC/AMC revision - part of larger drive to produce composite guidance...



Composite Safety and Certification Initiative (CS&CI)



History: Revision A was 1984 etc

Meeting held in Gatwick 2003 to consider new revision:

Gatwick
2003
meeting

- AC20-107 rewritten by joint USA/Europe 1982-1984
- ACJ25.603 created with “same” text
- Intentions
 - Minimal text
 - Aircraft and helicopters included
 - Reference back to relevant requirements
 - Only thermosets in mind
 - QA and repairs covered in other docs



SUMMARY STATEMENT

From: FAA/US Industry - AASC/AECMA Specialists Groups.

Subject: Draft AC20-107A "Composite Aircraft Structure".

1. The above groups met for a joint coöperative effort to establish a mutually satisfactory document for guidance in certification of composite structure for commercial aircraft structure.
2. The FAA Advisory Circular published in the Federal Register in March 1983 (also known as Mod. 10) and the Discussion Paper, dated 20 June 1983 under development by the JAR Structures Group were the initial bases for discussion.
3. As a result of several meetings, a common ground has been established and documented in a revised version of the FAA Advisory Circular identified as Mod. 16 dated 8 Dec. 1983.
4. It is understood by all that the JAR Group will recommend to the JAR Structures Group that the FAA Advisory Circular should be used essentially verbatim as JAR guidance material.
5. It is agreed by all that this joint effort has been mutually beneficial, that this level of cooperation should be considered in other technical areas, and that this group should be reconstituted in no more than five years to update the guidance material to reflect technology developments.

J. Soderquist
Federal Aviation Administration

D.S. Warren
Mc Donnell Douglas Aircraft Company

J. McCarthy
Boeing Commercial Airplane Company

A.M. James
Lockheed-California Company

J.W. Bristow
Civil Aviation Authority

L. Baranes
Service Technique des
Programmes Aéronautiques

B. Chaumette
Avions Marcel Dassault-
Breguet Aviation

T.W. Coombe
British Aerospace Aircraft Group

J.F. van der Spek
Rijksluchtvaartdienst

20-107 Agreement

Gatwick
2003
meeting



AC20-107- ACJ25.603 Differences

Gatwick
2003
meeting

- Original
 - Limit versus Ultimate load
 - Non structural issues e.g.flammability
- Since
 - Helicopters broke away
 - Joe's part-23 special condition
 - JAA equivalent materials (AMC Note 2)



Suggested areas for consideration

Gatwick
2003
meeting

- JAA to recognise QA and repair doc
- Ensure generic doc covers helicopters
- Define environmental conditioning
- Create a max impact envelope
- Tidy up part 23
- Rationalise and cross reference between design, QA and repair docs
- Bonding, FMLCs, MMCs
- Update chemical characterisation



AMC20-29/AC 20-107B Team – EASA/FAA/TCCA

(meetings April 2008 Köln, June 2008 Seattle, + various CMH-17 meetings)

EASA:	Jean Rouchon	JAA
	Martin Belz	(JAA/LBA)
	Simon Waite	Structures and Materials Certification Specialist
FAA:	Larry Ilcewicz	Chief Scientific and Technical Advisor (CS&TA) - Composites
	Lester Cheng	Small Airplane Directorate
	Evangelia Kostopoulos	Small Airplane Directorate
	David Ostrodka	Wichita Aircraft Certification Office
TCCA:	Maurizio Molinari	Aircraft Structures - Certification
	Alain Douchant	Aircraft Structures - Certification

Plus input from Airbus and Boeing:
FAA/EASA/Airbus/Boeing F&DT workshops



CS23/25.603 AMC becomes AMC 20-29 – schedule (draft):

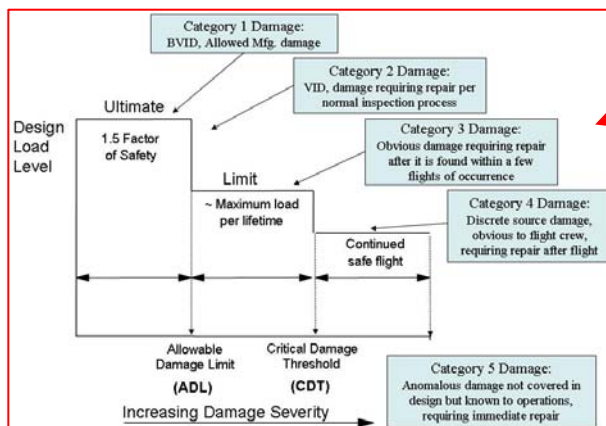
- **Ottawa CMH-17 meeting (Aug 2008)** – first delivery of intent/document outline to industry
- **European Industry meeting (Jan 2009)** - European specific delivery of Ottawa content
- **FAA completes legal tech editing (mid-March 2009)** - supplies EASA with a copy of the final text
- **EASA document review (March 2009)** - ensure that no significant changes have occurred wrt agreed text, alters the obvious EASA specific differences (e.g. ref. to high level EC rules etc), and prepares the document for release for comment with FAA AC (**April 2009**) – (note FAA (30 day) and EASA (3 month) comment periods)
- **North American Industry Comments Meeting + FAA & TCCA (April-May 2009).**
- **European Industry Comments Meeting + FAA & TCCA (June-July 2009).**
- **EASA Disposition of Comments from Public Commenting Process (TBC Sept 2009)**
- **EASA final Issuance of AMC 20-29 (Jan 2010)**

