

European Bonded Structure Meeting @ EASA

13th to 14th of June 2013, Köln



Damage in sandwich structures Best practices for prevention & detection

Presented by
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Preliminary

- *From the beginning Airbus has accumulated a large experience in composite.*
- *The in-service experience of monolithic composite parts has validated the designs the certification approach and the maintenance concept.*
- *While the in-service experience of sandwich structures has revealed some weak points.*
- *Sandwich design improvements are considered and change in inspection programs are implemented*

Damage in Sandwich Construction

Best practices for prevention/detection

Flight Control Sandwich Structures

In Service experience

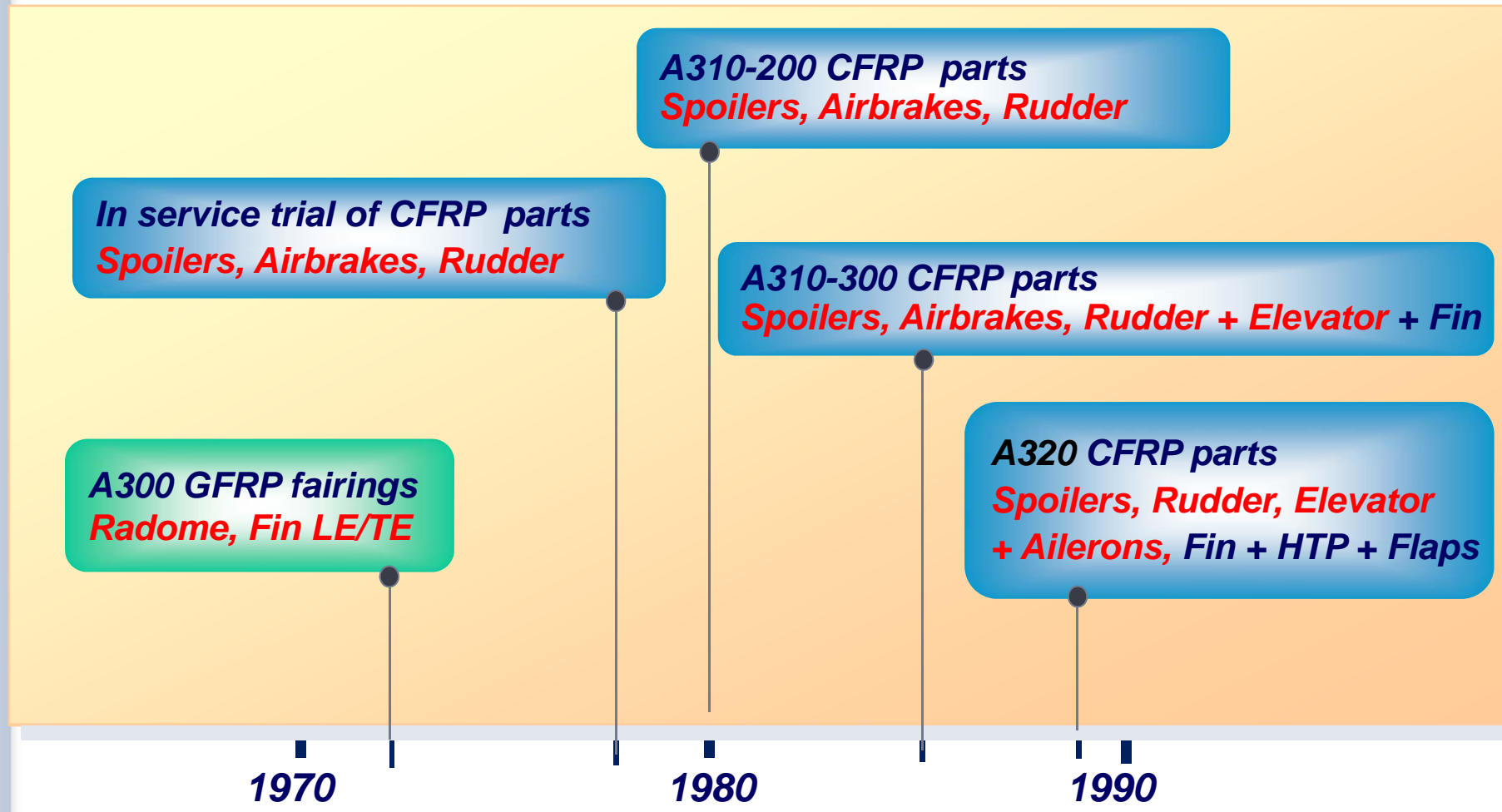
Consequences of findings on inspections

Structure improvements

Key messages

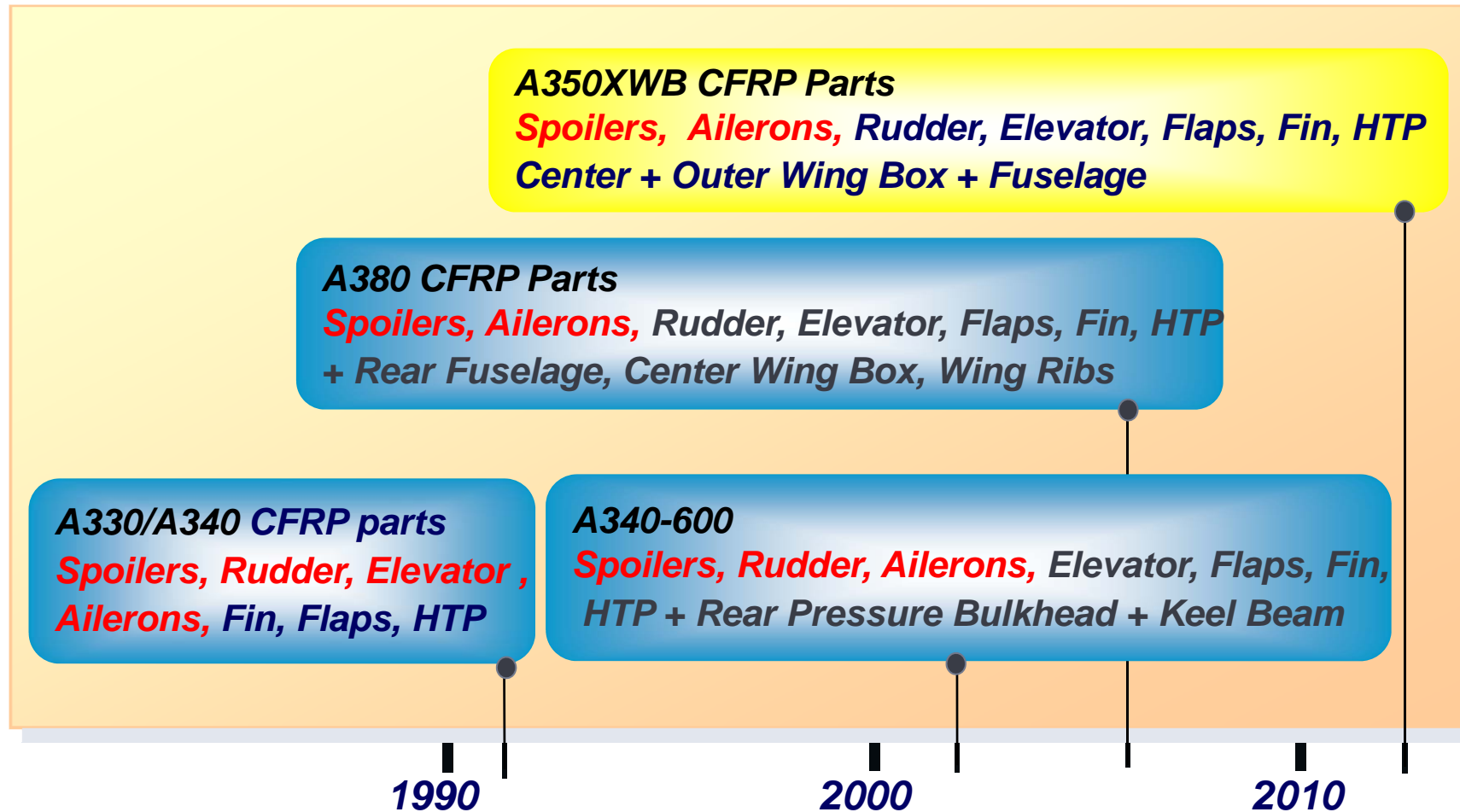
Flight Control Sandwich Structures

Introduction of sandwich 1972 - 1990



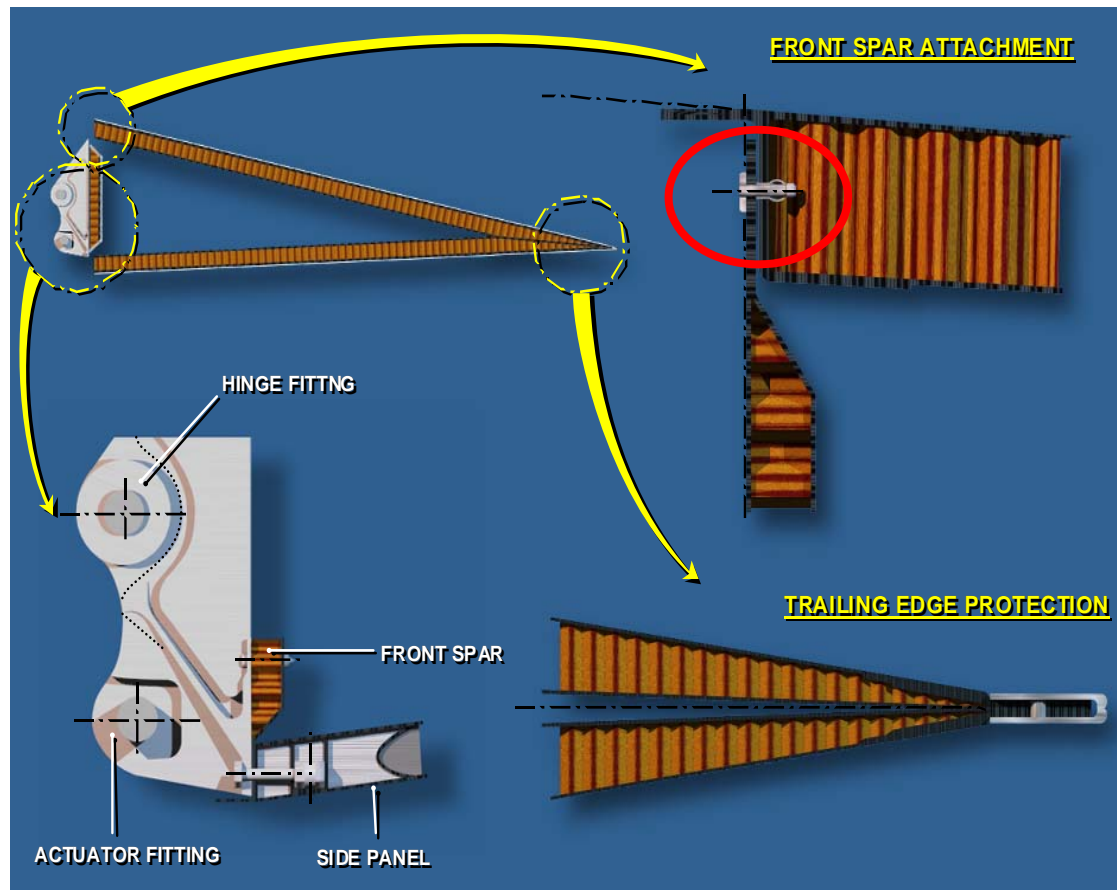
Flight Control Sandwich Structures

Introduction of sandwich 1990 -



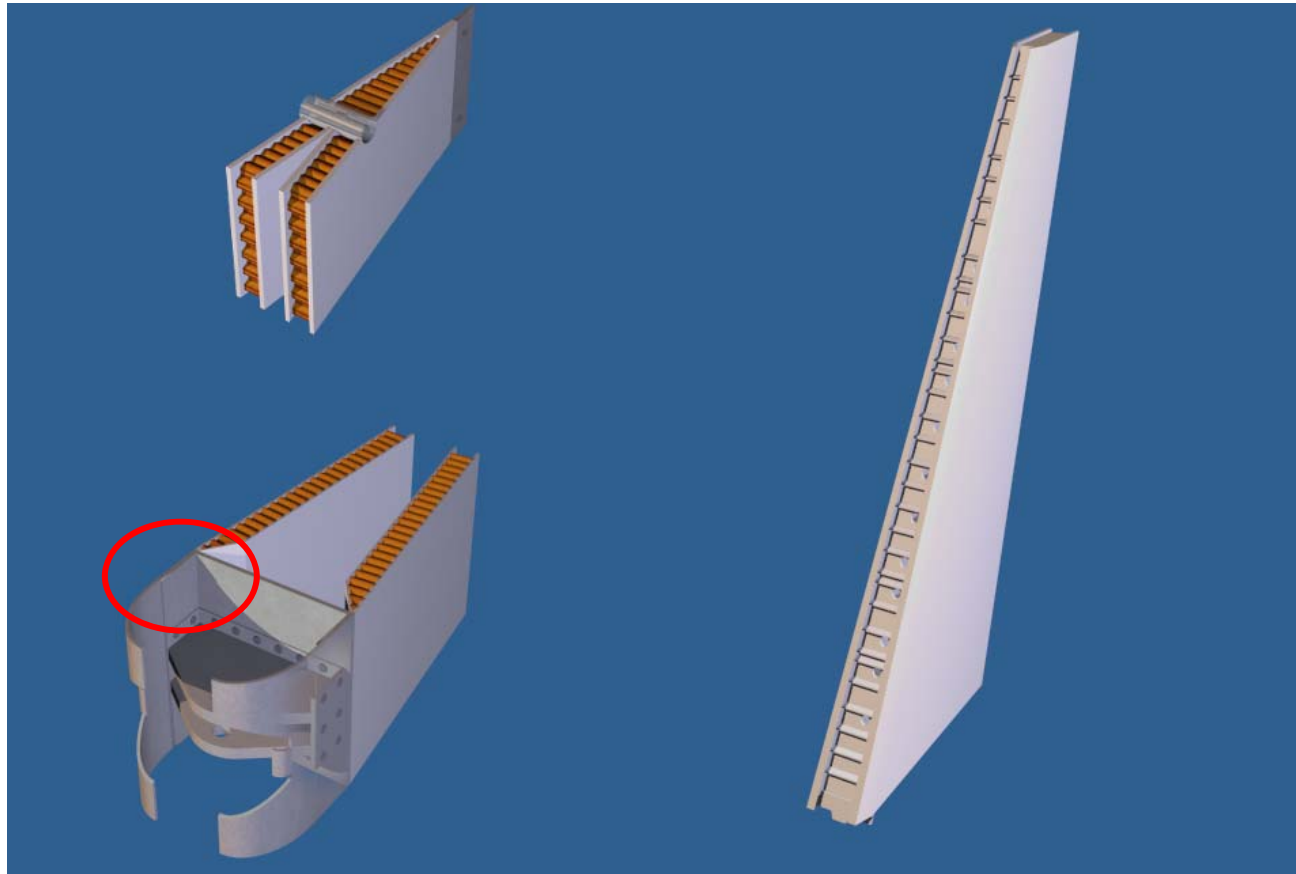
Flight Control Sandwich Structures

A310/A300-600



