Federal Aviation Administration

FAA / CAAs “Composite Meeting”

- CMH-17 (Rev G): Volume 3, Chapter 3 -

Tutorial: Introductory Training

Larry Ilcewicz
Lester Cheng
FAA Composite Team

Singapore, Singapore
September 1-4, 2015

FAA / CAAs “Composite Meeting”
- CMH-17 V3C3 Development & Content -

- Development of CMH-17 V3C3
  - Background – Environment & CMH-17
  - Working Group – Charter & Execution
  - CMH-17 V3C3 Content Outline
- CMH-17 V3C3 – Content Review
  - Regulation and Certification
  - Design Substantiation
  - Production – Essentials
  - Maintenance – Technical Issues
- CMH-17 V3C3 Tutorial – A Glance

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CMH-17: V3C3 Tutorial

"Aircraft Structure Certification and Compliance"

- Building on V3C3: A tutorial was populated as a 6-Hour short lessen plan (2007-2008).
- First offered in CMH-17 Meeting in Ottawa (Aug/2008). Tutorial well received (needed a larger room ≈ 70+).
- Tutorial has been offered in every CMH-17 Coordination Meeting since 2008. [missed Meeting in SLC (Mar/2015)]
- Tutorial was offered in the special CMH-17 European Meeting in Delft/Netherland (Sep/2011).
- Tutorial had been offered on-site for Boeing and aroused interest of a few major concerns (e.g., P&W, NASA, USAF).
- Revenue from Tutorial has been used to support the operation of CMH-17 Organization.
- Key instructors include: Charlie Seaton, Hank Offermann, Simon Waite, Larry Ilcewicz.

CMH-17: V3C3 Tutorial
- Organization & Lesson Plan Glance -

- Tutorial Lesson Plan was structured/developed basically follows the V3C3 outline and contents.
  - "Module #" ↔ "Section #"
    [e.g., Module X ↔ Section. 3.X]
  - "Objective #" for info contained in Sections & Sub-Sections.
    [e.g., Objective 1 ↔ Sec. 3.1 (Introduction)]
    [e.g., Objective 3 ↔ Sec. 3.2.1 (Initial Airworthiness)]
  - V3C3 Section 3.7 (Guidance and Reports) is included in Module 6 as Objective 33.
- Some contents were extended from Level I paving path for Level II courses.
- Key instructors include: Charlie, Hank, Simon & Larry.
  A typical tutorial organization is illustrated in a follow-up chart.
- A tutorial registration fee of $500 is typically charged. This fee covers also CMH-17 Meeting registration.

Composite Materials Handbook-17
Tutorial
CERTIFICATION

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COMPOSITE MATERIALS HANDBOOK

Module 1 (Objective 2)

Tutorial organization

START	END	MODULE	OBJ	V3C3	PRESENTER
8:00 AM	8:10 AM	ONE: INTRODUCTION	1	3.1.1	Seaton
			2	3.1.2	Seaton
8:10 AM	9:00 AM	TWO: CERTIFICATION	3	3.2.1	Offermann
			4	3.2.2	Offermann
			5	3.2.3	Offermann
			6	3.2.4	Offermann
9:00 AM	9:35 AM	THREE: REGULATIONS	7	3.3.1	Offermann
			8	3.3.2	Offermann
			9	3.3.3	Offermann
9:35 AM	9:55 AM	**BREAK**			
9:55 AM	10:40 AM	FIVE: PRODUCTION	23	3.5	Offermann
			24	3.5.1	Offermann
			25	3.5.2	Offermann
			26	3.5.3	Offermann
			27	3.5.4	Offermann

Module 1 (Objective 2)

Tutorial organization

START	END	MODULE	OBJ	V3C3	PRESENTER
10:40 AM	11:50 AM	FOUR: DESIGN SUBSTANTIATION	10	3.4	Waite
			11	3.4.1	Waite
			12	3.4.2	Waite
			19	3.4.9	Waite
			20	3.4.10	Waite
			21	3.4.11	Waite
			22	3.4.12	Waite
11:50 AM	12:20 PM		13	3.4.3	Offermann
			14	3.4.4	Offermann
			15	3.4.5	Offermann
			16	3.4.6	Offermann
			17	3.4.7	Offermann
12:20 PM	1:30 PM	LUNCH			
1:30 PM	2:30 PM	FOUR: DESIGN SUBSTANTIATION	18	3.4.8	Waite
2:30 PM	2:45 PM	SIX: MAINTENANCE	28	3.6	Offermann
			29	3.6.1	Offermann
2:45 PM	3:30 PM		30	3.6.2	Seaton
			31	3.6.3	Seaton
			32	3.6.4	Seaton
			33	3.7	Seaton

