



# EASA

European Aviation Safety Agency

# Product Certification and Design Organisation Approval Workshop

## 22<sup>nd</sup> – 23<sup>rd</sup> November 2017

**Your safety is our mission.**

An agency of the European Union 

TE.GEN.00409-001



**EASA**  
European Aviation Safety Agency

# 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



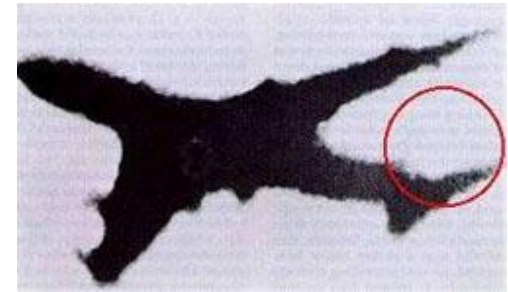
## How critical can repairs be?

- 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

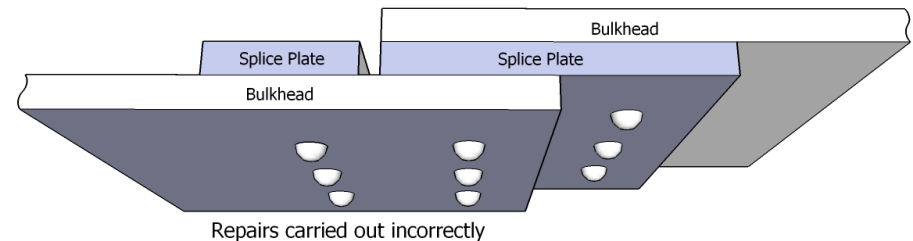
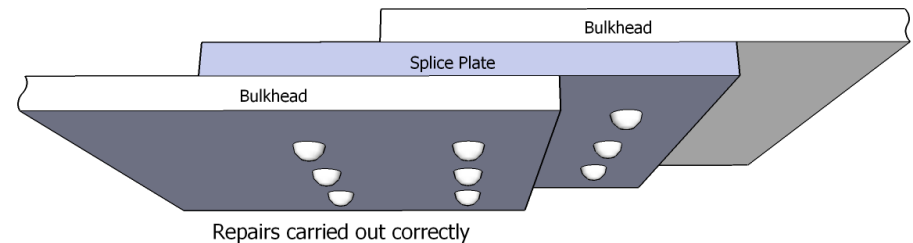


[www.youtube.com/watch?v=QKENZWQKkz0](http://www.youtube.com/watch?v=QKENZWQKkz0)



## 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







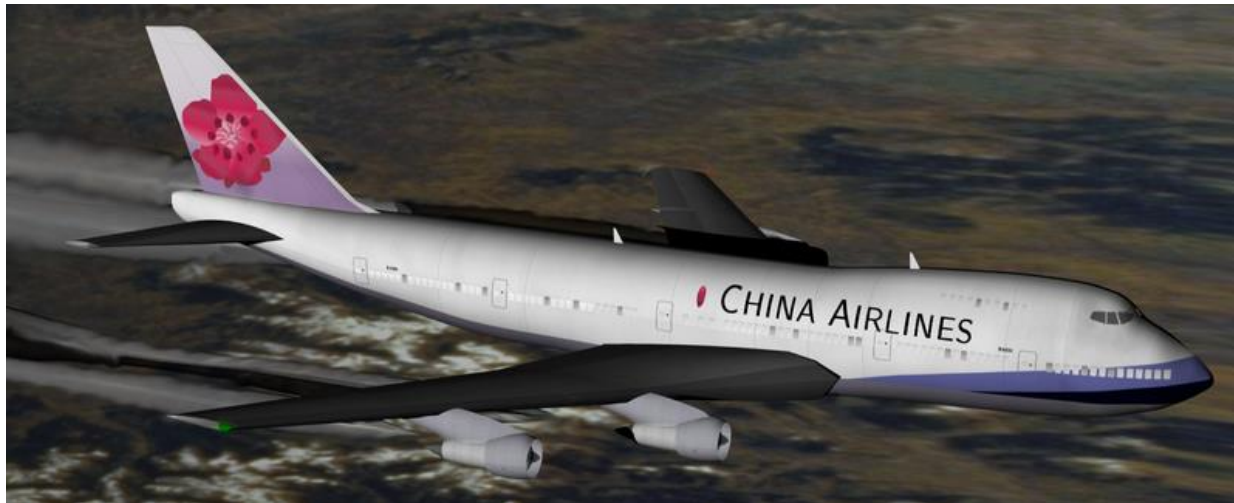
# Definition (cont'd)

