

Presented by  
Dr Roland Thévenin  
Senior Expert Composite  
Structure Conformance



# ***Airbus Composite Structures***





## ***Perspectives on safe maintenance practice***

# Preliminary

- Good in service experience validates as well the certification as the design and safe maintenance practice.
- But findings/events may lead to modifications.
- The following presentation is to illustrate through 2 cases the changes that were necessary to introduce within the sandwich structure concepts (Design and Maintenance).

# Airbus Composite Structures





## *Table of Content*

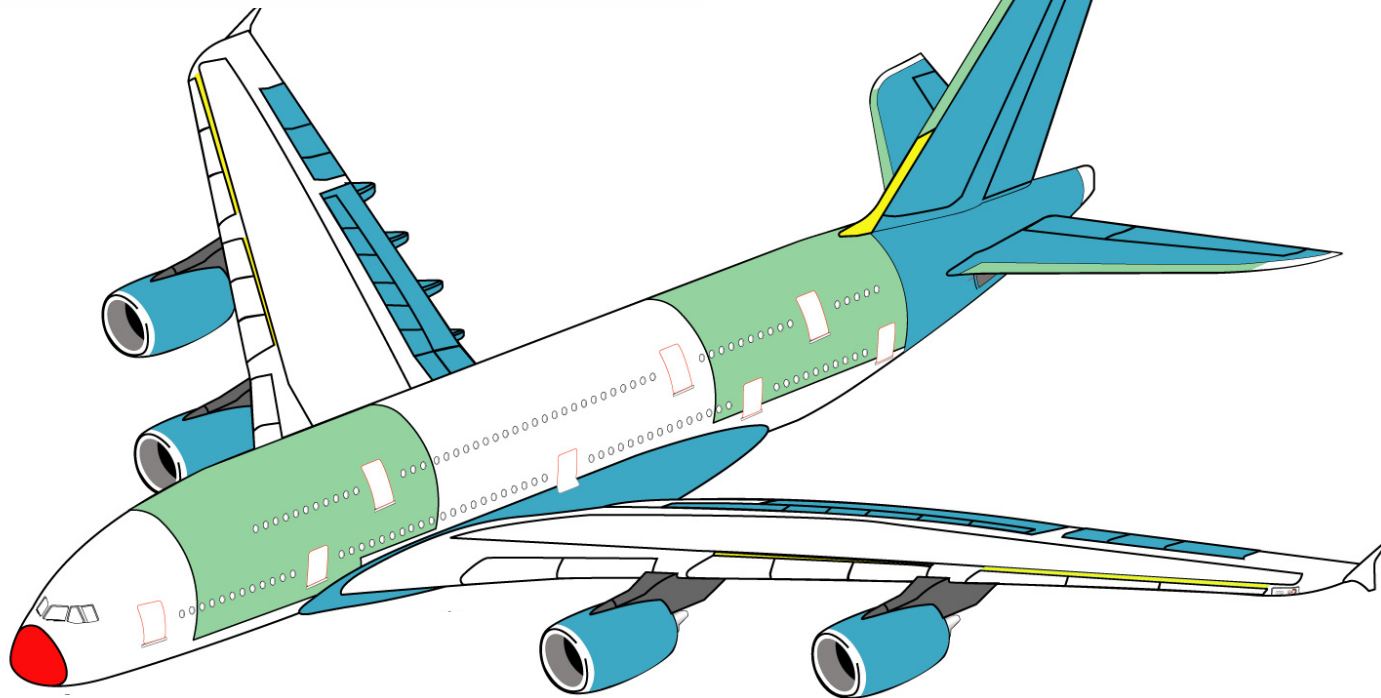
-  **1. Overview of Composites**
-  **2. A320 Elevators**
-  **3. A310/A300 Rudders**
-  **4. Key messages**

## ***1. Overview of Composites***

# Overview of Composites

## A380 Composite applications

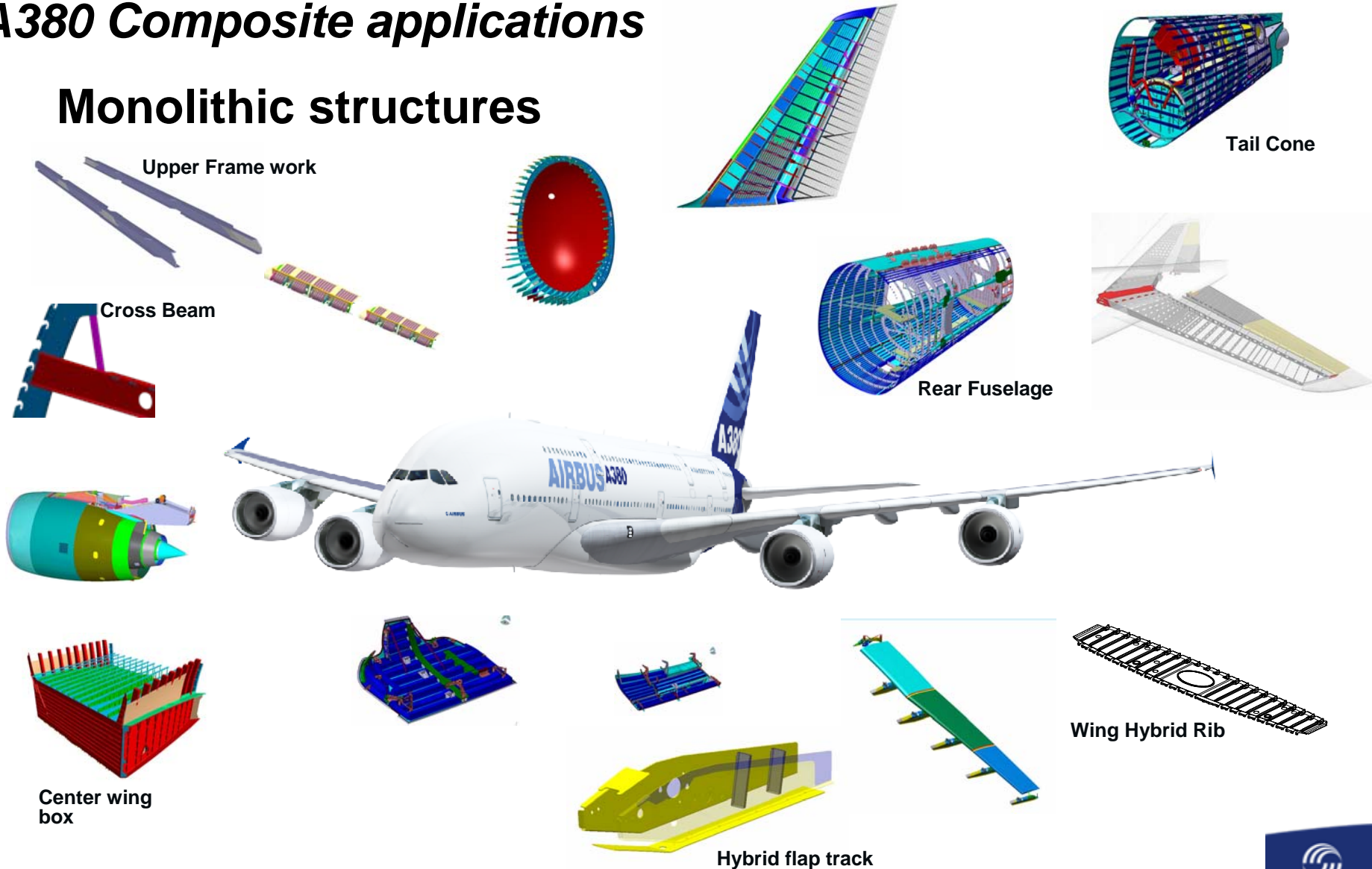
-  Carbon fiber reinforced plastic (CRFP)
  -  Glass fiber reinforced plastic (GFRP)
  -  Quartz fiber reinforced plastic (QFRP)
  -  Glass Reinforced Aluminium Laminate (GLARE)
- } 25% of Structure weight