Module 1: Introduction (Section 3.1)

- **Objective 1: Background, purpose and scope**
- Objective 2: Organization

Module 2: Certification (Section 3.2)

- **Objective 3: Initial airworthiness**
- Objective 4: Continued airworthiness
- Objective 5: Product modification
- Objective 6: Qualified workforce and teamwork

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Module 3: Regulations (Section 3.3)

- **Objective 7: Structure, design and construction**
- Objective 8: Production approval
- Objective 9: Maintenance and repair

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Module 4: Design Substantiation (Section 3.4)

- **Objective 10: Critical technical issues**
- Objective 11: Design and process documentation (3.4.1)
- Objective 12: Materials and adhesives qualification (3.4.2)
- Objective 13: Environmental exposure (3.4.3)
- Objective 14: Structural bonding (3.4.4)
- Objective 15: Tooling and part cure processes (3.4.5)
- Objective 16: Defect detection overview (3.4.6)
- Objective 17: Structural conformity (3.4.7)
- Objective 18: Structural substantiation (3.4.8)
- Objective 19: Flutter substantiation (Aero-elastic stability) (3.4.9)
- Objective 20: Thermal issues (3.4.10)
- Objective 21: Lightning strike protection (3.4.11)
- Objective 22: Crashworthiness (3.4.12)

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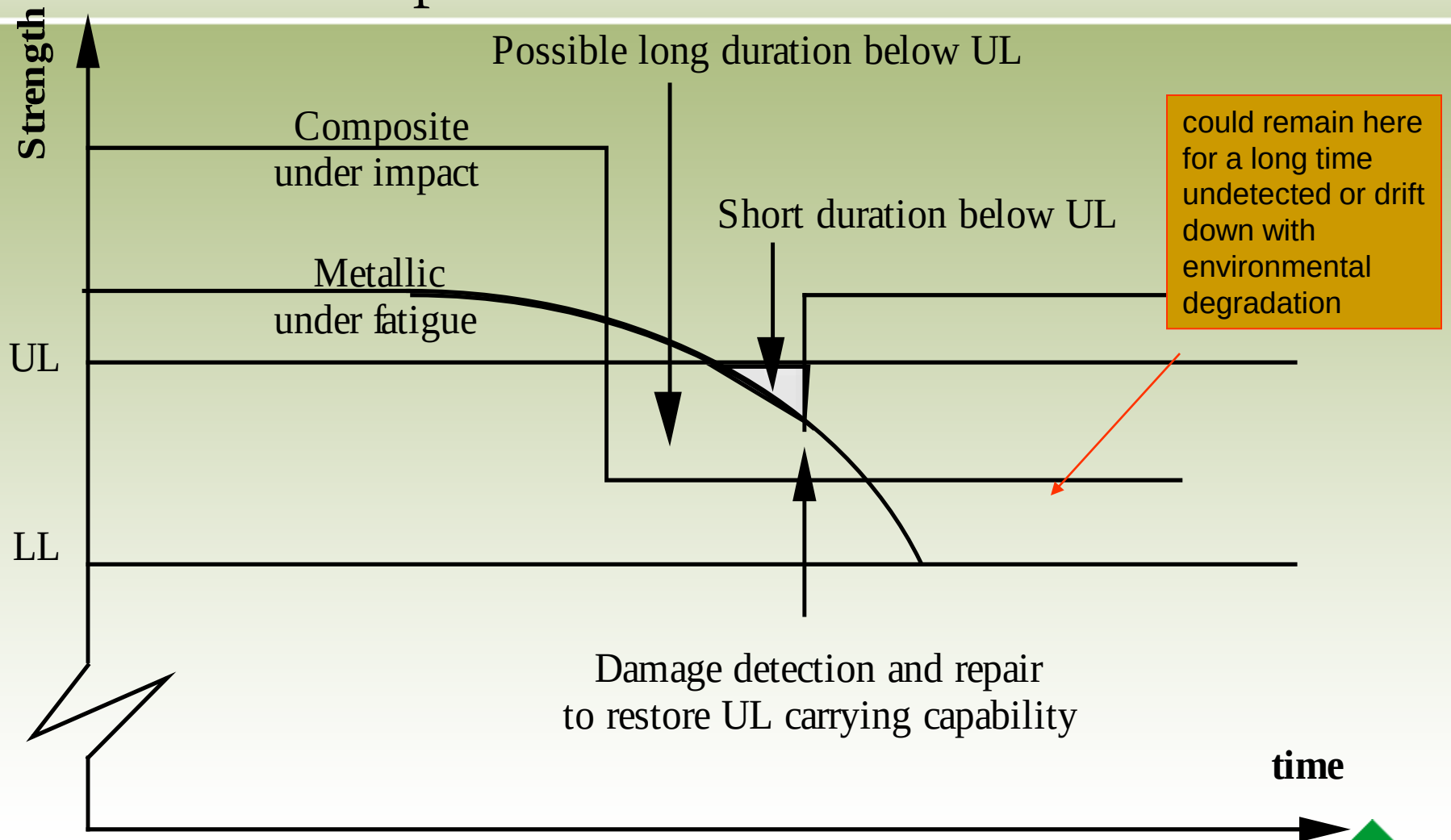
Damage tolerance
Composite vs. metallic behavior