* Although the emphasis is upon harmonisation, Europe will obviously still have the opportunity to include any significant differences within its document but only if considered to be necessary.



Document Revision Development AMC 20-29/AC20-107B: in part, by using

- industry input via the new **CMH-17** composite certification chapter (V3C3)
- inputs from various **recognised sources**, e.g. harmonised AC/AMC, **AC29 2C MG8**
- **Composite Certification Roadmap Oct.2003**
(Standards Office – Small Airplane Directorate)
- **ideas presented to industry on several occasions**, e.g. the damage category idea (Cat 1,2,3,4 &5) presented at workshops and several CMH-17 meetings



Damage Categories.....

FAA/EASA/Industry Damage Tolerance and Maintenance Workshops

- Chicago July 2006

- Amsterdam May 2007





CMH-17 Mission Statement (Recent Draft):*

*Composite Materials Handbook 17 (CMH-17) will **develop comprehensive engineering information that is proven reliable regarding design, characterization, processing, databases, statistics, testing, and industry standards for composite materials and structures.** This information will be available to all interested parties in written handbooks, web-based training resources and other suitable means to disseminate the information. **All information will be reviewed by industry, government, and academia in a thorough, methodical review process prior to circulation.***

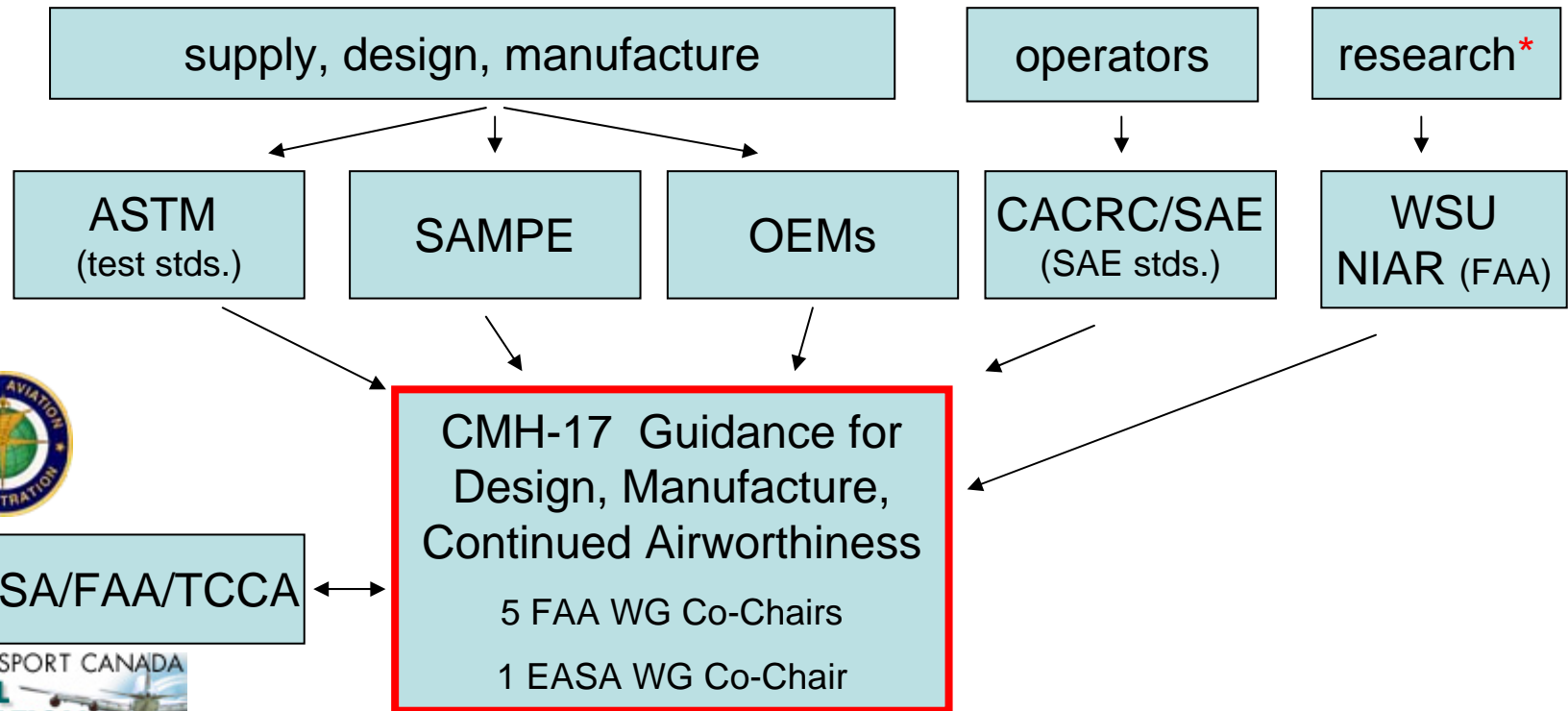
** Now Composite Materials Handbook-17 - CMH-17 Rev.G due 2010*



