



EASA

European Aviation Safety Agency

Product Certification and Design Organisation Approval Workshop

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TE.GEN.00409-001



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Repair Design: An Overview

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Regulatory references for repairs (not exhaustive)

- Part 21, Subpart M dedicated to “REPAIRS”
- For aircraft:
 - Part 26: paragraphs 26.320, 26.330, 26.360 (see opinion 12-2016)
 - AMC 20-20 “Continuing Structural Integrity Programme”
 - CS-25: in particular 25.305/25.307 (static strength), 25.571 (fatigue and damage tolerance)
- For engines:
 - CS-E: in particular E 70 (materials), E 90 (corrosion), E 100 (strength), E 110 (drawing, marking)



Definition (cont'd)

What is a repair? (21.A.431, 21.A.433)

- It is the elimination of damage and/or restoration to an airworthy condition **following initial release into service** by the manufacturer of any product, part or appliance.
- Elimination of a damage by replacement without design activity is maintenance and does not require an approval under Part 21
- The applicant shall demonstrate compliance with the type-certification basis

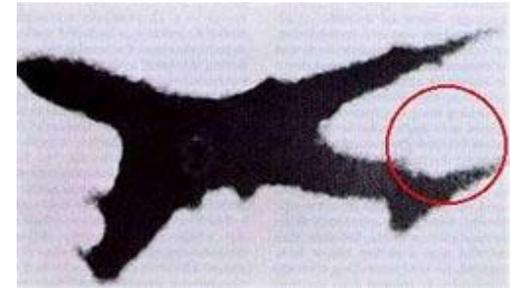


How critical can repairs be?

- Improper repairs can lead to the loss of the aircraft
- See next slides for some examples....

JAL B747 accident 1985

- ▶ Improper repair on the aft fuselage bulkhead 7 years before
- ▶ Failure of the bulkhead lead to loss of the tailfin and hydraulic power
- ▶ Lead to 520 death and 4 survivors
- ▶ Deadliest single aircrafts accident in history

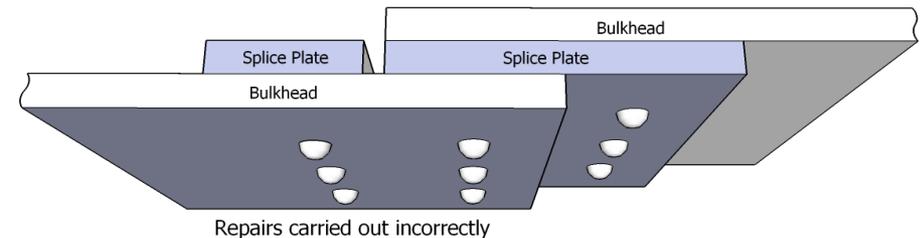
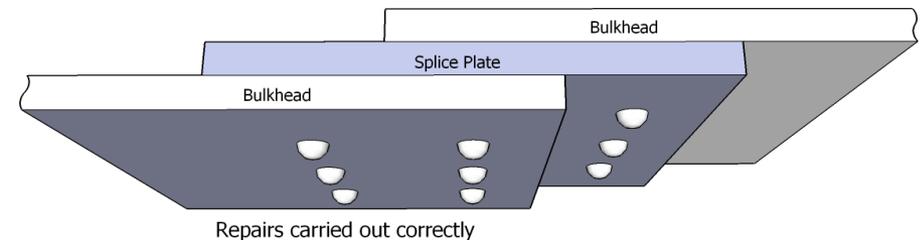


www.youtube.com/watch?v=QKENZWQKkz0



JAL B747 accident 1985

- Failure of the bulkhead lead to loss of the tailfin and hydraulic power
- Improper repair on the aft fuselage bulkhead
- By this only one rivet row carries the loads
- Incorrect repair had a calculated lifetime of only 10000 flights
- Failure was 12319 flights after repair