Comparison of Composite Non-Growing Damage and Metal Fatigue Crack Damage (from CMH-17 Fig. 12.2.2.2(c))

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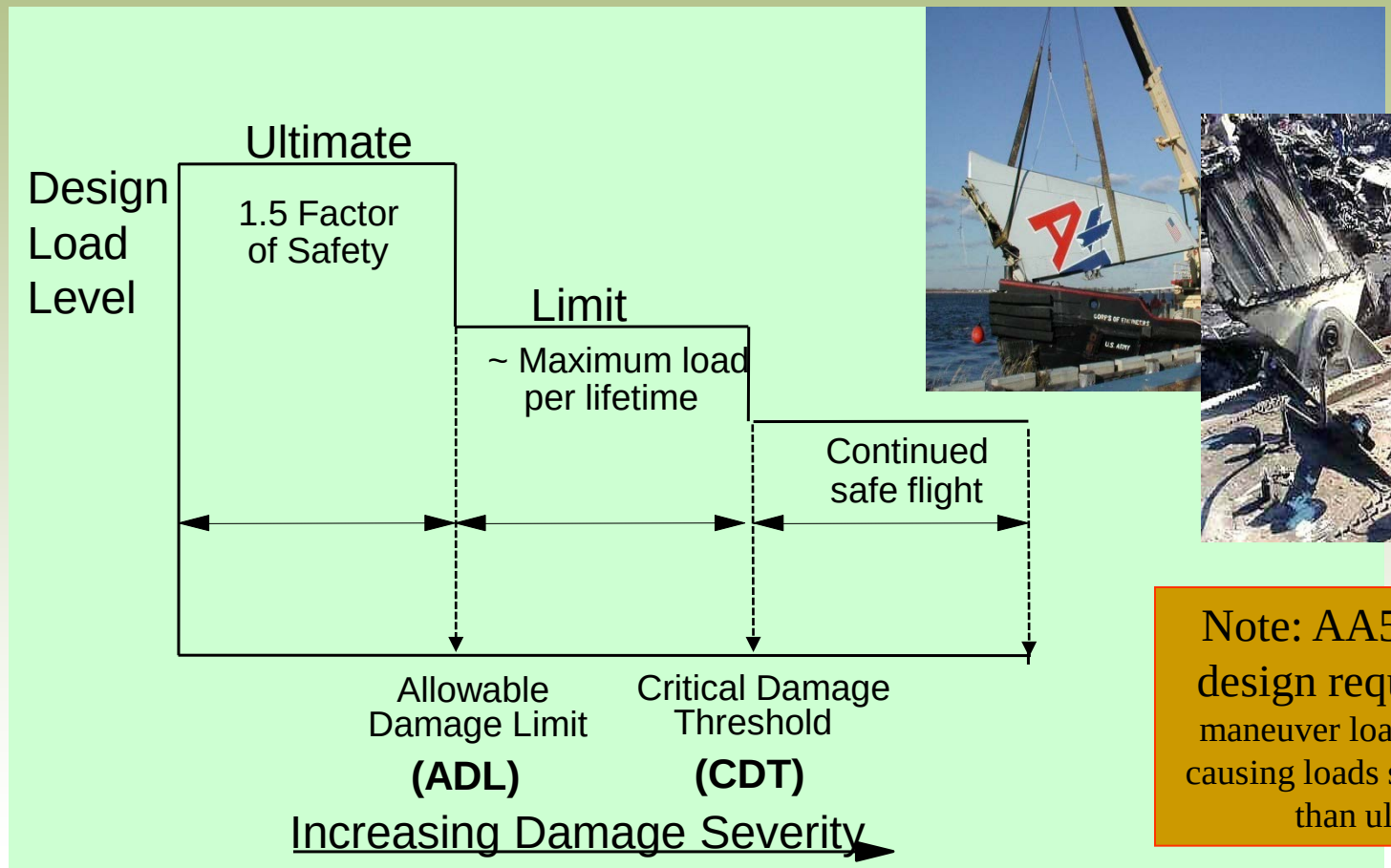
Load requirements
Overview