# Overview of Composites

## A380 Composite applications

### Monolithic structures



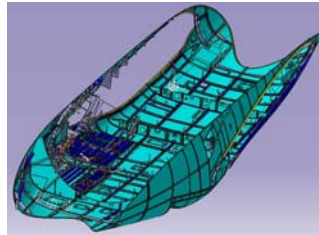
# Overview of Composites

## *A380 Composites - Basic applications*

### Sandwich structures



- Radome
- Pylon Aft Access Panels
- Empennages LE & TE panels
- Floor panels
- Wing TE panels



## ***2. A320 Elevators***

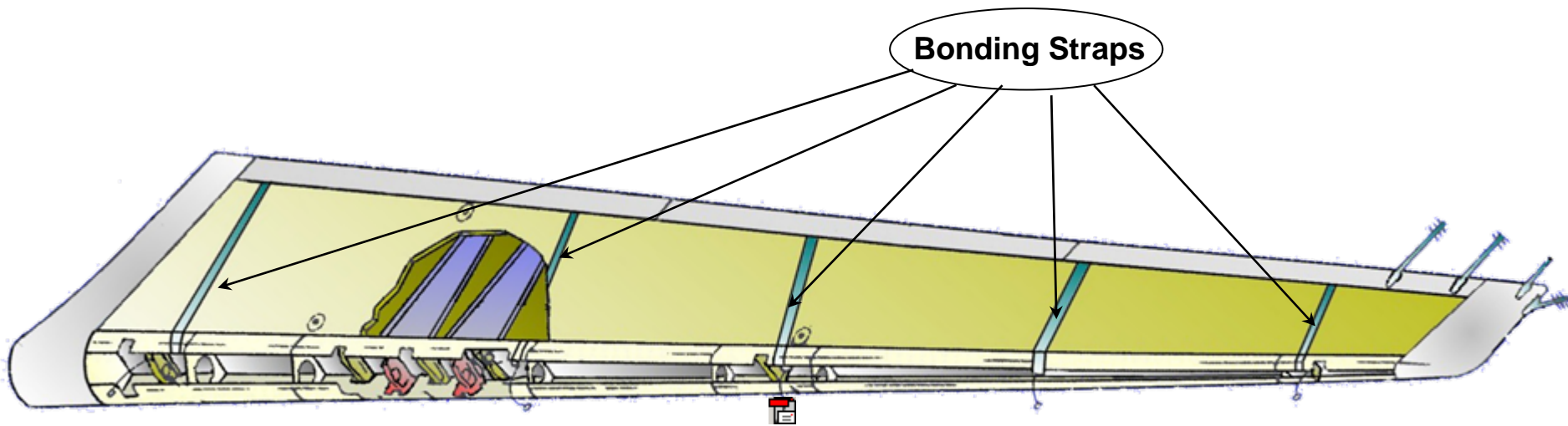


## ***Content***

- ▶ Structure description
- ▶ Example of water ingress
- ▶ Water ingress mechanism
- ▶ Improvements
- ▶ Comparison pre and post-mod elevators
- ▶ Further design improvements
- ▶ Conclusions