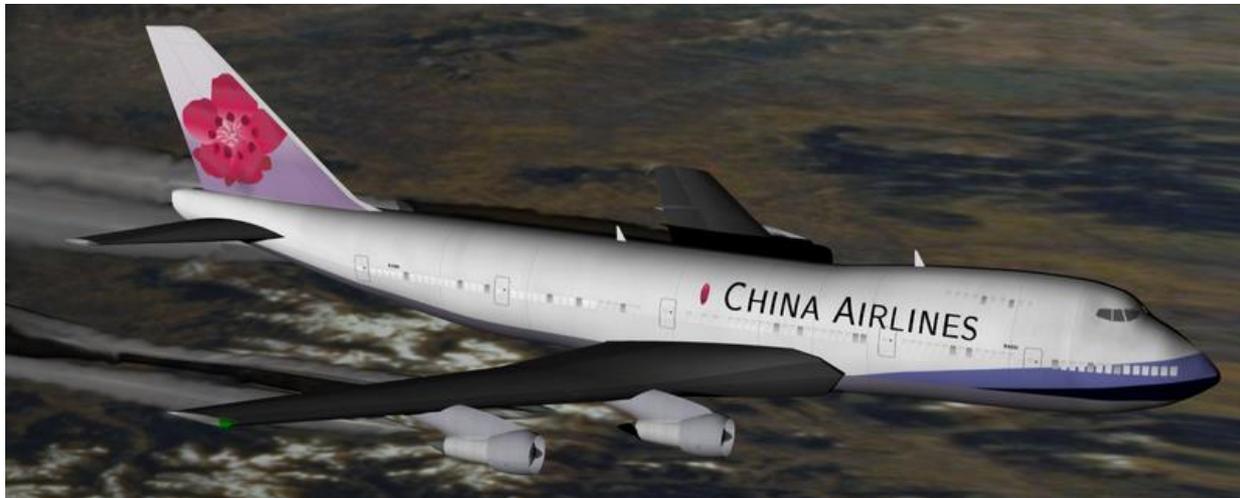


Definition (cont'd)

China Airlines B747 accident 2002

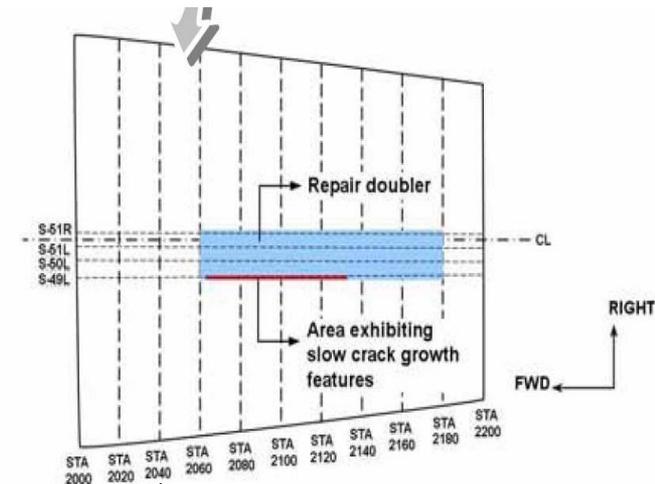
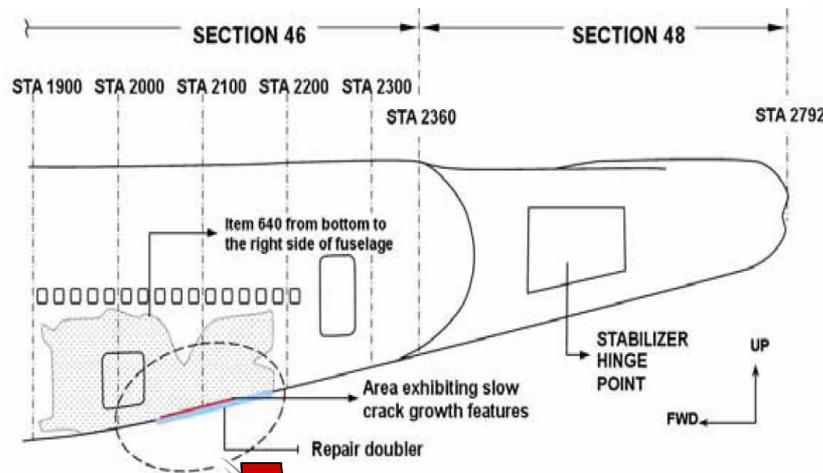
- Again improper repair after tail strike during landing 22 years before
- The accident killed all 225 people on board