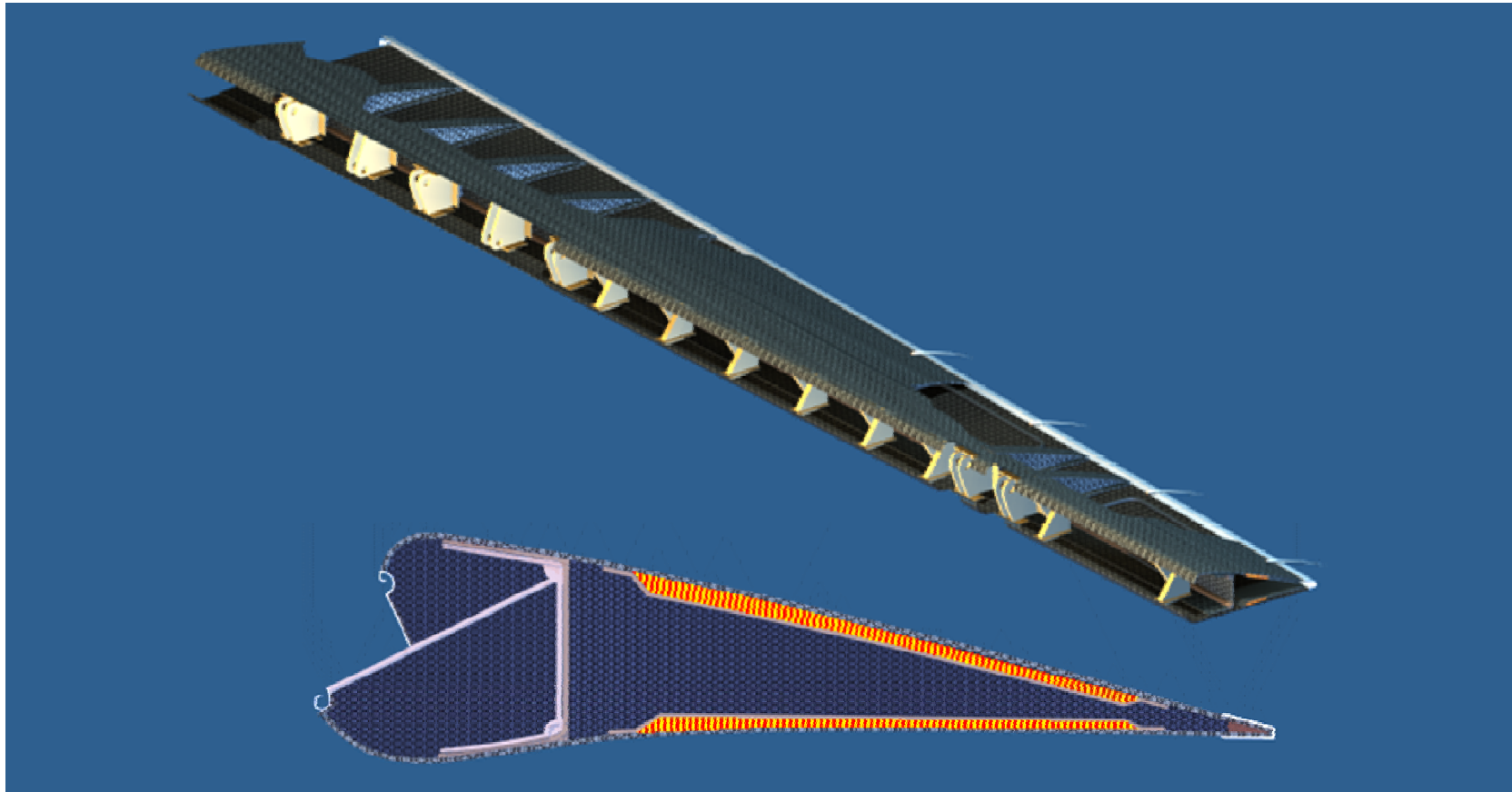
Flight Control Sandwich Structures

A320 Rudder



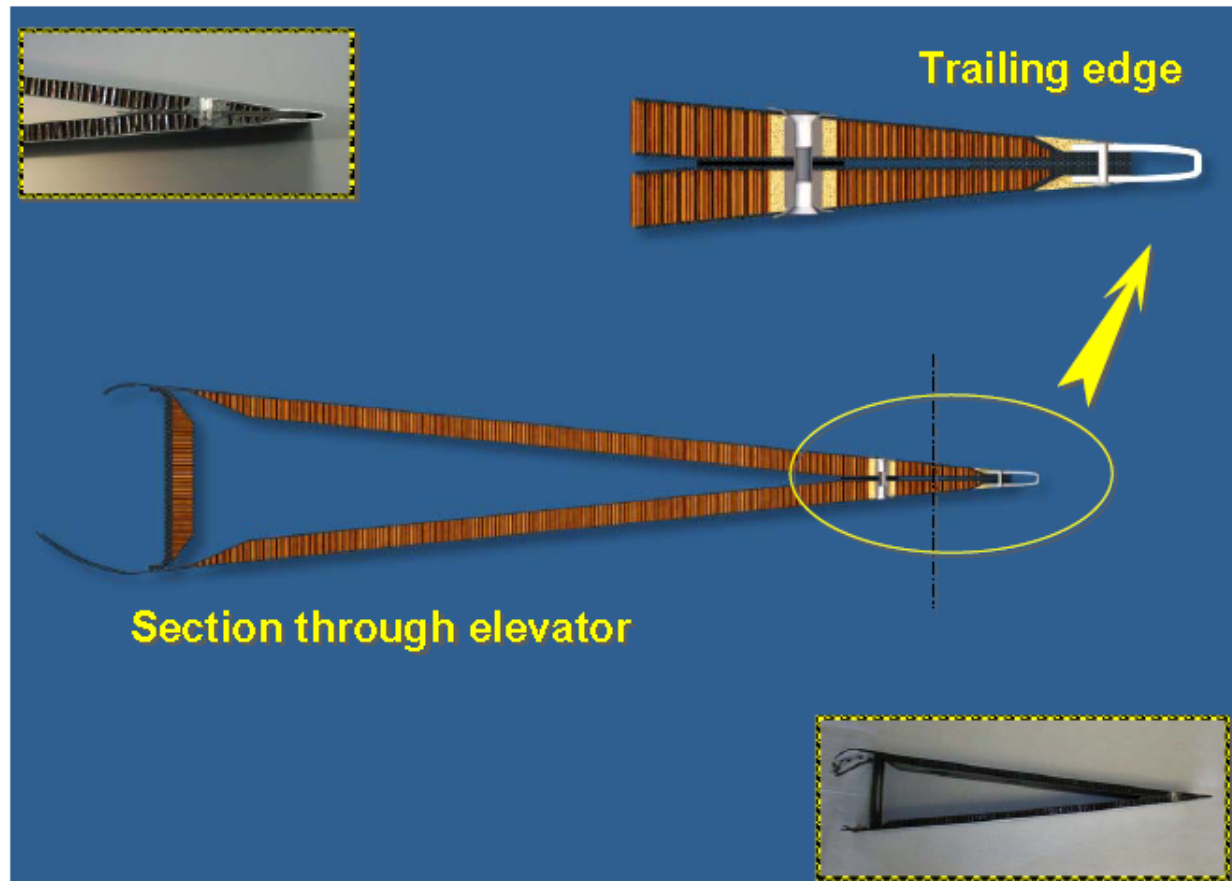
Flight Control Sandwich Structures

A320 Ailerons



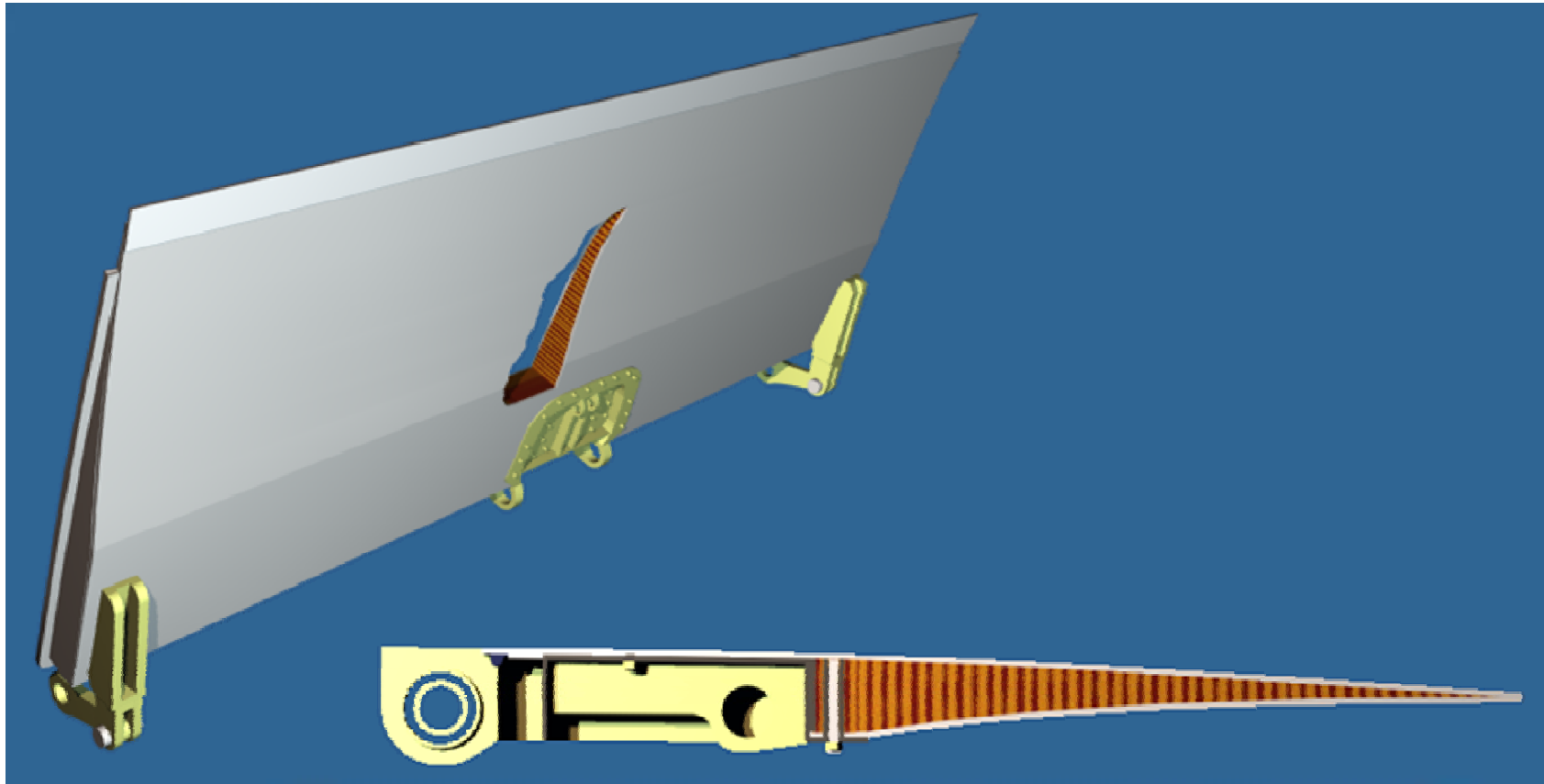
Flight Control Sandwich Structures

A320 Elevators



Flight Control Sandwich Structures

A320 Spoilers



Damage in Sandwich Construction

Best practices for prevention/detection

Flight control Sandwich structures

In Service experience

In service experience

Ailerons

- Sandwich Design: All excepted A320 (recent mod)
- In service experience: Good

Spoilers

- Sandwich Design: All