Composite Materials Handbook -17 Global Platform for...



Composite Safety and Certification Initiative (CS & CI)



CS & CI objective: review, and evolve, composite rule and guidance material as technology matures (Design, Manufacture, and CAW)

ASTM (American Society for Testing of Materials) CACRC (Commercial Aircraft Composite Repair Committee)

SAMPE (Society for the Advancement of Materials and Process Engineering) NCAMP (National Centre for Advanced Material and Performance) 22



CMH-17 – 6 Volumes:

- 1/ Guidelines for Characterisation of Structural Materials
- 2/ Material Properties
- 3/ Material Usage, Design, and Analysis
- 4/ Metal Matrix Composites (MMC)
- 5/ Ceramic Matrix Composites (CMC)
- 6/ Composite Sandwich Structure



CMH-17 Vol.3 (draft outline):

V3C3 NEW
CHAPTER

- 1 General Information
- 2 Introduction to Composite Structure Development
- 3 Structural Certification and Compliance
- 4 Building Block
- 5 Materials and Processes
- 6 Quality Control of Production Materials
- 7 Design of Composites
- 8 Analysis of Laminates
- 9 Structural Stability
- 10 Bonded Joints
- 11 Bolted Joints
- 12 Damage Resistance, Durability and Damage Tolerance
- 13 Crashworthiness
- 14 Supportability
- 15 Thick Section Composites
- 16 Structural Safety Management
- 17 Environmental Management

building block
for AC20-107A & CS
25.603 AMC rev.

icw recent other
documents, e.g. AC29
2C MG8, and workshop
input



Chapter 3 'Structural Certification and Compliance':

scope/objective:

- provide a top level guidance to the regulations, paying particular attention to composites (previously missing from CMH-17)
- provide guidance regarding the basic Certification process
- provide guidance regarding possible approaches to showing 'means of compliance'
- considers design, production, initial and continued airworthiness



AC29 2C MG8 'Substantiation of Composite Rotorcraft Structure' (Rule CS 29.573)

- recognised need to supplement AC20-107A
- primary structure utilisation ahead of fixed wing
- static strength: Rotorcraft and fixed wing substantiation similar for both metallic and composite structure
- fatigue: differences between rotorcraft and fixed wing – airframe and dynamic components, unique loads, severe spectrum, specialised comprehensive fatigue environment

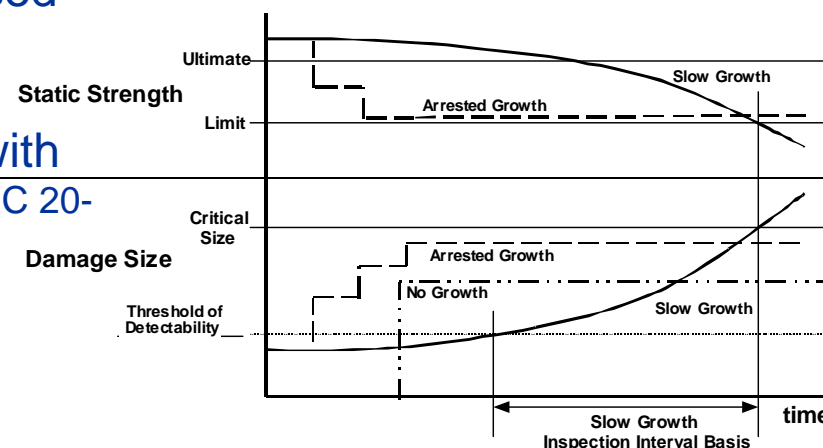




AC29 2C MG8 (Rule CS 29.573)