www.youtube.com/watch?v=omOljl6ZecE

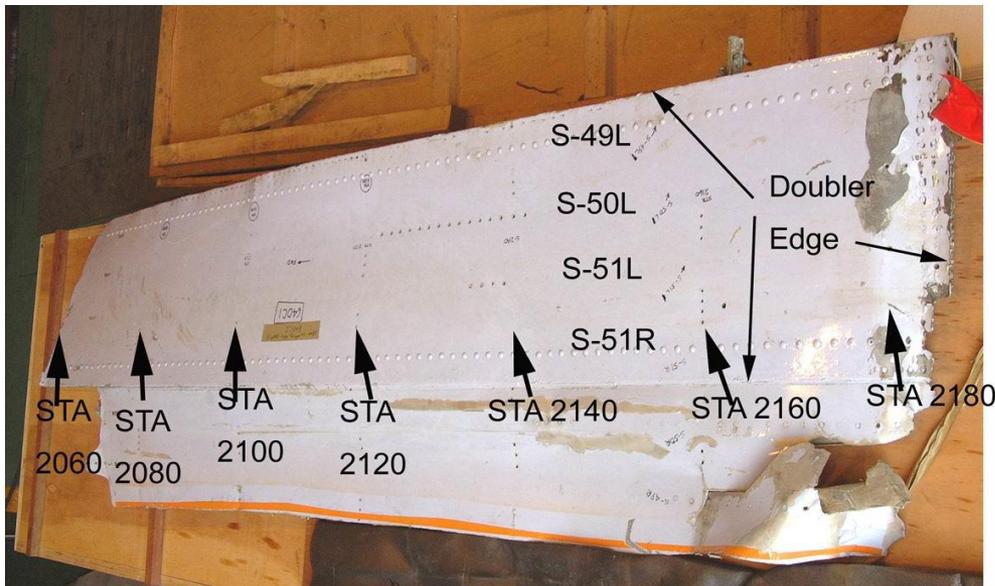


China Airlines B747 accident 2002

- Doubler was applied barely covering the damaged skin area (dents and scratches)
- Cracks developed in the skin underneath the doubler and resulted in loss of the tail section in flight



China Airlines B747 accident 2002





Classification: Minor/Major

Classification of repairs (21.A.435 & GM 21.A.435(a))

- Similar to Changes
- **Major:**
 - Appreciable effect on structural performance, weight, balance, systems, operational characteristics
 - Extensive static, fatigue and damage tolerance strength justification and/or testing, or needs methods, techniques or practices that are unusual
- **Minor:**
 - The effect is known to be without appreciable consequence

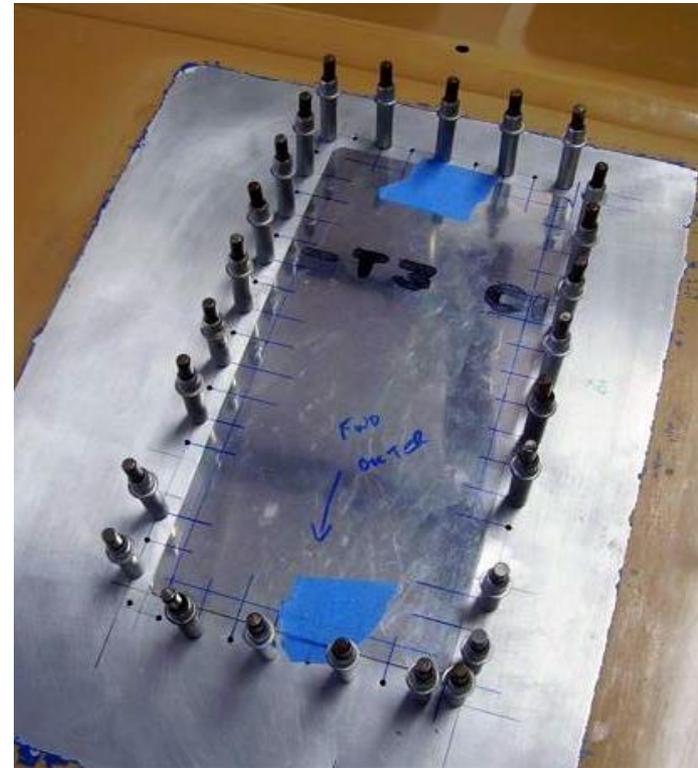
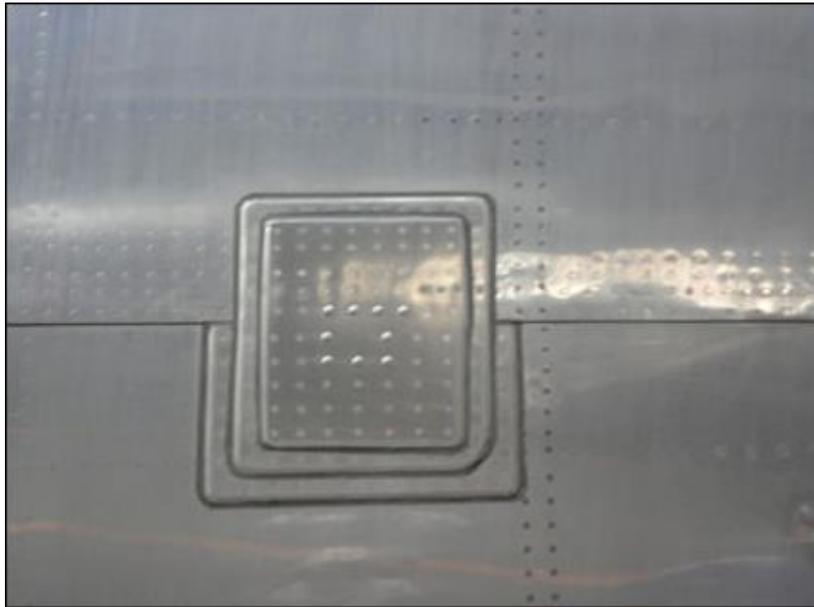