- In service experience: Good

Elevators

- Sandwich Design: WB, A320, A330, A340
- In service experience: Water ingress but good design improvements have been implemented as well as new maintenance program.

In service experience

Rudders

- Sandwich Design: WB, A320, A330, A340, A340-500/600
- In service experience:
 - Excepted the initial AFRP panels (large disbond) declared unfit to fly , until the “Structural failure in flight” the Rudders showed satisfactory in-service experience.
- In service experience: since March 05
 - Disbond between skin and honeycomb core
 - Lower front corner (inner skin)
 - Z-profile area above BR7 (inner skin)
 - Around hoist point (outer skin)
 - Under lightning plate

In service experience

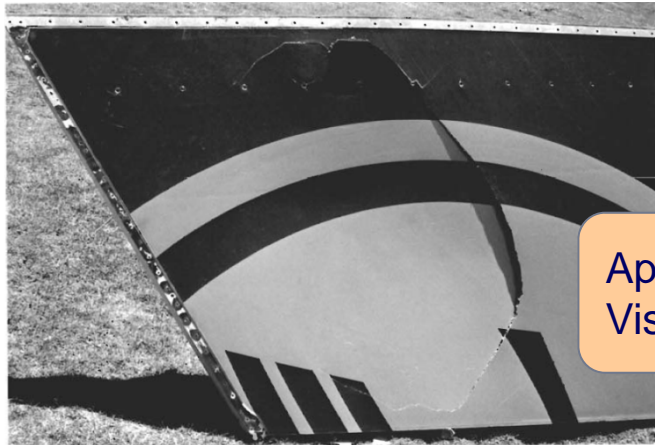
Rudders (cont'd)

- In service experience: since March 05 (cont'd)
 - Fluid ingress
 - Blind rivets (Skydrol)
 - Hoisting points (water)
 - Trailing edge screws (water)
 - Leading edge screws (Skydrol & water)
 - Incorrect repairs
 - Repair not correctly bonded
 - Skin abraded up to core during sanding
 - Excessive paint built-up => cracking

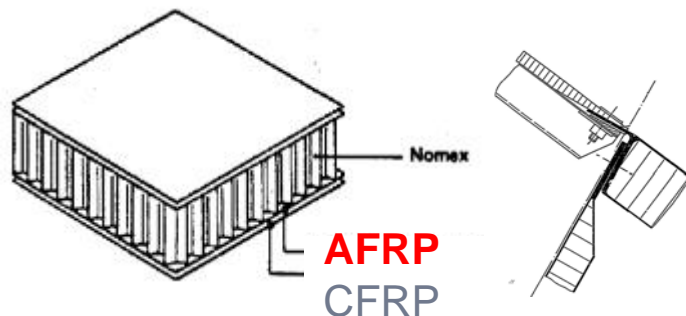
In service experience

Skin / Core Debonding (1989/1990)