Minimum generic load requirements are (metallic and composites):



Note: AA587 outside the design requirements: (yaw maneuver load exceeded 25.351 causing loads significantly greater than ultimate load)

Damage types
Overview

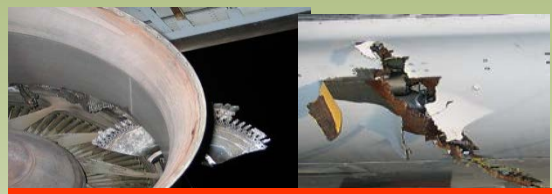
Define damage and defects – terminology to aid communication:

Category	Examples (not inclusive of all damage types)
Category 1: Allowable damage that may go undetected by scheduled or directed field inspection (or allowable mfg defects)	**Barely visible impact damage (BVID), scratches, gouges, minor environmental damage, and allowable mfg. defects that retain ultimate load for life**
Category 2: Damage detected by scheduled or directed field inspection @ specified intervals (repair scenario)	**VID (ranging small to large), deep gouges, mfg. defects/mistakes, major *local* heat or environmental degradation that retain limit load until found**
Category 3: Obvious damage detected within a few flights by operations focal (repair scenario)	**Damage obvious to operations in a "walk-around" inspection or due to loss of form/fit/function that must retain limit load until found by operations**
Category 4: Discrete source damage known by pilot to limit flight maneuvers (repair scenario)	**Damage in flight from events that are obvious to pilot (rotor burst, bird-strike, lightning, exploding gear tires, severe in-flight hail)**
Category 5: Severe damage created by anomalous ground or flight events (repair scenario)	**Damage occurring due to rare service events or to an extent beyond that considered in design, which must be reported by operations for immediate action**

Damage types: Categories 3 and 4

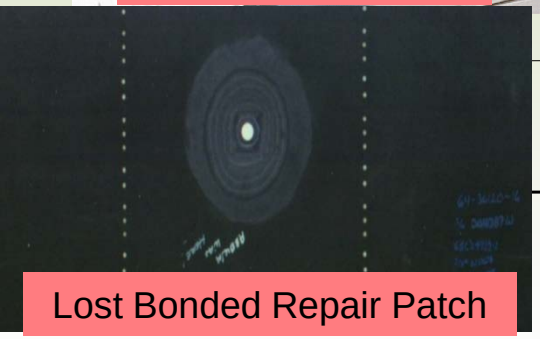
Category 4: Discrete source damage known by pilot to limit flight maneuvers (repair scenario)

Category 3: Obvious damage detected within a few flights by operations focal (repair scenario)