## 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](http://www.youtube.com/watch?v=omOljl6ZecE)

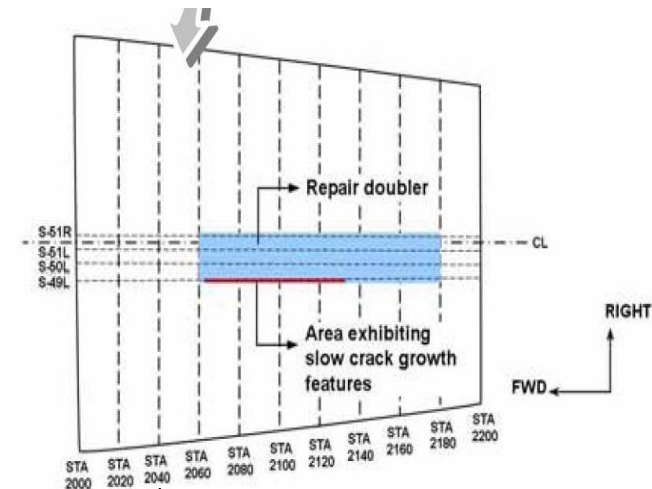
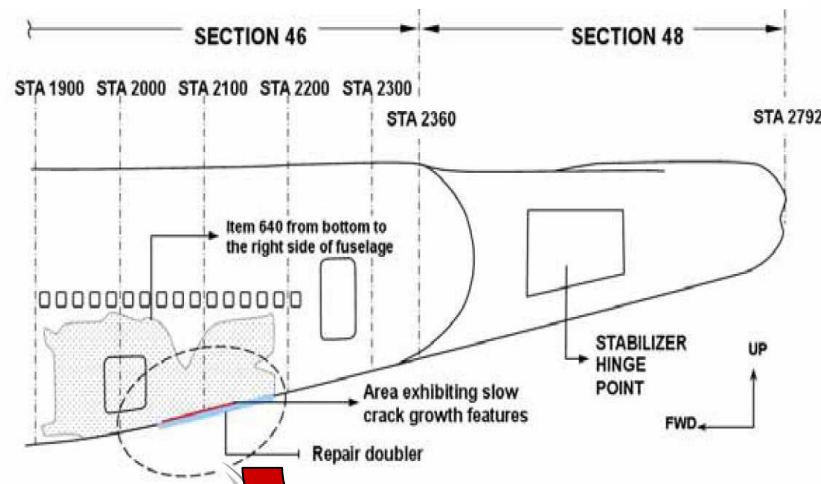