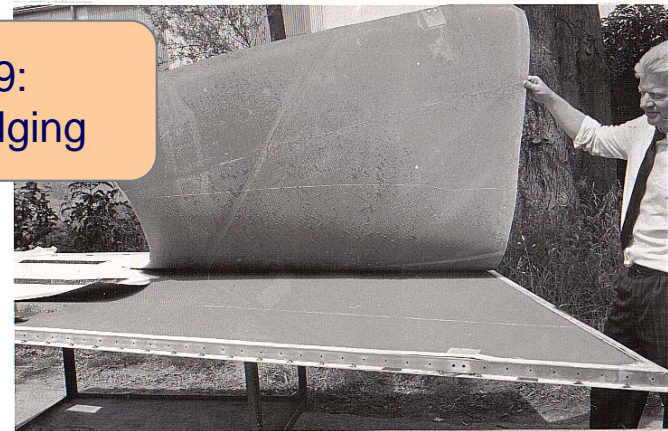
- “Aramid” Rudders



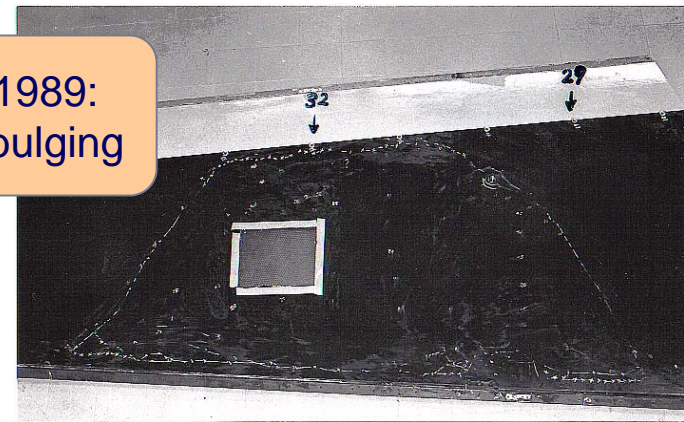
April 1990
Visible surface cracks



March 1989:
Surface bulging



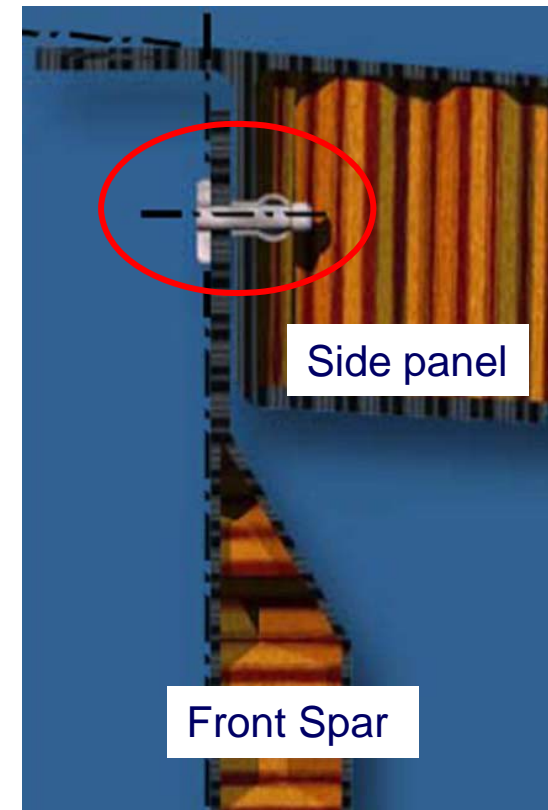
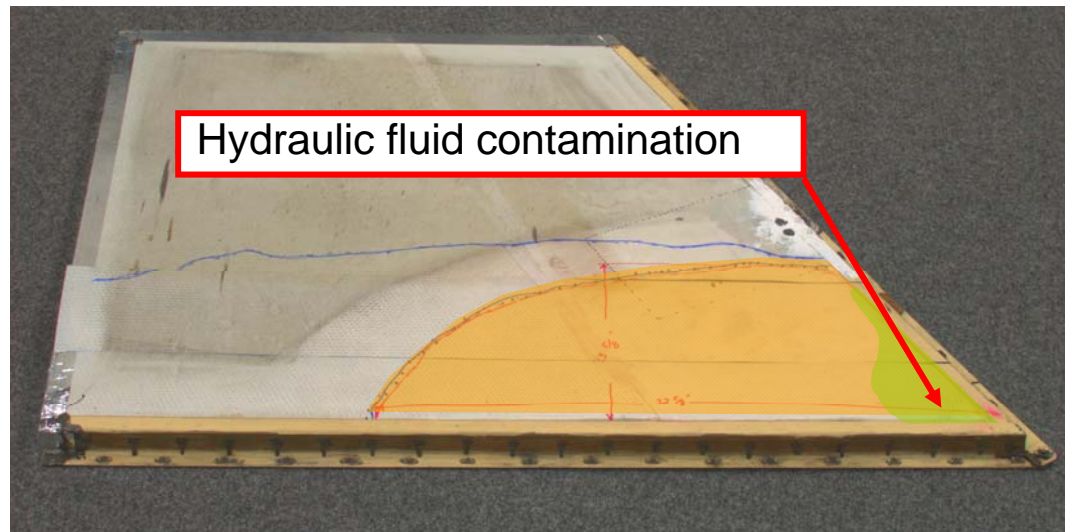
October 1989:
Surface bulging