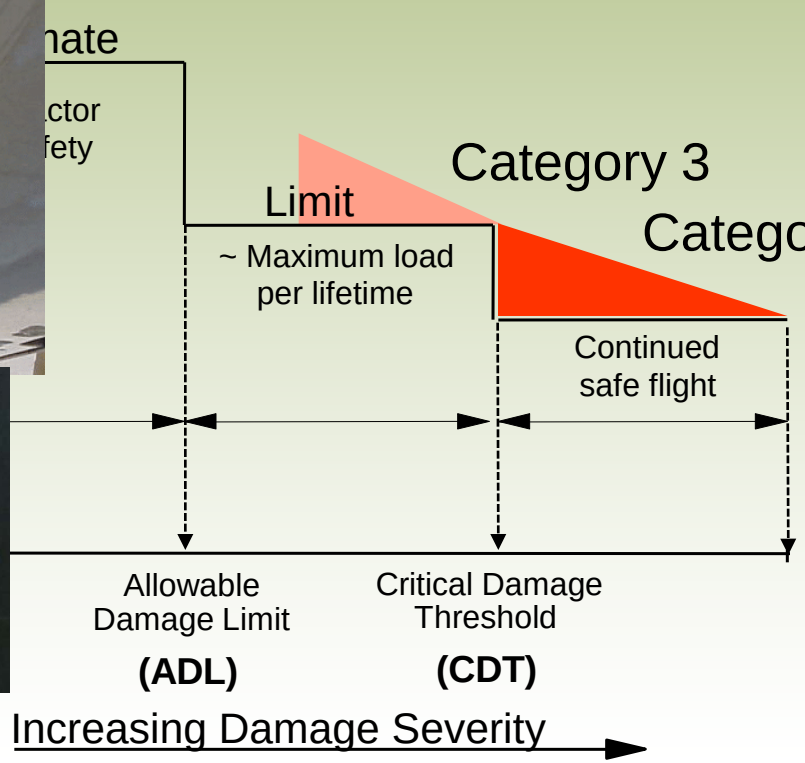


Disk Cut Through the Fuselage to Reach Opposite Engine

Accidental Damage to Lower Fuselage



Lost Bonded Repair Patch

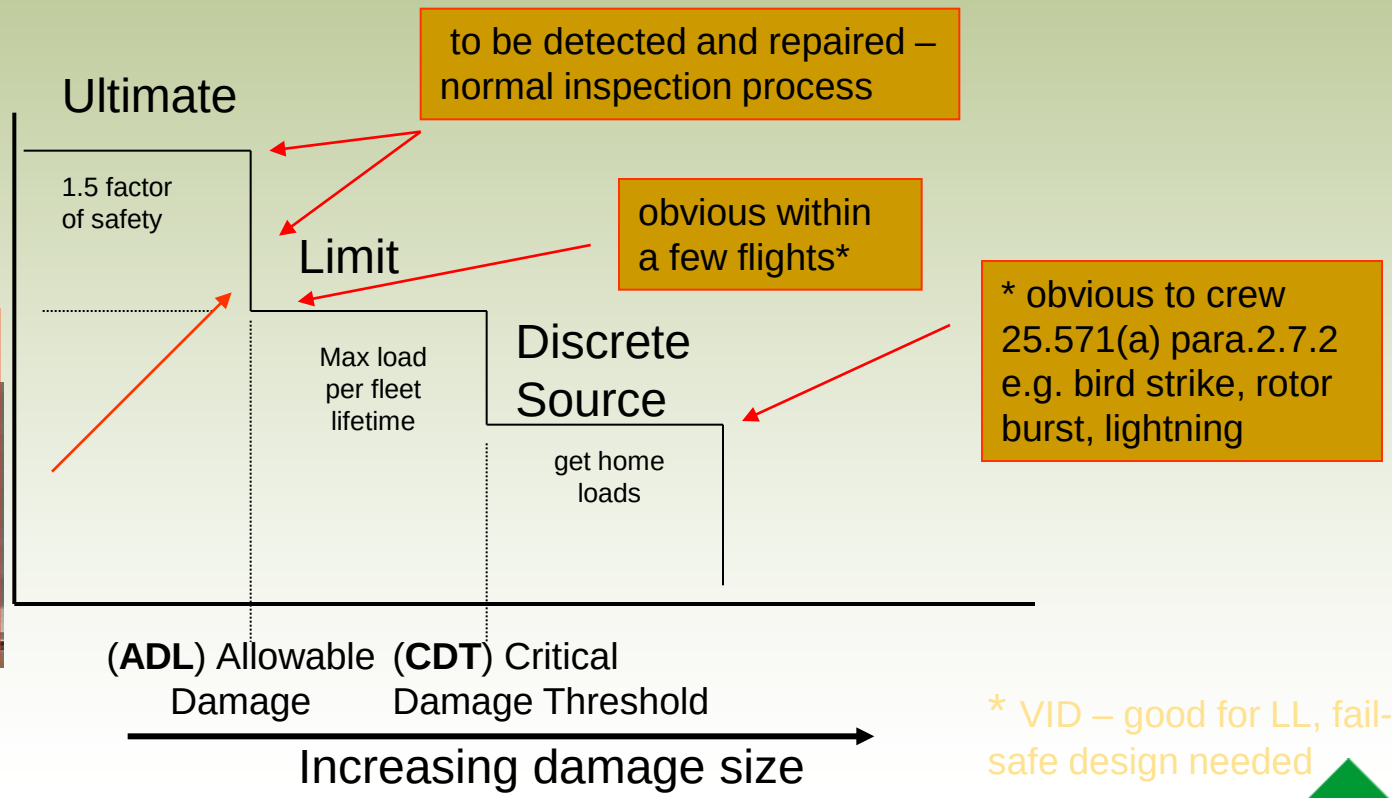


Severe Rudder Lightning Damage

Repair Overview

Australian Air Force survey (1992) - 42% of repairs where actions to replace previous failed bonded repairs!

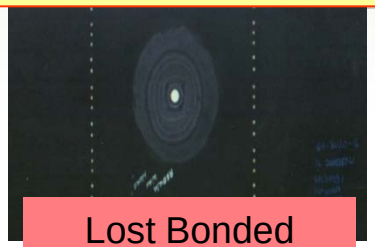
Design Load and Damage Considerations for Durability & Design – Bonded Repair (from CMH-17 Fig. 12.2.1(a))



Design Load

failed bonded repair should be detectable within a few flights and part maintain LL

– unable to detect weak and tight disbonds*



Lost Bonded Repair Patch

