European Aviation Safety Agency

Composite Structure
'Re-manufacturing'

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‘Re-manufacture’

Objective: this brief presentation is intended to start dialogue regarding how industry and the regulators manage ‘re-manufacturing’ in the ‘real world’:

Background:

- increasing use of composite in exposed Primary/PSE structure applications

Caution! - even fairings need further consideration due to increasing size
(impact with downstream Primary/PSE structure, loss of aerodynamic control, flutter etc)

Note: loss to bird strike – not repair – but could be equivalent to repair failure

- Operators/MROs are looking for more extensive composite repair capability

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Commercial Pressure: we are all aware of…

- ‘real world’ damage beyond repair limits occurs
- operators are time limited (lost service/stand time often the cost driver)
- limited spare availability
- lease costs high
- remanufacture could be quicker than a repair (drying time etc)
- repair may destroy the part (temporary or permanent)

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…tempting to build a new part – ‘re-manufacture’ when:

- repair limits exceeded

- multiple repairs
(particularly when close together)

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History: - ‘re-manufacture’ has been used by operators and MROs for

- secondary structure
- relatively simple field area Primary structure
(e.g. fairings, floor panels, radomes)

- often without adequate OEM support
- we may have been lucky not to see problems due to:
  - majority of applications having been minor
  - over design of parts (due to uncertainty or production needs)

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OEMs:

OEMs provide ADLs and Repair Limits for a good reason –

- Repair (bonded in particular) probably sized for LL if it fails - unless otherwise informed (such a repair loss should be obvious very quickly)

- the OEM should have accounted for the limitations of the repair environment when sizing (operator/MRO production level statistically credible process control unlikely)

-limited confidence in NDI finding weak and kissing bonds*

*“Bonded Joints and Structures - Technical Issues and Certification Considerations”

[PS-ACE100-2005-10038, September 2005]

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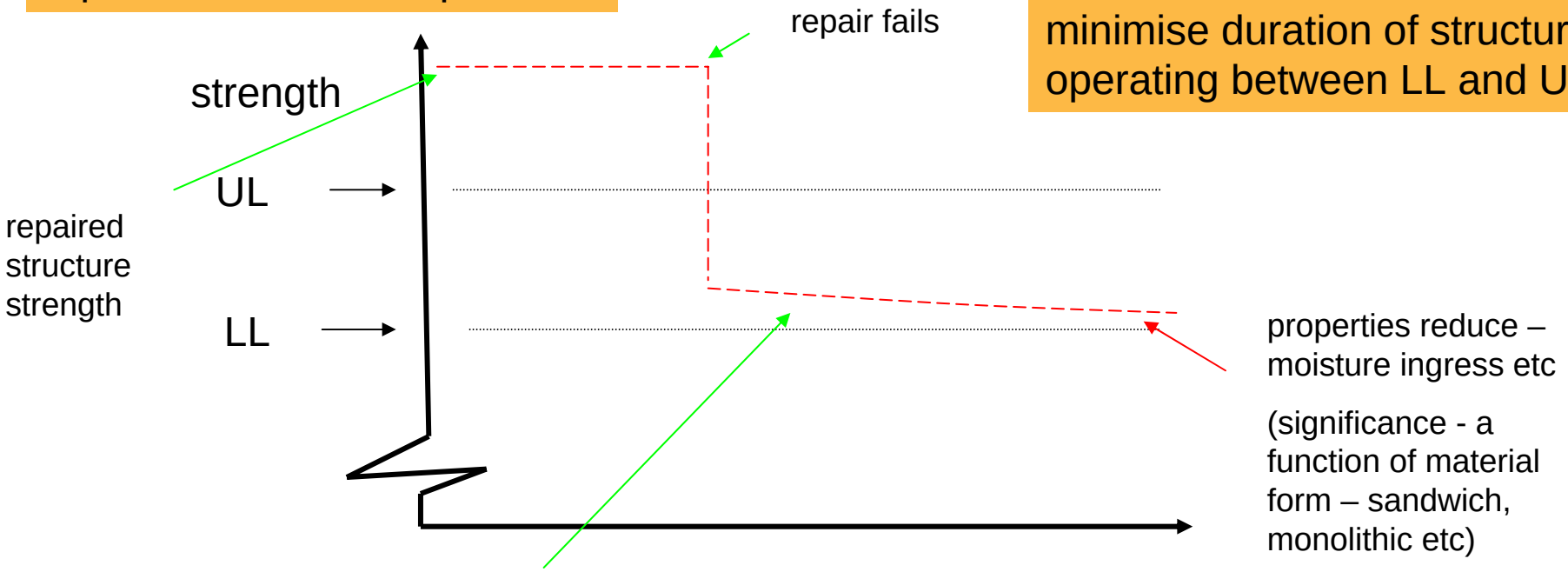
repair sizing based upon production part standards and repair environment repair