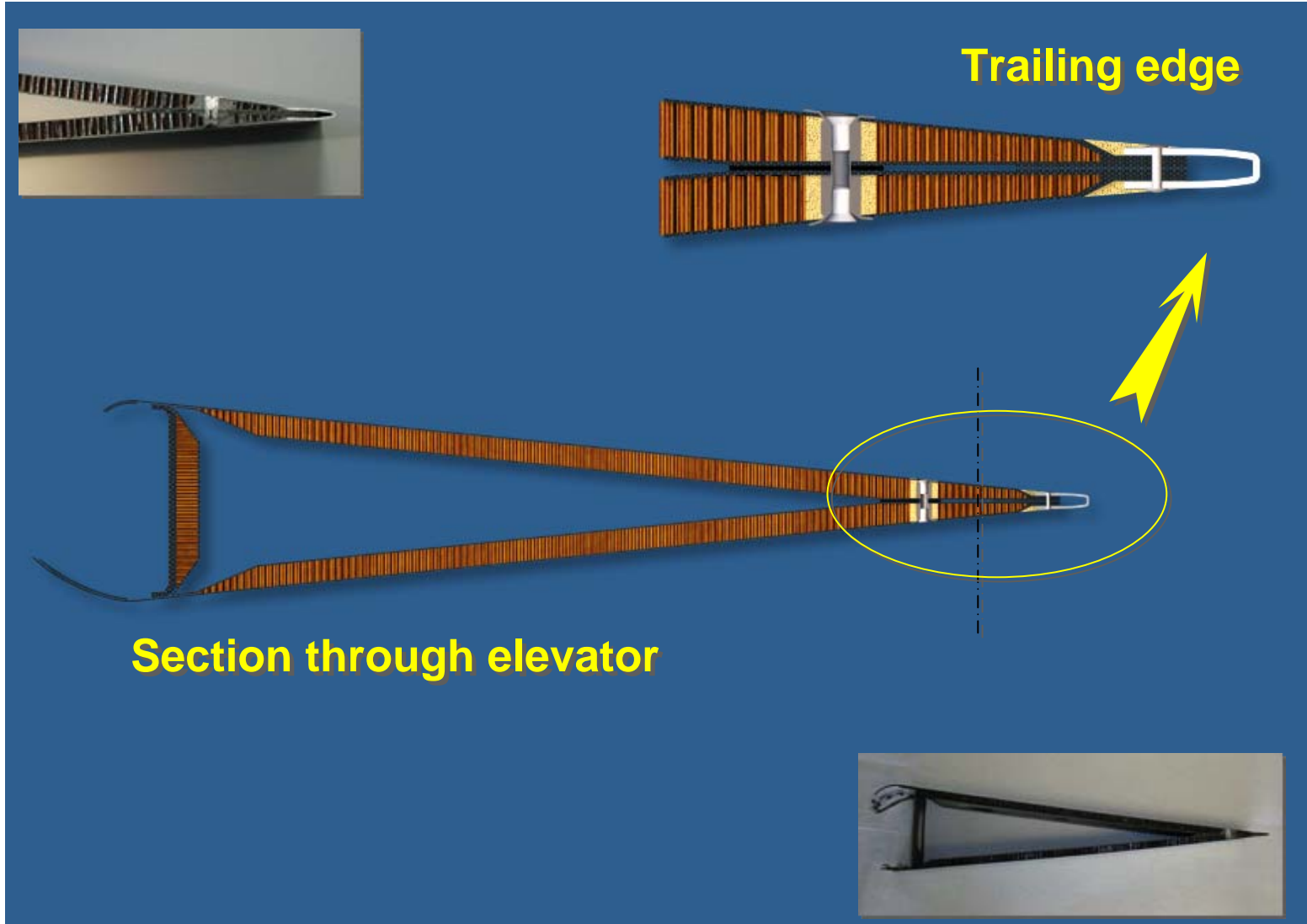
# A320 Elevators

## *Structure description*



# A320 Elevators

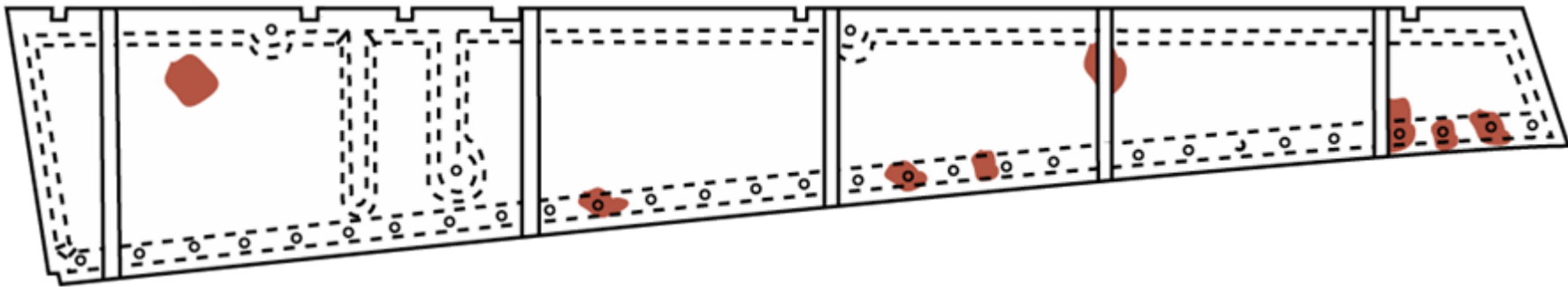
## Structure description



# A320 Elevators

## *Example of water ingress*

- **Upper panel**
  - Inspection by thermography



- Affected areas
  - Trailing edge inserts
  - Bonding straps
  - Panel surface

## *Water ingress mechanism*

- **It is a combination of several parameters**
  - ▶ Structure: Discontinuity or/and Porosity of the Skin
  - ▶ Environment: Heat and Humidity
  - ▶ A/C performance: Flight profile
- ▶ All when combined together in a critical way, present for the panel risk of : ***Water Ingress***
- **Which Lead in most of the case to:**
  - ▶ Deterioration on the honeycomb / skin bonding line
  - ▶ Delamination
  - ▶ Weight increase

## Improvements

- In production

- By adding one adhesive film
- Systematic Water Leak Test

### Post-mod



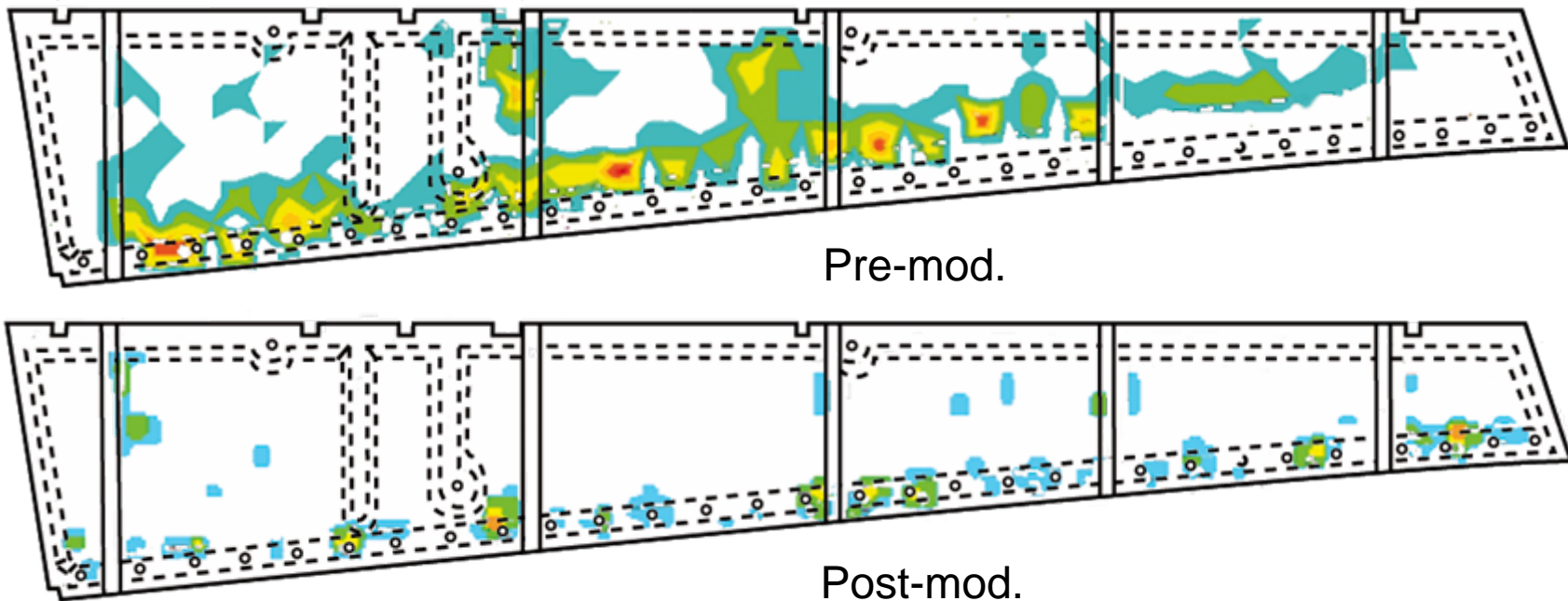
- SB A320- 55-1024

- 1 time thermography inspection mandatory at 10 Years
- Re-protection with 1 additional layer of pore filler and new paint
- All completed in 2002