'Substantiation of Composite Rotorcraft Structure'

- Composite Fatigue and Damage Tolerance ideas developed:
 - 'Arrested-growth' and 'Slow-growth' addressed explicitly
- introduces damage tolerance text/figures with broader value to fixed wing (used in new AMC 20-29/AC20-107B)
- other issues: developed consideration of bonded structure, creep etc



Residual Strength/Damage Size Relationship -
Fail-Safe Substantiation



Extensive Research and Development input:
FAA research subjects include :

Damage Tolerance of Composite Structures

Structural Integrity of Adhesive Joints

Composite Maintenance Practices

Environmental and Aging Effects for Composite Structures

Cabin Safety Issues Unique to Composite Materials

Specifications for Material Control and Test Standards for Advanced Materials

Fatigue & Damage Tolerance for Dynamic Composite Structural Applications

Advanced Materials & Processes

plus much more....



Growing Research and Development input: Europe and EASA

Effect of Preload on Bird Strike Damage in Carbon Fibre Polymer Composite Beams - UK CAA /Cranfield University

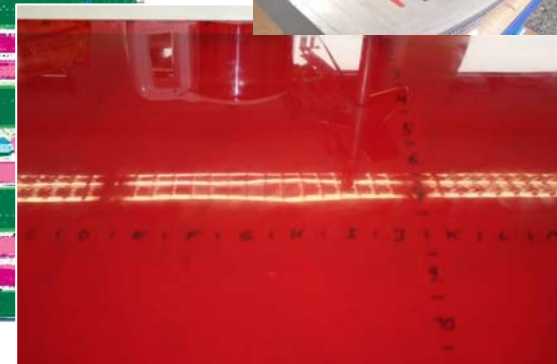
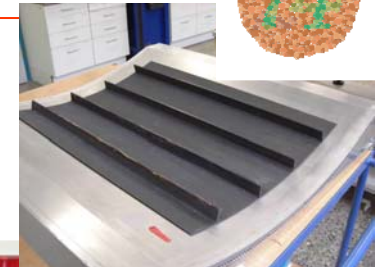
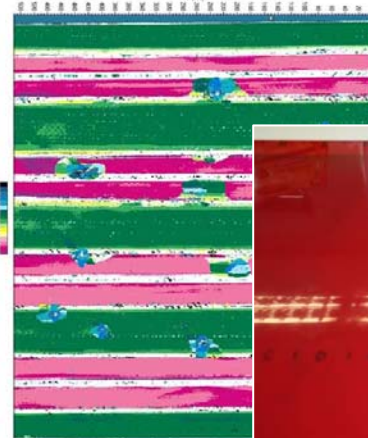
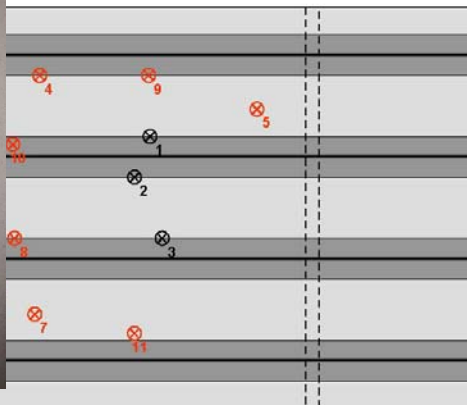
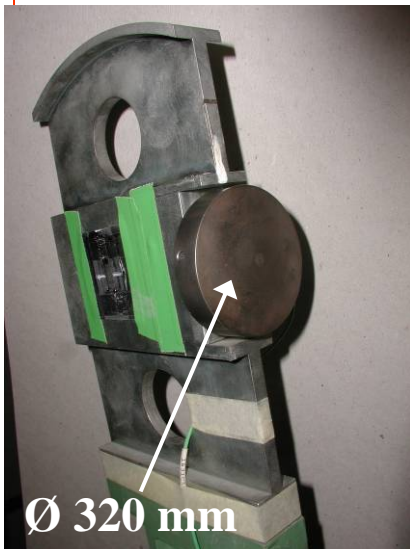
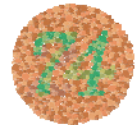
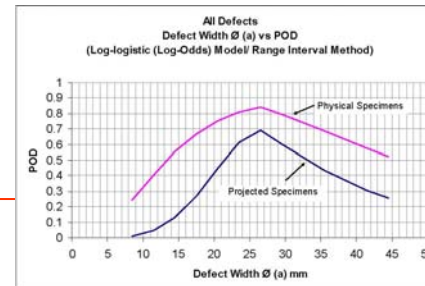
Reliability of Damage Detection in Advanced Composite Aircraft Structures - UK CAA /Cranfield University