Repair Limits

the closer to repair size is to the repair limit, the more obvious its loss should be to minimise duration of structure operating between LL and UL



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OEMs:

- often only part of the structure identified as Primary/PSE Structure in SRMs is critical. However, the OEM needs to give a broader definition to ensure:

- visibility of events
(encourage Operator/MRO communication with OEM)

- provide a safety margin

- keep SRM to manageable proportions (operator tech. services often fill gap between SRM data points, but do not extend size of repairs)

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Operators/MROs:

Operator/MRO* is unlikely to know (without OEM data):

- which parts of the Primary/PSE structure are critical
(Minimum Margin Locations, Load Cases, Failure Modes)

- without knowledge of the failure modes, locations, etc one can only guess at the appropriate validating tests necessary (tension, shear, compression, peel etc)

- part substantiation test pyramid
(coupons, elements, sub-components etc – higher levels important)

- part F&DT test sequence

* MRO possibly less likely to get OEM data – not direct customer. However, also note that EASA PART M requires communication of data from Operator to maintenance/repair organisation

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Operators/MROs:

- even when OEM specifications and drawings are available:

  - Operator/MRO usually does not complete all the tests identified in the specifications - particularly fatigue/ environmental testing (time consuming and expensive)

  - usually does not include complete production process information

  (e.g. AC21-26, tooling, sequence information etc. note: AC145-6 is concerned with a repair process not a production process and is still bounded by need for OEM design data)

- testing unlikely to be to a statistically credible level within an established process (probably not at production level)