# A320 Elevators

## Comparison pre and post-mod elevators

- Sampling of 22 elevators in each configuration

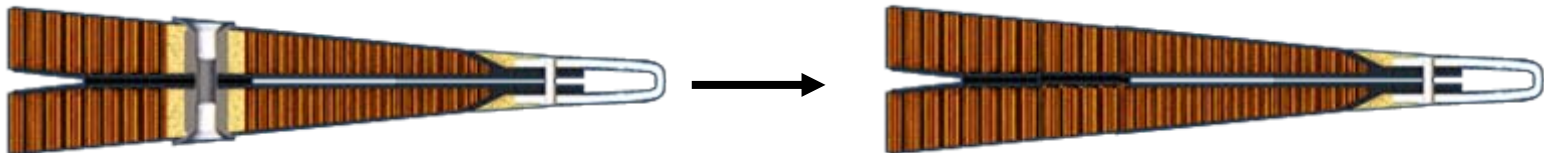
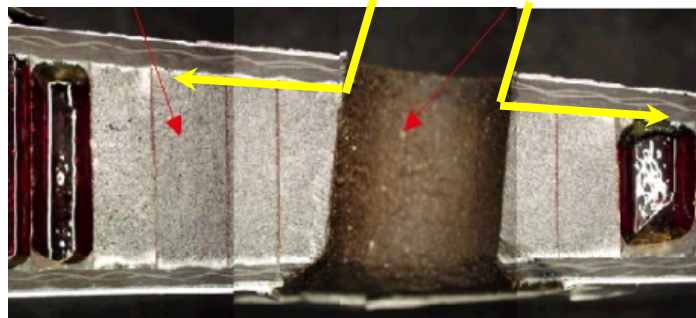
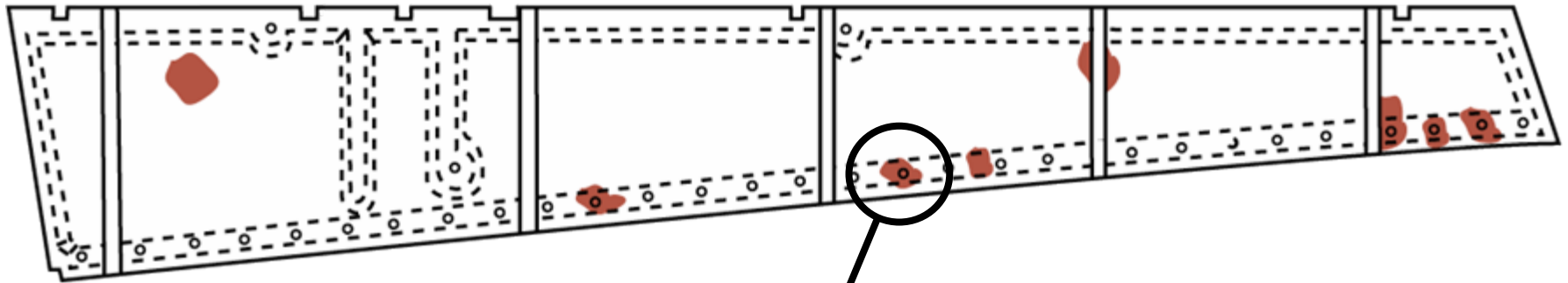


- **Post-mod / Post-SB elevators are also affected at lower extent**
  - ▶ Trailing edge inserts
  - ▶ Bondings straps
  - ▶ Panel surface

# A320 Elevators

## Further Design Improvements

- Trailing edge inserts

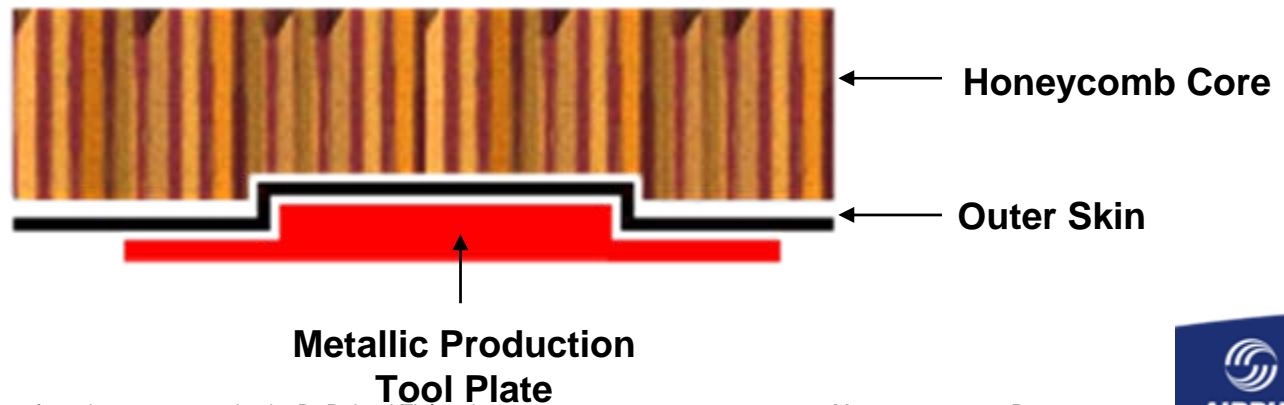
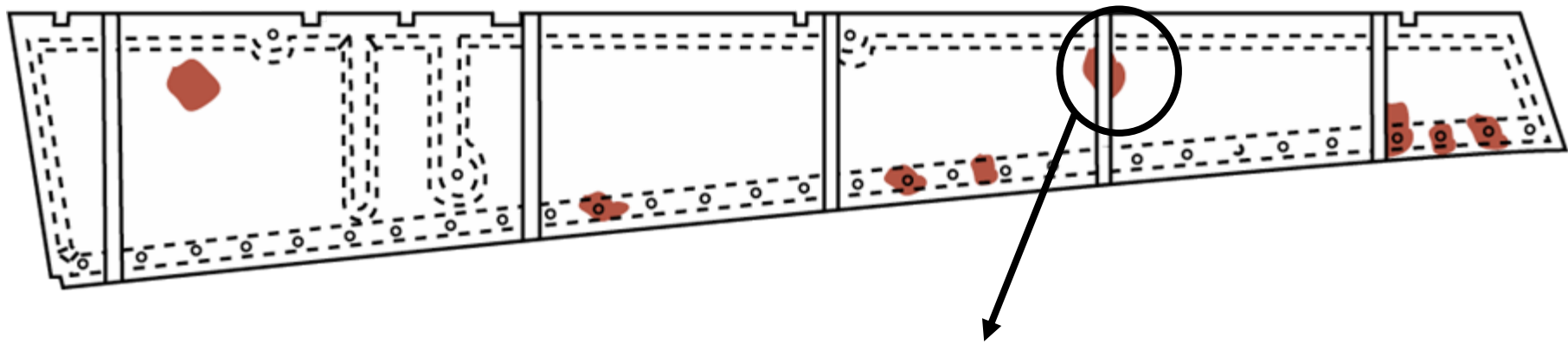