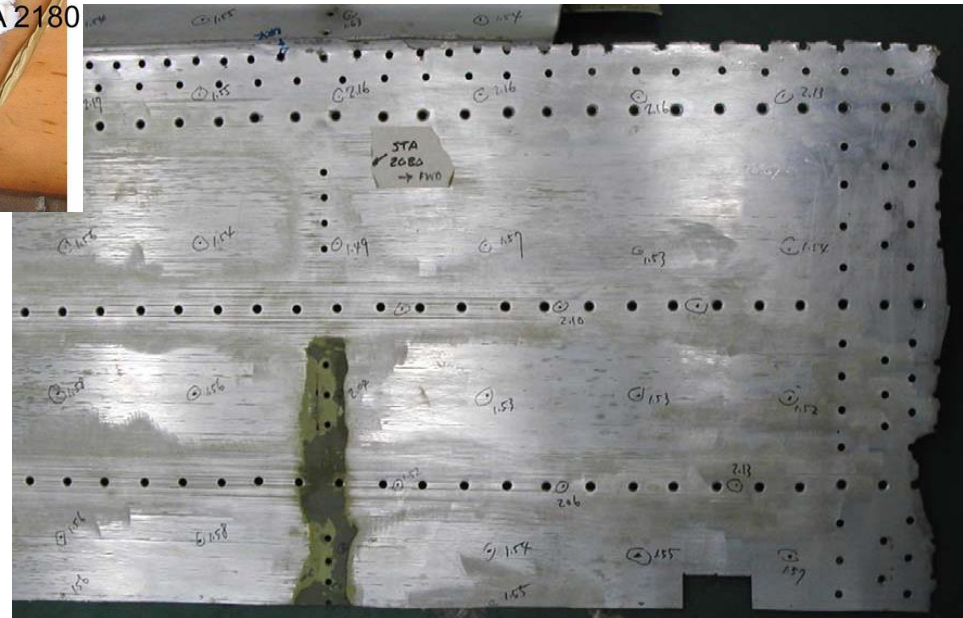
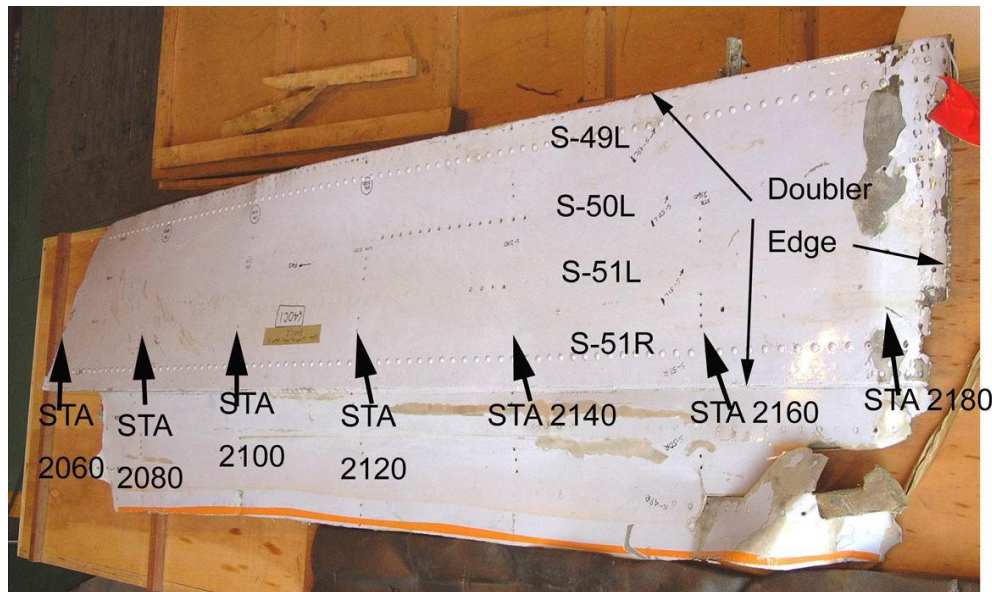
# Definition