* VID – good for LL, fail-safe design needed

*ref. "Bonded Joints and Structures - Technical Issues and Certification Considerations" [PS-ACE100-2005-10038, September 2005]

MH17 MPOSITE MATERIALS HANDBOOK

Module 5: Production Essentials (Section 3.5)

- **Objective 23: Manufacturing substantiation**
- Objective 24: Critical elements regarding production implementation
- Objective 25: Manufacturing quality control
- Objective 26: Defect disposition requirements
- Objective 27: Modifications in the production process

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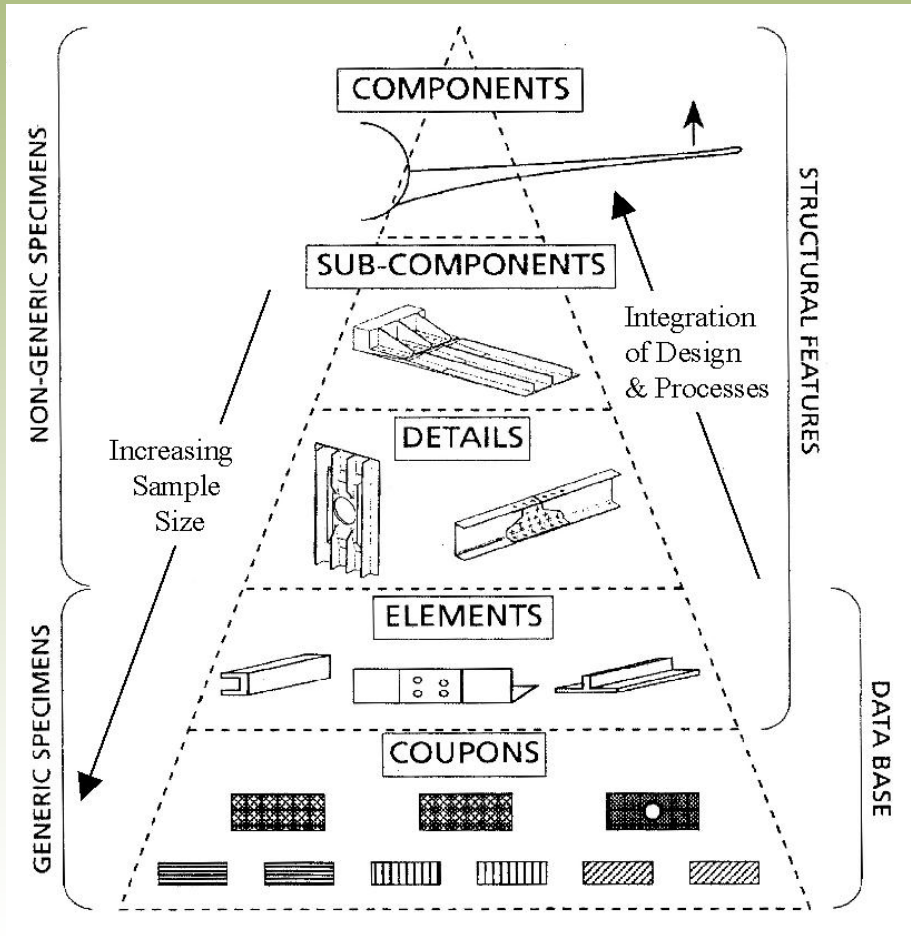
Manufacturing substantiation
Issues in production and type design substantiation