In service experience

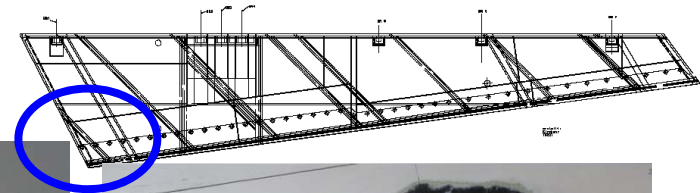
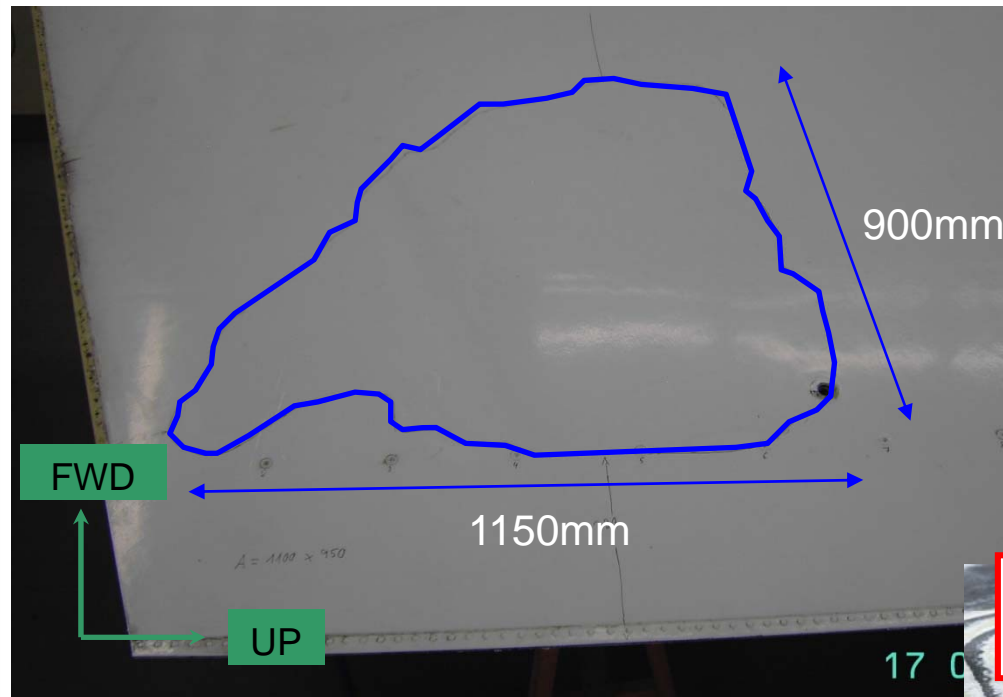
Skin / Core Debonding (Dec 2005)

- Hydraulic fluid contamination through blind fasteners



In service experience

Repair disbond (Aug 2009)



Further disbond propagation within the honeycomb core

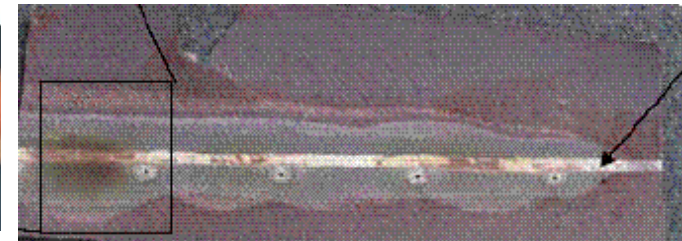
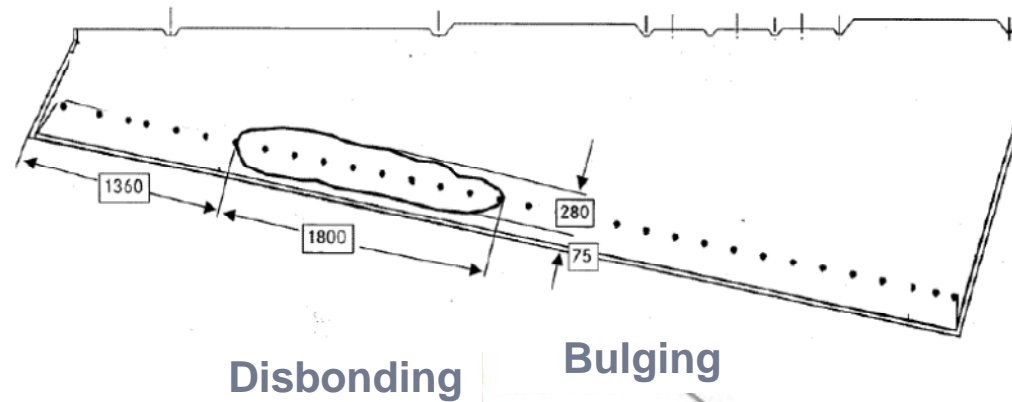
Inner skin to core separation



In service experience

Repair disbond

- Overheating created the disbond (heat lamps >> 125°C)



In service experience

Lesson learnt

- Improve designs
 - No Kevlar
 - Apply additional layer of sealing (surfacing film)
 - Increase the skin thicknesses
 - Use of low flow controlled resin
 - Reduce insert applications and blind fasteners
- Improve quality control
 - Introduce water leak test at manufacturing stage
- Improve SRM repair instructions
- Improve maintenance program
 - New maintenance tasks (Health Check)
- Identification of GAG phenomenon
- Provide bonded repair limitation

In service experience

GAG-Cycle [Ground-Air-Ground Cycle]

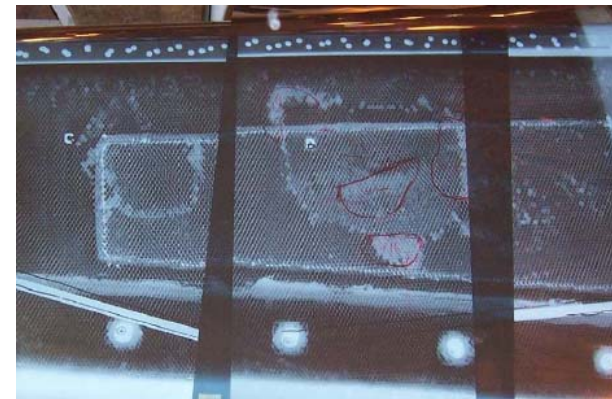
- In-Service occurrences with Sandwich Structures triggered comprehensive studies. Disbond due to:
 - Contamination.
 - Failed repair.
- The cause: Sandwich Damage Growth under GAG-cycle (Ground-Air-Ground)
- Airworthiness importance of the subject for primary structures
- Issue of adequate inspection methods & program to detect sandwich disbond and contamination.