# A320 Elevators

## Further Design Improvements

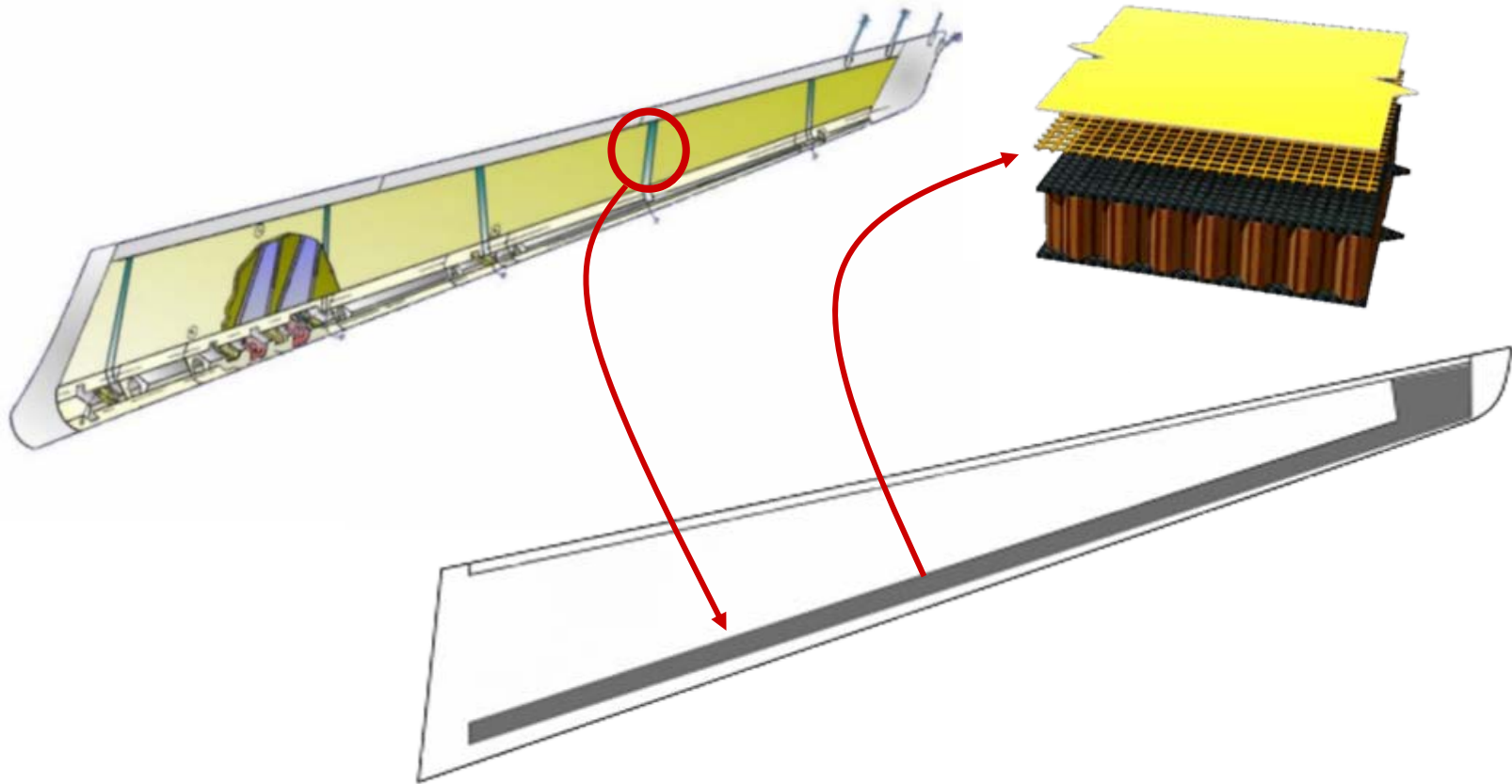
- Bonding straps replaced by mesh



# A320 Elevators

## *Further Design Improvements*

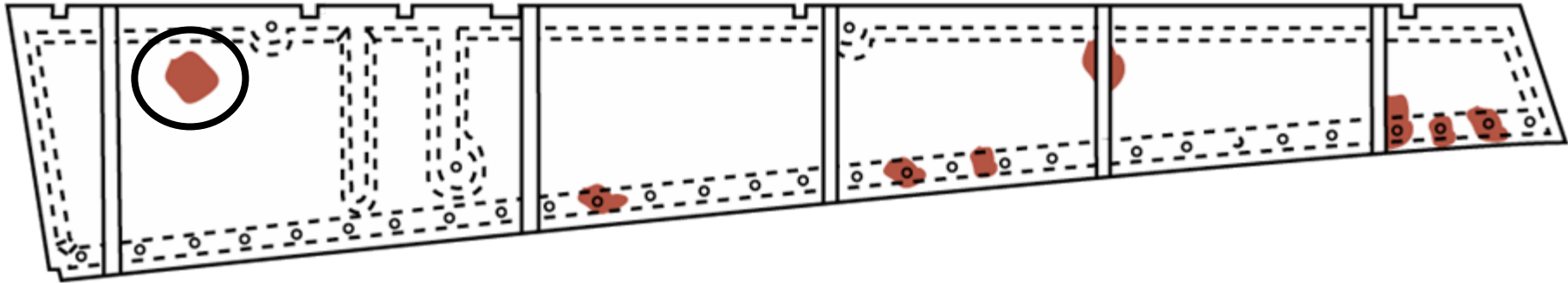
- **Bonding straps replaced by mesh**



# A320 Elevators

## *Further Design Improvements*

- Panel surface



- Origin:
  - Porosity from production
  - Unrepaired paint or structural damage
- Improvement:
  - New prepreg used in production with higher resin rate
  - Glass honeycomb replaced by Nomex
  - Low resin flow control

## ***Conclusions***

- ▶ Significant rate of findings on post-mod / Post SB 55-1024 elevators
- ▶ The mod. improved the situation but did not definitely preclude elevator water ingress
- ▶ Water cannot be left unrepaired on elevator composite sandwich primary structure
- ▶ To date, no future design improvement on sandwich can totally preclude water ingress
- ▶ Mandatory repeated thermography inspection is required

## ***3. A300/A310 Rudders***

## ***Content***

- ▶ In service experience
- ▶ Original design
- ▶ Rudder Pre - Post mod 8827
- ▶ Rudder Maintenance tasks
- ▶ Rudder specific inspection programs since march 05
- ▶ Rudder In service-findings since March 05
- ▶ Conclusions

## *In service experience*

- **Pre Structural failure in flight**

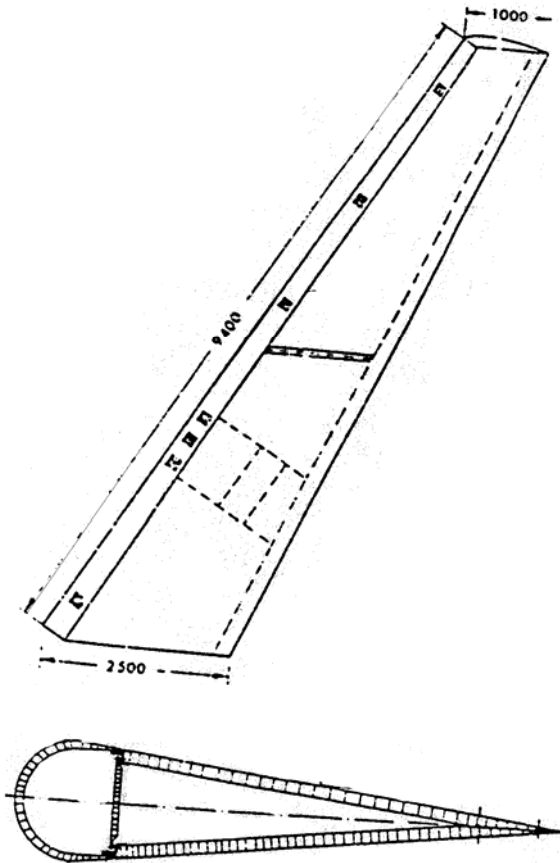
- ▶ Rudders showed satisfactory in-service experience:
  - No disbond issue
    - except AFRP panels declared unfit to fly if not retrofitted
  - No fluid ingress issue
  - No manufacturing issue
  - No repair/maintenance issue

- **Post Structural failure in flight**

- ▶ Findings since implementation of AOTs
  - Most not covered by currently published inspection techniques
  - Upon operators' inspection initiatives (increased awareness versus sandwich inspections)

# A300/A310 Rudders

## Original design



### •In-service damage

- ▶ Large skin-core disbonding
- ▶ Due to the Aramid layer between the core and the carbon fiber skin (poor resin adhesion on Aramid)
- ▶ Production modification 5844 replaced the Aramid with Glass layer