- Fabricate and assemble the certification test articles per design with specifications and processes *intended* for production
- Strive for manufacturing process maturity prior to large-scale tests
- Identify any process problems or bad design details

Manufacturing substantiation
Building block substantiation

- Protect large non-recurring costs for certification and production
- Risk mitigation for design-specific detail and complex internal loads
- *Establish material and process control*
- *Design and manufacturing integration*
- *Manufacturing process scaling*
- Analysis validation
- Study variability, environmental, and damage effects as part of structural substantiation



Module 5 (Objective 24)
Production implementation issues

- Identify key manufacturing steps
- Define manufacturing tolerances and any process limits, and sensitivities
- Develop test plans that substantiate manufacturing processes applied to production
- Develop test pyramids to best suit the material form and associated processes
- Maintain thorough manufacturing records of all products produced

Cirrus Factory

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Details of Production Implementation for Composite Aircraft Structures

Composite material and component manufacturing occur simultaneously (i.e., properties being built into the fabrication process requires stringent quality control)

- Production conformity to type design must be performed throughout the composite lay-up, cure and assembly process
  - Essential for large integrated composite structures with reduced part count, e.g., thick bonded structure may become inaccessible after initial bond assembly (787 below: The nose and front fuselage shown here are molded from a single piece)

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Module 5 (Objective 26)
Defect disposition requirements

- Often difficult to forecast prior to production
- Primary methods of avoiding defects:
  - Regular quality control to ensure ***consistent raw materials***
  - Close ***process control of manufacturing*** operations
  - ***Experience and related training*** for specific part details
- Defects, which may not be detected by factory inspections, should be included in structural substantiation for type certification
  - Additional databases are often needed with production experiences
- Composite design and maintenance practices rely on strict material and process quality controls, coupled with thorough factory NDI

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Module 6: Maintenance (Section 3.6)

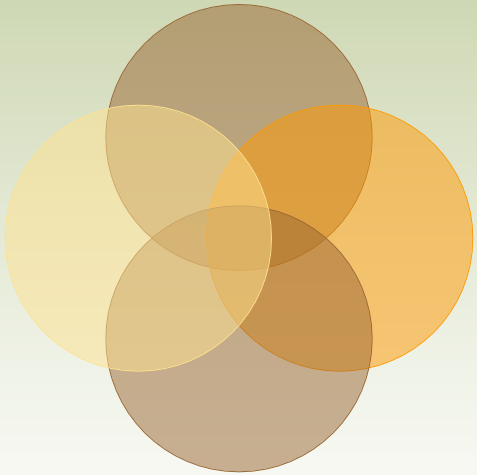
- **Objective 28: Continued airworthiness**
- Objective 29: Substantiated repair designs
- Objective 30: Importance of teamwork
- Objective 31 Damage detection and characterization
- Objective 32: Bonded and bolted repair processes
- Objective 33: Guidance and reports by regulatory bodies

Team success depends on skills and information of the participants

Detection and disposition of damage

OEM damage tolerance substantiation forms the basis for detection and disposition of damaged parts