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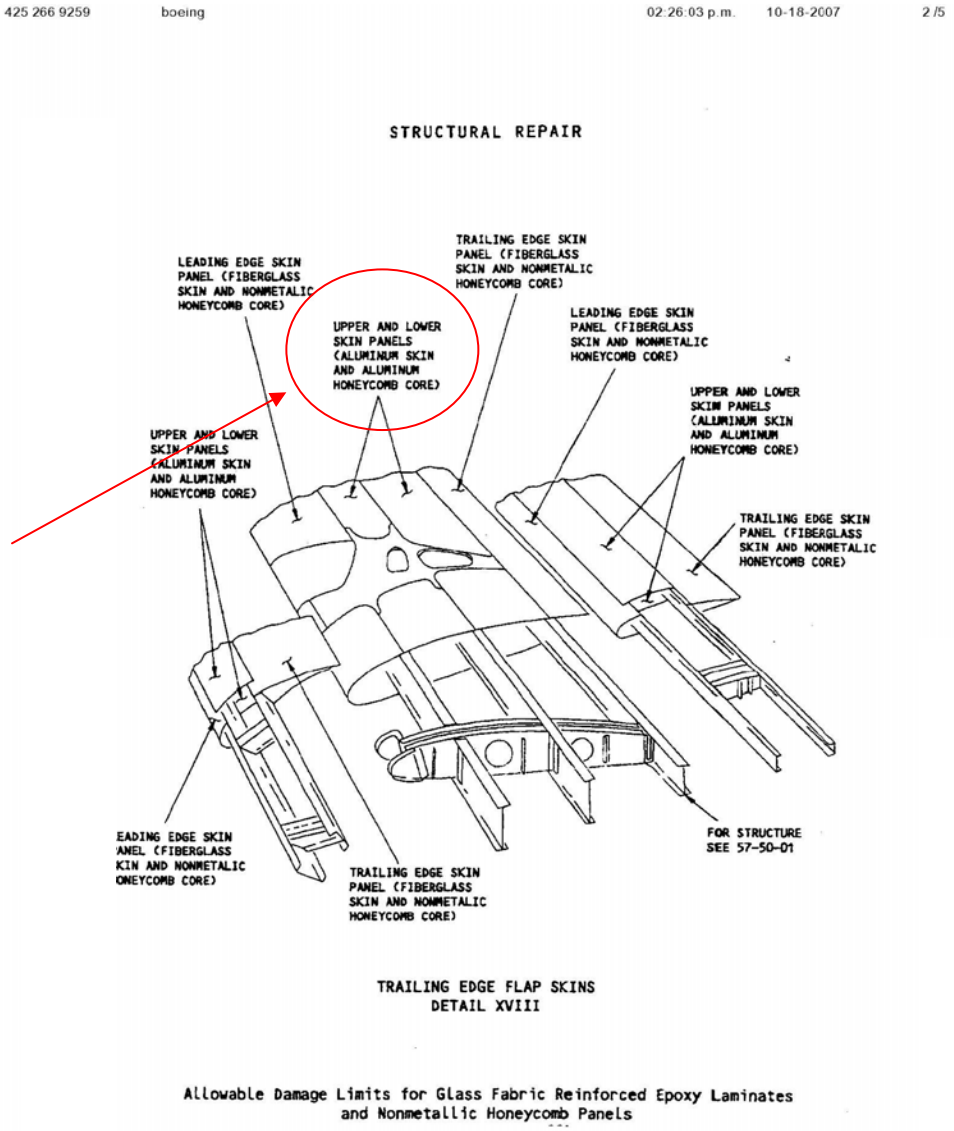
Recent Example :B747 Outboard Mid-Flap Upper Spar Box Skin (one of many)

Structure: Metallic Skin, with Honeycomb core stiffening between rib and spar, skin mechanically fastened to rib and spar structure (a non-metallic structure would increase the number of variables - and concern)

Process: 2 stage cure bonded structure



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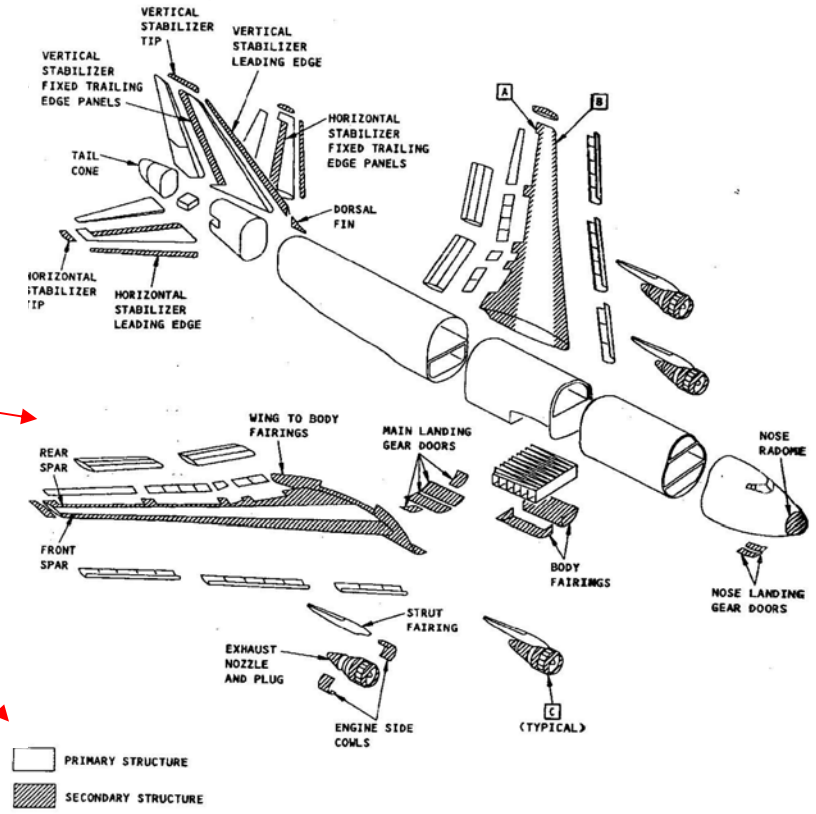
Primary