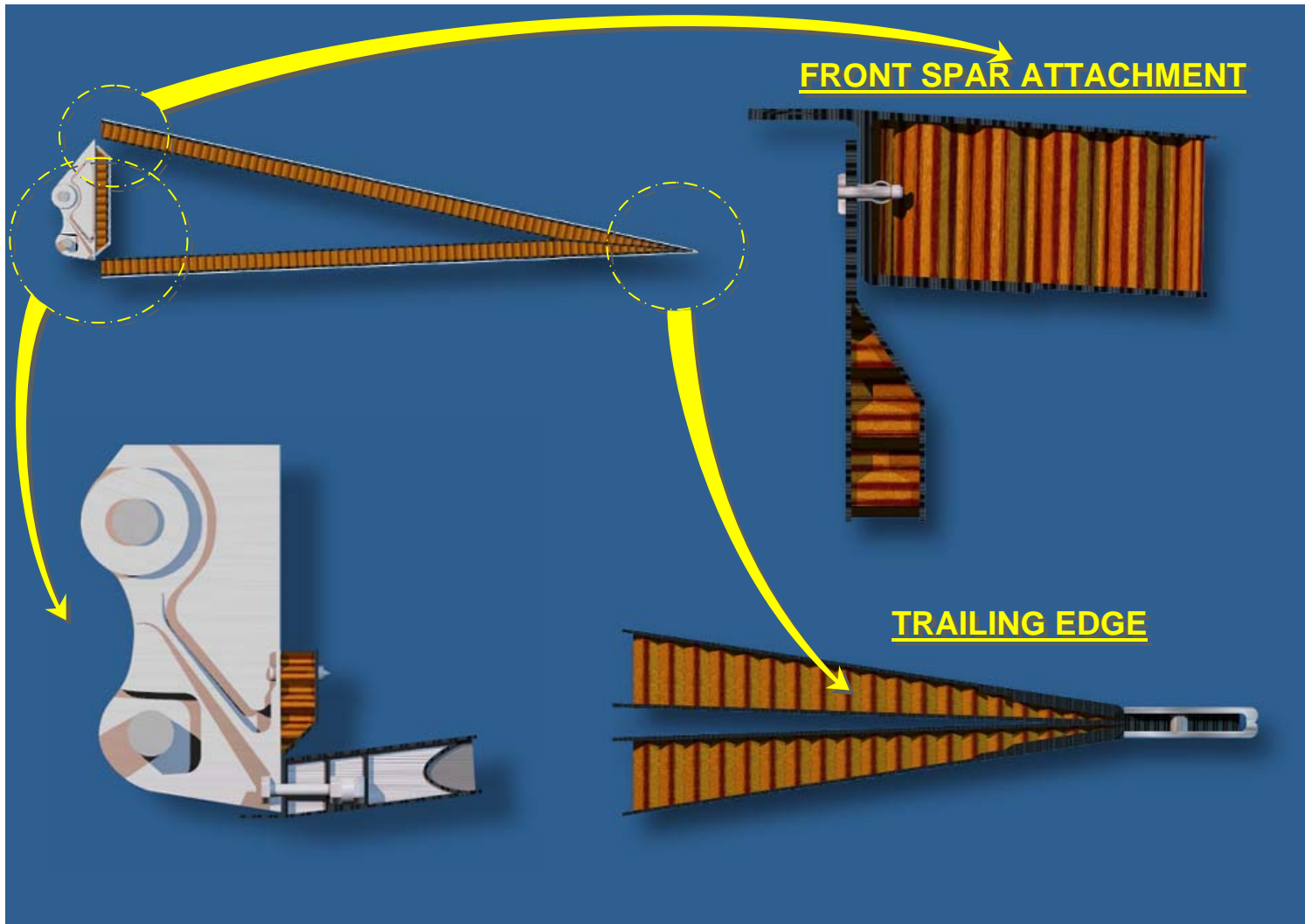
### •Current status

- ▶ All affected rudders replaced (80)



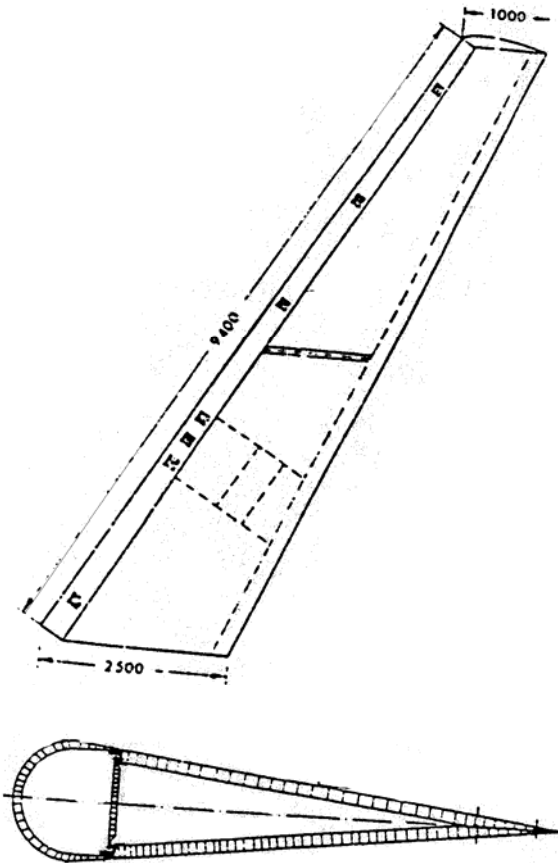
# A300/A310 Rudders

## Pre Mod 8827



# A300/A310 Rudders

## Pre Mod 8827



### •In-service damage

- ▶ Skin-core disbonding in the bottom area
- ▶ Due to the attachment of the Front Spar through the honeycomb.

### •Current status

- ▶ AOT has been launched to inspect any damage and the status of the structure (contamination...) Production modification 8827 has modify the attachment

# A300/A310 Rudders

## ***Pre Mod 8827***

- **Maintenance tasks**

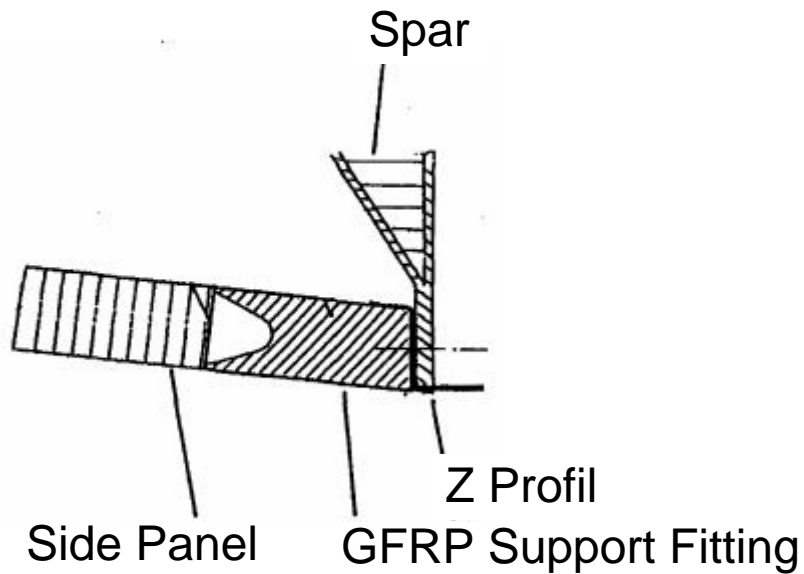
- ▶ Zonal program (MPD section 6)
  - ZL326-01/02-1 (2C): GVI of rudder
- ▶ Structure program (MPD section 7)
  - 554003-01-1 (5Y): DET of rudder front spar forward face and internal structure, as far as visible
  - 554004-01-1 (5Y): SDET of rudder side panels GFRP blocks areas (*non SRM repaired rudders only*)
  - 554005-01-1 (5Y): SDET (tap test) of the rudder side panels
- ▶ Unscheduled tasks
  - Lightning strikes, high lateral loads, hail impact...