Detection of damage



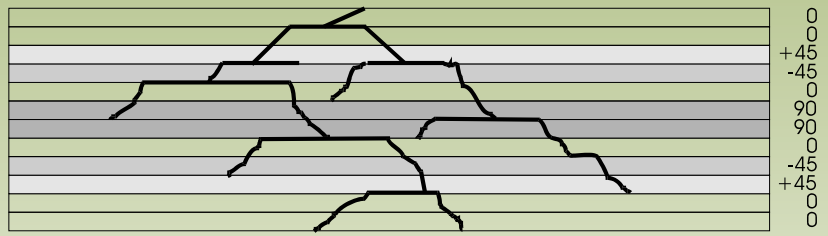
Mapping of damage

Complete damage characterization

Component records and source documentation consultation for ADL and RDL

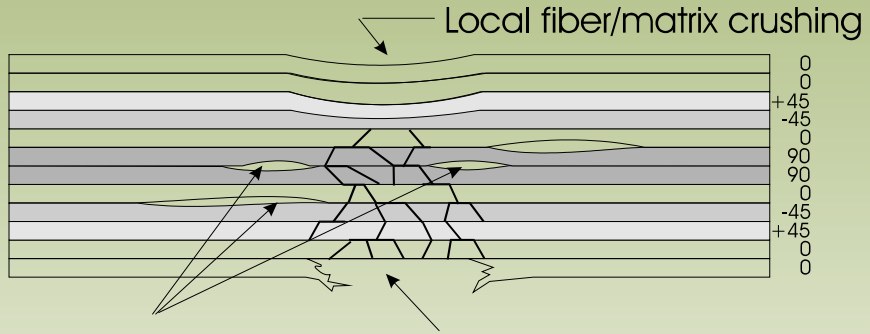
Damage Types

Low Energy Impact

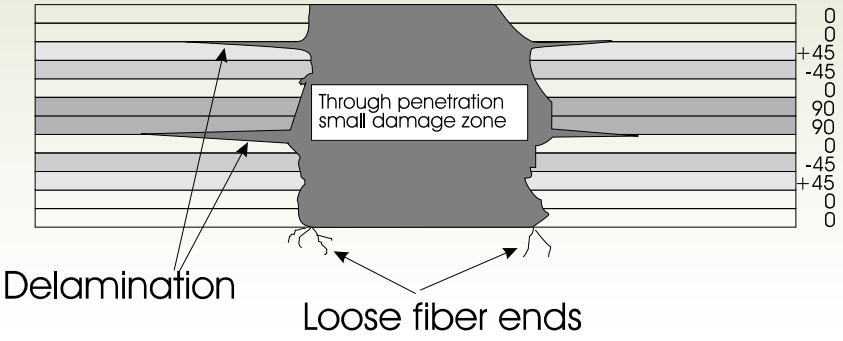


Pyramid Pattern Matrix Crack from impact.

Medium Energy Impact



High Energy Impact



Selecting bonded or bolted repairs

Bonded repairs:

- Provide effective load transfer - Capable of restoring the original strength of the damaged part
- More efficient for thin laminates (< 2 mm) – less weight
- Requires increased technician skills due to the greater degree of complexity

Bolted repairs

- More efficient for thick laminates – less material removal from undamaged sections
- More easily inspected for structural integrity than are bonded repairs
- Bolted repairs do not require the same strict bond surface preparation and controls necessary for bonded repair

Module 6 (Objective 33)
Regulatory reports and guidance

- FAA Regulatory and Guidance Library: http://www.airweb.faa.gov
- FAA Technical Reference and Research Library: http://actlibrary.tc.faa.gov
- EASA: http://www.easa.europa.eu
- TCCA: http://www.tc.gc.ca/air/
- SAE AIR Report: http://www.sae.org

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CMH-17: V3C3 Tutorial
Current Update Plan & Effort

- CMH-17 V3C3 Tutorial
  - Update content reflecting regulatory changes
  - Add content reflecting recent safety guidance
  - Include value-added data from CSET/CMfgT/CMT
  - Update content reflecting lessons learned
  - Elevate presentation matching V3C3 Rev H

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- **Thanks for Opportunity.**
- **Questions and/or Thoughts?**
- **Further Discussion.**

We Meet Tomorrow (9 AM)
“AC 20-107B”