Visual Inspection of Composite Structures - EASA/ DLR

Hail Threat – EASA/Met Office/Qinetiq (with FAA)*



*increasing
EASA/FAA/Industry
harmonised R&D





European Aviation Safety Agency



HARMONISED
AC/AMC INPUTS



Blunt Impact – EASA/AIRBUS/FAA/BOEING/BOMBARDIER*

*increasing EASA/FAA/Industry harmonised R&D

Proposed study

(Impact Damage Formation on Composite Aircraft Structures – Hyonny Kim*):

- all points are of interest, but **EASA priorities are...**

2. Objectives

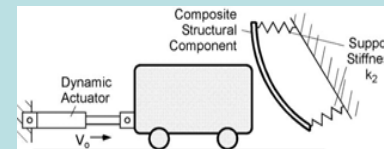
Low-Velocity High-Mass Wide-Area Blunt Impact:

1/ Identify which blunt impact scenarios are commonly occurring and are of major concern to airline maintenance organizations and aircraft manufacturers.

2/ Develop Methodology for **Blunt Impact Threat Characterization and Prediction.**

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.**

3/ Damage tolerance assessment of blunt impact damaged structures with focus on conditions related to loss of limit load capability for level of damage incurred, and which types of structural configurations and details are more prone to this loss of capability.



Cat 2, 3, and unreported
Cat 5 damage

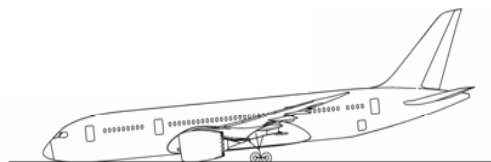
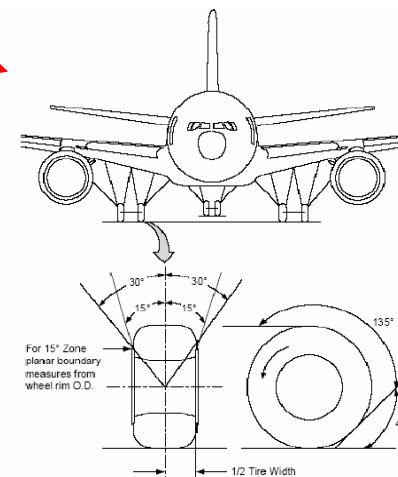
Can NVD/BVID level
indications be produced
by 'reasonable threats' ?

- primary interest is
ground impact



EASA Composite Related Rulemaking Activities

- Impact Threat Standardisation (Task 25.028) – Bird, Tyre, Engine, other Debris (runway debris etc)
- Crashworthiness (metal and composites) – (Task TBD)
- Flammability (CS25.856? plus MOC threat) – (Task TBD)





Meeting Objectives:

- provide opportunity for those not at the Ottawa meeting to see outline of changes in preparation for release of the text for comment
- review intent of proposed changes with necessary improvements in mind
- determine if there are any European specific issues/conflicts
- identify any errors/inconsistencies

Result: an up-dated and improved guidance document:

AMC20-29

Remember:

- harmonisation is an objective which benefits many organisations in a fragmented global market
- this is guidance, not a rule



The rule: (similar intent CS 23, 27, & 29)

CS 25.603 Materials (For Composite Materials see AMC No. 1 and No. 2 to 25.603.)

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

- (a) Be established on the basis of experience or tests;
- (b) Conform to approved specifications, that ensure their having the strength and other properties assumed in the design data (See AMC 25.603(b); and
- (c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.



AMC 20-29/AC20-107B - CONTENTS

1. PURPOSE
 2. CANCELLATION
 - ? TO WHOM THIS AMC APPLIES (added since Ottawa – AMC/AC to be renumbered)
 3. RELATED REGULATIONS AND GUIDANCE
 4. GENERAL
 5. MATERIAL AND FABRICATION DEVELOPMENT
 6. PROOF OF STRUCTURE – STATIC
 7. PROOF OF STRUCTURE – FATIGUE AND DAMAGE TOLERANCE
 8. PROOF OF STRUCTURE – FLUTTER
 9. CONTINUED AIRWORTHINESS ← New Section
 10. ADDITIONAL CONSIDERATIONS
- APPENDIX 1
- APPENDIX 2
- APPENDIX 3 ← Developed AC25.603 AMC Note 2

Generally: changes considered minor, some re-organisation,
but new content - existing 10 pages becomes 36