# A300/A310 Rudders

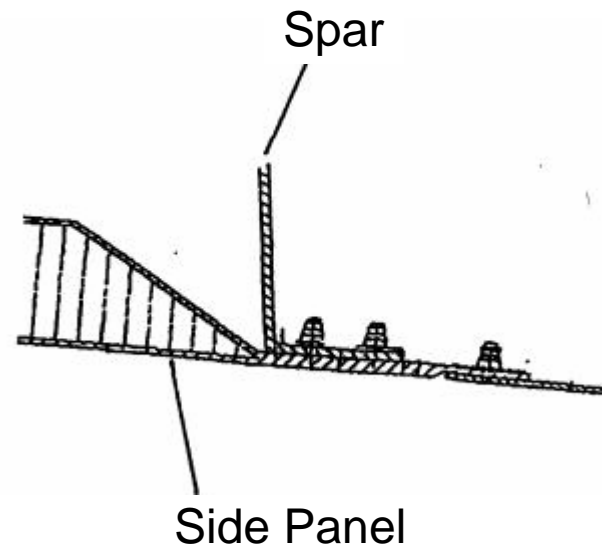
## *Pre Mod 8827*

- Spar attachment principles

Pre Mod



Post Mod



# A300/A310 Rudders

## ***Pre Mod 8827***

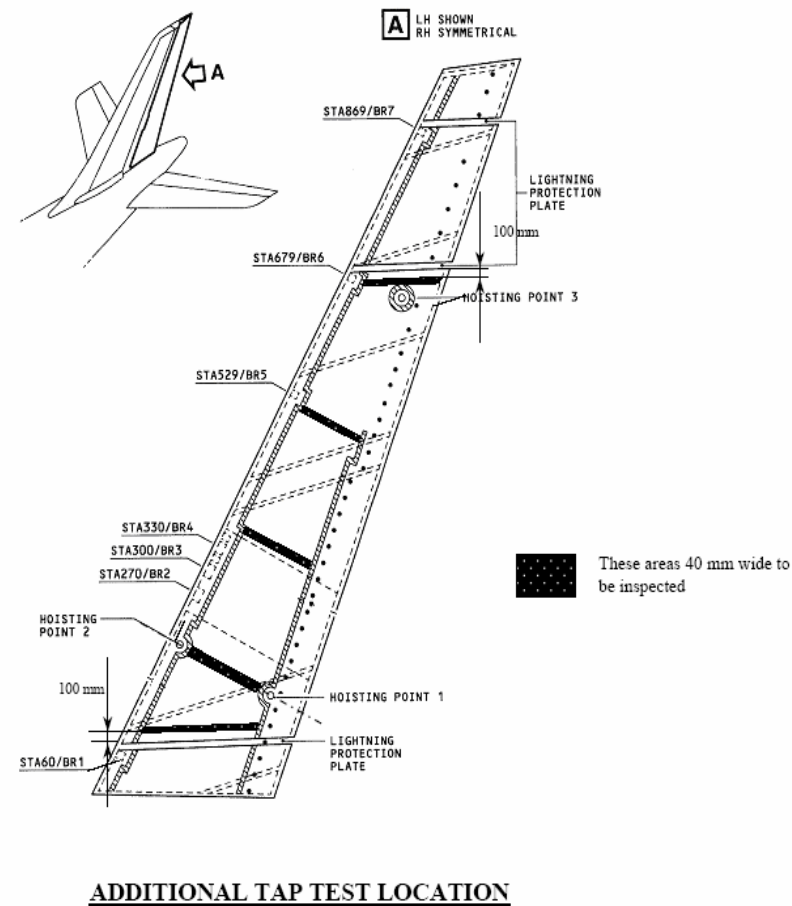
- **Rudder event**

- *See Flight Safety presentation*

# A300/A310 Rudders

## Pre Mod 8827 - Post rudder event

- **Precautionary inspection AOT#1**
  - ▶ Precautionary fleet wide inspection of in-service rudders launched post even
    - AOT's 55A6035 and 55A2035 dated 17-Mar-05
    - About 400 similar P/N rudders (pre mod 8827)
    - Detailed visual inspection plus a tap testing of specific areas
  - ▶ Inspection was based on existing 5Y MPD and AMM tasks
    - Most of findings would have been captured during regular maintenance



# A300/A310 Rudders

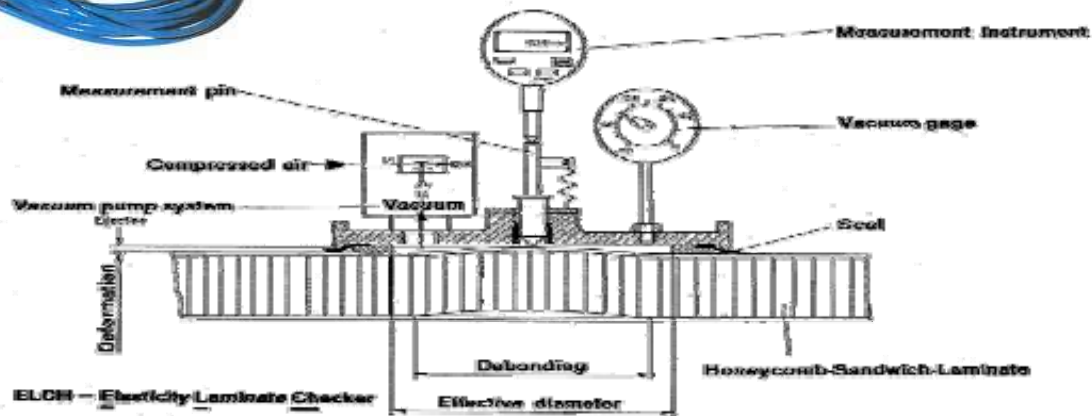
## *Pre Mod 8827 - Post rudder event*

- **Precautionary inspection ELCH#1 (Elasticity Laminate Checker)**

- ▶ Inspection principle:

- Principle : vacuum based tool:

- Check for no stiffness changes
- Allows checking correct skin bonding condition (inner not directly accessible)



# A300/A310 Rudders

## ***Pre Mod 8827 - Post rudder event***

- **Precautionary inspection (ELCH#1)**

- ▶ To allow checking for the bonding condition of skin to honeycomb core, 24 rudders have been deeply inspected:
- ▶ Inspection of complete rudder skin panels with 75 mm grid
  - Allows identifying damages greater than 100 cm<sup>2</sup> either at the inner or at the outer skin
- ▶ Tap test follows to indicate whether or not outer skin is affected
- ▶ All rudders were found to be in good condition