Examples of major repairs

- A repair that requires a **permanent additional inspection to the approved maintenance programme**, necessary to ensure the continued airworthiness of the product.
- A repair **to life limited or critical parts**.
- A repair that introduces a change to the **Aircraft Flight Manual**.



Examples of major metallic structure repairs





Classification of repairs : specific cases

- **Temporary repairs (21.A.443):** life limited repair replaced by a permanent (final) repair after a limited service period
- **Unrepaired damage (21.A.445):** If a damage is left unrepaired and not covered by previously approved data, the evaluation for its airworthiness shall be done by
 - EASA
 - Appropriately approved DOA
 - If it is not the TC or STC holder, the organization shall justify all information for the evaluation is coming either from own resources or from (S)TC holder.

How is a repair approved? (Part 21.A.437)

- For major repairs:
 - By EASA, or,
 - By an approved organization (DOA), being the TC, STC or APU ETSO approval holder, with the appropriate privilege
- For minor repairs by a DOA, with the appropriate privilege, or by EASA
- For unrepaired damage that is not covered by previously approved data, EASA or a DOA can evaluate the consequences for the airworthiness
- Refer to the applicable TIP with FAA (USA) and TCCA (Canada) for the reciprocal acceptance of approved repairs



Approval (cont'd)

What must be considered? (AMC 21.A.433 (a))

- Damage identification
- Structural performance including static strength, fatigue, damage tolerance, flutter and stiffness characteristics
- Weight and Balance
- Changes to load path
- Repairs to engine or APU critical parts would normally only be accepted with the involvement of the TC holder

Read the AMC 21.A.433 (a)

Manufacturing of repairs (Part 21.A.439)

- ▶ A repair can be manufactured by a
 - ▶ production organization (Part 21 Subpart F or G)
 - ▶ maintenance organization

- ▶ Always in accordance with the approved design data



Embodiment of a repair (Part 21.A.441)

- Shall be done by an approved maintenance or production organization
- The DOA should provide all necessary installation instructions
- Appropriate markings must be specified in the repair instructions (21.A.451)



What is the aircraft Structural Repair Manual (SRM)?

- The SRM is considered an approved document, and is identified as such in the TIP
- It publishes a collection of approved repairs:
 - descriptive information, instructions and specific data relative to structural repairs
 - damage acceptability criteria
 - the identification of structure materials and repair data applicable to the structural elements that are the most exposed to damage
 - information on the standard repair procedures



Typical certification issue:

- ▶ For non TC Holder, assumptions made by the TC holder are not accessible. Evaluation developed by comparison/similarity with existing repairs (SRM) does not always produce consistent justifications



Typical certification issue

Major Repair vs STC Application:

- ▶ a **major repair** is going to be performed, when the original design has to be recovered after an **accidental damage** (may also result in a design change, see also GM 21A.435(a) Classification of repairs)!
- ▶ a **major STC** application is going to be launched, when the **design** is being **changed on purpose**.
- ▶ Please don't smear those two applications!