Structural Classification Diagram

Structure clearly identified as both Primary and PSE* in SRM

* identified as PSE in Fig.3 table 1

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SRM Repair Limits:

Flaps – Al Honeycomb

25% area

7 in. separation edge to edge

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STRUCTURAL REPAIR

REPAIRABLE DAMAGE FOR ONE PANEL ONLY

		ITEM SEE FIGURE 1 FOR LOCATION	MAXIMUM SIZE (% OF PANEL AREA)	MINIMUM SPACING (EDGE TO EDGE OF DAMAGE AREAS)
1		LANDING GEAR WING DOOR	25 PERCENT	7.0 INCHES
2		WING INTERSPAR OUTBD OF WS 1543.2	15 PERCENT	
3		TRAILING EDGE FLAPS	25 PERCENT	12.0 INCHES
4		SPOILERS		
5		VERTICAL STABILIZER TORQUE BOX		
6		VERTICAL STABILIZER TRAILING EDGE		
7		HORIZONTAL STABILIZER TRAILING EDGE		
8	JT9D-3, JT9D-7, JT9D-7Q, JT9D-7R4	INLET COWL, OUTER SKIN	20 PERCENT	6.0 INCHES
9		INLET COWL BY-PASS DOORS		
10		THRUST REVERSER FAN SLEEVE	SEE 54-00-02	
11		BLOCKER DOORS		
12		FAN COWL	20 PERCENT	6.0 INCHES
13		PYLON TRAILING EDGE	25 PERCENT	3.0 INCHES
14		FAN THRUST REVERSER DIAPHRAGM	SEE 54-00-02	
15		FIXED LIP NOSE COWL ALL ALUMINUM INNER ACOUSTIC PANELS		
8	GE CF6	NOSE COWL OUTER SKIN	20 PERCENT	6.0 INCHES
12		FAN COWL		
13		PYLON TRAILING EDGE	25 PERCENT	3.0 INCHES
13	JT9D-70	PYLON TRAILING EDGE	25 PERCENT	3.0 INCHES
13	ROLLS-ROYCE RB 211-524	PYLON TRAILING EDGE		

Repairable Damage for Aluminum Honeycomb Structures

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Organisation: - Part 145 (no POA - Production Organisation Approval)

- Part 21 Subpart J (DOA – Design Organisation Approval)

- Scope of Approval: ‘Minor Repair’

Repair:

Repair Classification: ‘Minor’ (not a Repair, cannot be assumed to be ‘Minor’)

Data Available: Part Drawings, Material Specifications. (no OEM Approval)

Local Testing: peel tests (separate test panel – not off-cut)

Observation: - quality of repair work looks good

- mechanical fastening exists between skin, ribs, and spars

(nature of honeycomb stiffened structure suggests flutter and/or deformation could be critical – but this is unknown)

- if this particular case could be justified, what precedent is being set?

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Summary:

- damage beyond limits is a ‘real world’ problem

- operational pressure is a ‘real world’ problem

-‘re-manufacture’ could be a safer option than extended repair, but only when correctly supported and approved

- component airworthiness is based upon production standards and repair based upon repair standards – not production based upon repair standards!

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Summary:

- any attempt to repair or ‘re-manufacture’ PSE/Primary Structure outside published data limits must directly involve the OEM (unless fully substantiated with regulator agreement)

- Operators/MROs need to understand the terms of their approvals (if in doubt ask!)

- OEMs may need to expand the published scope of what can be repaired
(e.g. to identify in more detail the more critical parts of the Primary /PSE structure)

- Operators/MROs, OEMs, and Regulators need to work together for a safe and economic way to prevent problems developing

QUESTIONS?