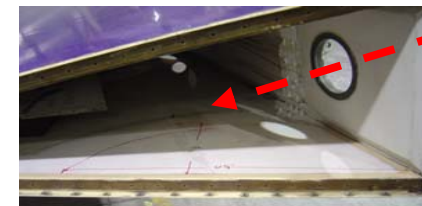
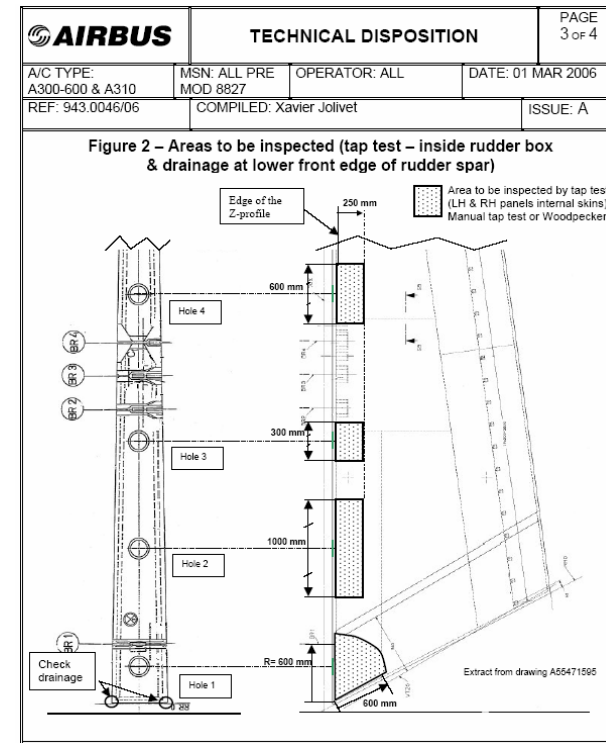


# A300/A310 Rudders

## Pre Mod 8827 - Post rudder event

- Precautionary inspection - AOT#2

- ▶ Issued after rudder inner skin disbond finding
- ▶ Limited to pre-mod 8827 rudders
- ▶ AOT Inspection for:
  - correct drainage condition (visual)
  - fluid contamination traces (visual)
  - Inner skin disbond (tap test)
- ▶ **Results:**
  - No significant finding (few drains blocked and/or fluid stains, no tap test finding)



# A300/A310 Rudders

## Pre Mod 8827 - Post rudder event

- **Precautionary inspection (ELCH#2)**

- ▶ 2nd campaign in 2006 (5 airlines):

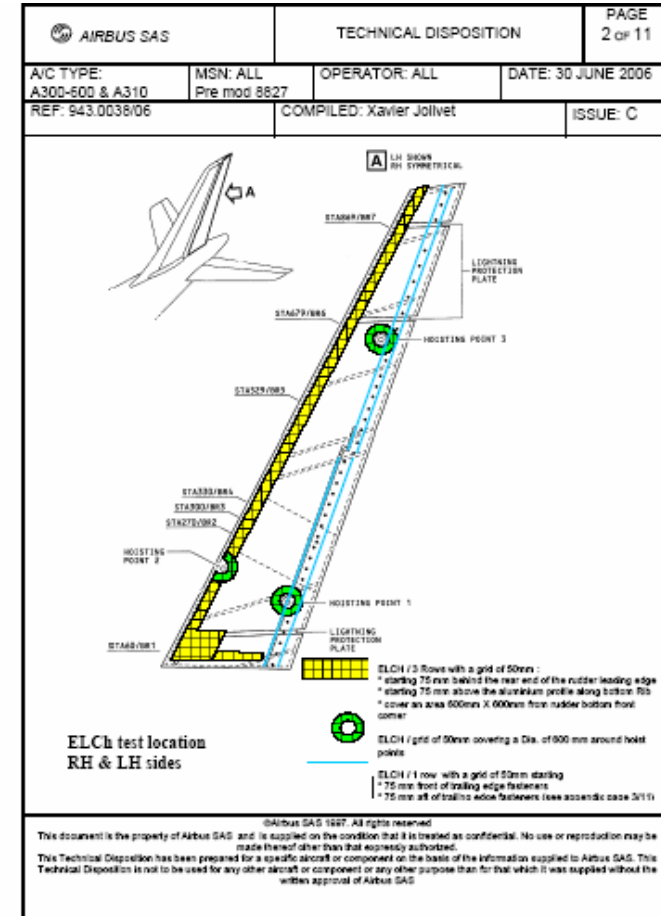
- Inspection on specific features

- ▶ Complete Panel borders
- ▶ Trailing edge screws
- ▶ hoist point surround

- Grid pitch decreased to 50 mm

- ▶ Detects disbond from 70 to 90mm

- 12 aircraft inspected / no finding



## ***Pre Mod 8827 - Post rudder event***

- **In service-findings since March 05**
  - ▶ **Disbond** between skin and honeycomb core
    - lower front corner (inner skin)
    - Z-profile area above BR7 (inner skin)
    - skin disbond around hoist point (outer skin)
    - under lightning plate (investigation running)
  - ▶ **Fluid ingress** (including Skydrol through blind rivets)
    - Hoisting points (water)
    - Trailing edge screws (water)
    - Leading edge screws (Skydrol & water)
    - Spar (water)
  - ▶ **Incorrect repairs**
    - repair not correctly bonded
    - skin abraded up to core during sanding
    - excessive paint built-up => cracking

## ***Conclusions (1/2)***

- ▶ Until March 2005, rudders showed satisfactory in-service experience (except Aramid early design – unfit to fly)
  
- ▶ Rudder occurrences triggered
  - 2 fleet inspections (AOTs) + 2 sampling inspection (ELCh)
  - A 3<sup>rd</sup> inspection, repetitive, is coming
  - Increased awareness towards composite sandwich specificity

## ***Conclusions (2/2)***

- ▶ Recent experience since March 2005 showed unexpected rudder damage types:
  - Disbond (skin to core)
  - Fluid ingress & skydrol contamination
  - Incorrect repairs
  
- ▶ Need to improve the inspection program and the associated NDT technique to cover invisible damages
  - ELCh, ultrasonic, X-Ray ...

## ***4. Key messages***

# Key messages

## **General**

- ▶ *Airbus continually evaluates the in-service performance of composites in order to evolve aircraft design and maintenance.*
- ▶ *Airbus also cooperates with other manufacturers, suppliers and airlines as part of the Commercial Aircraft Composite Repair Committee (CACRC) to include customer experience in future composite improvements especially sandwich designs*
- ▶ *Increased awareness towards composite sandwich and monolithic specificities.*

## ***Monolithic structures***

- ▶ *Wide use of monolithic structures*
- ▶ *More than 65 million flight hours reached with very good in-service behaviour*
- ▶ *The in-service experience of monolithic composite parts has validated as well the designs as the certification approach and the maintenance concept.*
- ▶ *Warning about the use of a given experience for other applications, other designs.*



## ***Sandwich structures***

- ▶ *Experience on these structures has revealed some weak points, most notably a lack of water tightness.*
- ▶ *New sandwich designs in used show good in-service behaviour*
- ▶ *Change in inspection programs are considered.*
- ▶ *In few cases, Sandwich is replaced by Monolithic, for instance about Elevators & Rudders.*

# Key messages



© AIRBUS S.A.S. All rights reserved. Confidential and proprietary document.

This document and all information contained herein is the sole property of AIRBUS S.A.S.. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. This document shall not be reproduced or disclosed to a third party without the express written consent of AIRBUS S.A.S. This document and its content shall not be used for any purpose other than that for which it is supplied.

The statements made herein do not constitute an offer. They are based on the mentioned assumptions and are expressed in good faith. Where the supporting grounds for these statements are not shown, AIRBUS S.A.S. will be pleased to explain the basis thereof.

AIRBUS, its logo, A300, A310, A318, A319, A320, A321, A330, A340, A350, A380, A400M are registered trademarks.



**AIRBUS**

**AN EADS JOINT COMPANY  
WITH BAE SYSTEMS**