Ageing Aircraft / EASA Part 26

Ageing Aircraft / EASA Part 26 (ref. opinion 12-2016)

Background: in the past not all repairs have been properly designed or certified in accordance with damage tolerance principles

- ▶ Part 26.320 and 26.330 require design approval holders to retro-actively review all published repairs (SRM, SB) and establish repair evaluation guidelines (TCH only), to allow operators to examine their existing repairs, for large aircraft with >30 pax and > 7500 lbs payload
- ▶ Part 26.360 ensures all future repairs are damage tolerant. A 3-stage approval process is allowed



Ageing Aircraft / EASA Part 26 (cont'd)

Ageing Aircraft : EASA Part 26 (ref. opinion 12-2016)

3-stage approval process (see AMC 20-20 appendix 3, annex 1)

Stage 1 : at initial approval Static strength compliance demonstration

Stage 2 : within 12 months following initial approval (extension can be granted if justified)

- Approval of Fatigue and damage tolerance evaluation to determine **inspection threshold**

Stage 3: before the threshold of stage 2 is reached approval of Fatigue and damage tolerance evaluation to determine **inspection interval and method**



Composite Repairs

Examples of Composite repairs

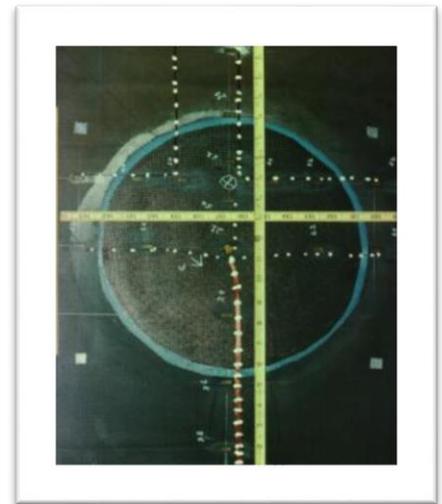
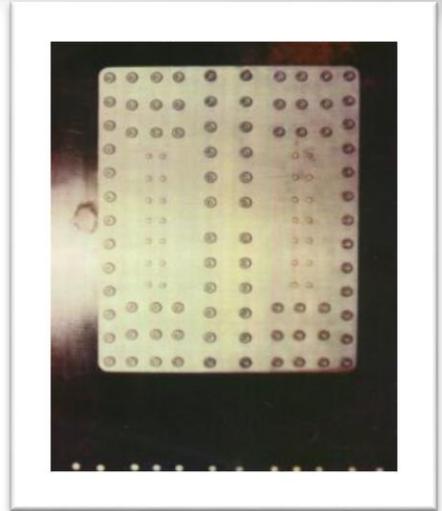
➤ Bolted

- Gives reproducible strength
- Maintenance facilities are familiar with this technique

➤ Bonded*

- Strength of bond is not testable (Weak Bond, Tight Disbonds)
- Aircraft has to withstand Limit Loads with failed repair
- Failed repair must be readily detectable

* AMC 20-29 / AC20-107B





Composite Repairs (cont'd)

Difficulties with Composite repairs

- Considerable property variation when performed in a maintenance environment
- Repair Organization is unlikely to know all details and assumptions of original part substantiation concerning e.g.
 - repair limits
 - Fatigue & Damage Tolerance (F&DT)
 - Flutter
 - test pyramid substantiation
 - minimum margins
 - critical load cases and locations
 - dominant failure modes



Bonded Repair Size Limits Policy – Harmonised Policy:

- ▶ EASA Certification Memo (CM): EASA CM No.: CM-S-005 Issue 01,11 September 2015 'Bonded Repair Size Limits in accordance with CS-23, CS-25, CS-27, CS-29 and AMC 20-29'

https://www.easa.europa.eu/system/files/dfu/final%20CM-S-05%20Issue%2001_Bonded%20Repair%20Size%20Limits_PUBL.pdf

- ▶ FAA Policy Statement (PS):PS-AIR-20-130-01 'Bonded Repair Size Limits'

[http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgPolicy.nsf/0/d215fb13ddad00dc86257e150055d038/\\$FILE/PS-AIR-20-130-01.pdf](http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgPolicy.nsf/0/d215fb13ddad00dc86257e150055d038/$FILE/PS-AIR-20-130-01.pdf)



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Questions?



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