## 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



# Classification: Minor/Major

## Examples of major repairs

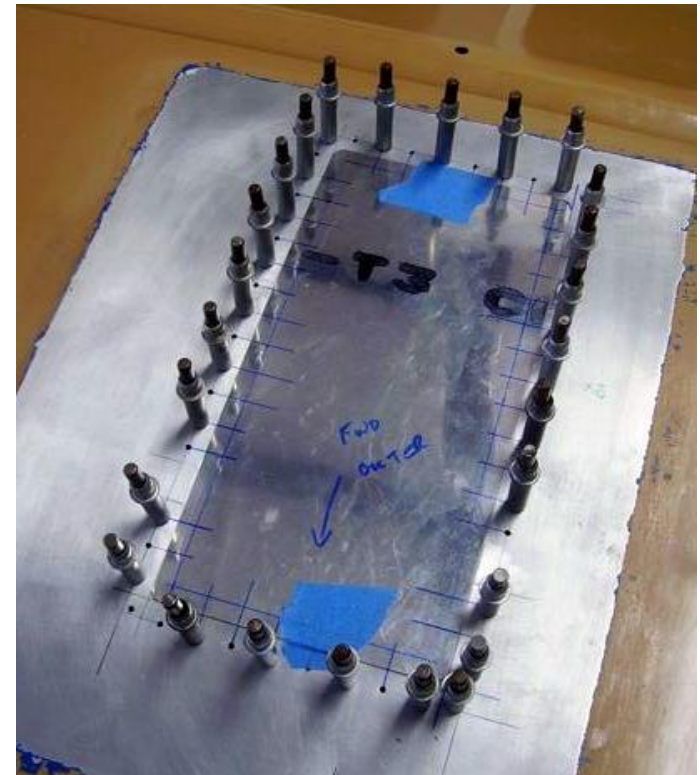
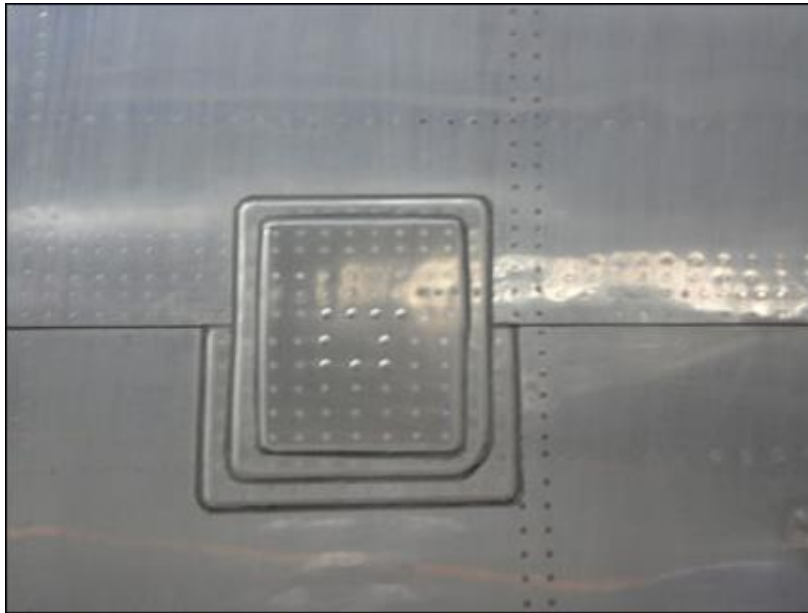
- A repair that requires a **permanent additional inspection to the approved maintenance programme**, necessary to ensure the continued airworthiness of the product.
- A repair **to life limited or critical parts**.
- A repair that introduces a change to the **Aircraft Flight Manual**.





# Classification: Minor/Major

## 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)



# Structural Repair Manual (SRM)

## 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

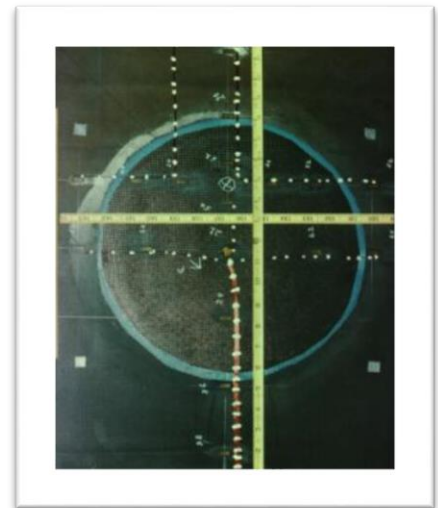
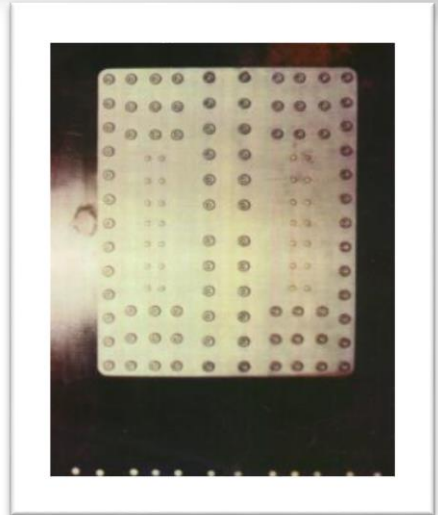
### ➤ Bolted

- 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](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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