In service experience

Bonded repair size limitations

- The today's limitations are due in part to badly performed bonded repairs which had subsequently failed in flight.
- These failures were due to inappropriate repair techniques, repair materials and repairs processes.
- The ongoing matter is the subject of scrutiny by forums and activities involving the Industry, FAA and EASA.
- The necessary steps for implementing a substantial improvement has not yet been achieved.



Damage in Sandwich Construction

Best practices for prevention/detection

Flight Control Sandwich Structures

In Service experience

Other experiences

Other experiences

Introduction

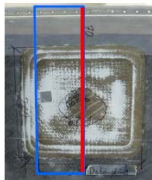
- Rudder inspections and repairs at Airbus facility detected several rudders with inadequate repair quality.
- **Indications are:**
 - repair disbonded
 - repair showing exothermic reaction within the core
 - repair on top of paint layers
 - repair crossing the lightning protection plate
 - core closing without outer skin repair
 - grinding thru the skin without repair
 - aggressive grinding of the skin (local grinding thru the skin plies)

Other experiences

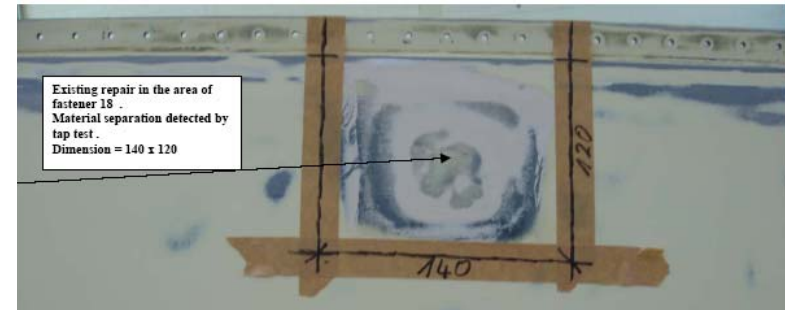
Disbonded repairs



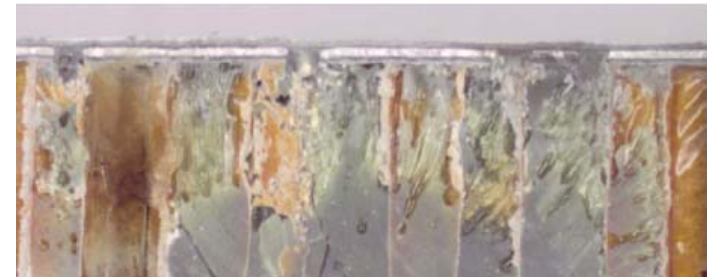
Disbonded repair and plies loosen on top of the skin



The outer skin and adhesive block underneath fractured and the skin was found disbonded



Disbonded (separation between the core and the repair skin plies)

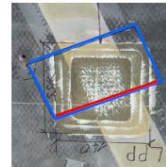
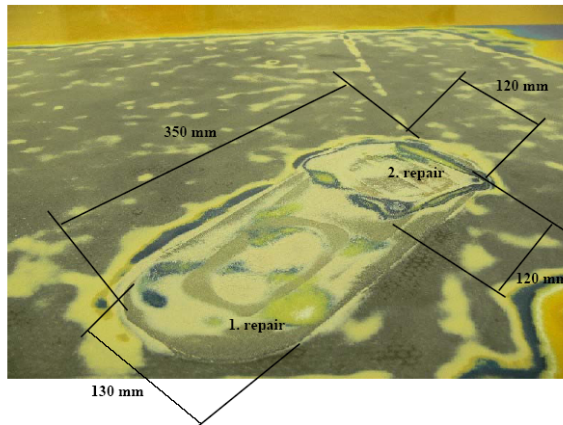


Resin injection in the core showing exothermic reaction

Other experiences

Disbonded repairs

Repair performed on top of existing paint layer. Combination of two repairs



Repair performed on top of existing Lightning Protection Plate



Core closing without outer skin repair plies



Other experiences

Paint stripping by grinding

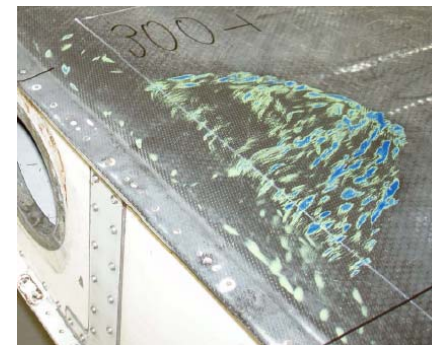
Local grinding through the skin, open honeycomb core



Thick paint scheme on the rudder (several paint systems)



Local aggressive grinding affecting the outer skin plies



Other experiences

Conclusions 1/2

- Based on the rudder repair in-service experience it is demonstrated that the basic requirements for composite repairs has not been achieved in some investigated repairs.
- Composite repairs require staff who is adequately trained and has professional composite repair knowledge.
- State of the Art composite repair knowledge
 - Environmental conditions (temperature, humidity, contaminants, condensation, composite repair shop vs. repair on A/C)
 - Use of materials which are specified in the SRM
 - Appropriate knowledge about the structure
 - Appropriate knowledge about the used materials and also auxiliary materials / consumables (storage, lifetime
 - Awareness of the consequence of repair step failure

Other experiences

Conclusions 2/2

- In case the sandwich repair is performed following the state of the art composite repair knowledge (see page before) the SRM repair principle provide good repair quality.
- A deviation to the SRM independent single or multiple process deviation can lead to inadequate repair quality.
- Need to increase composite repair awareness and repair knowledge
 - Through a common effort between AAs, Customers, MROs and Airbus (CACRC)
 - AC145-6 Repair Stations for Composite and Bonded Aircraft Structure from FAA is only a advisory circular guidance material and not a must.

Damage in Sandwich Construction

Best practices for prevention/detection

Flight Control Sandwich Structures

In Service experience

Other experiences

Consequences of findings on inspections

Consequences of findings on Inspections

Maintenance Program Improvements

- Based on the findings the maintenance manual for all Airbus sandwich rudders were improved.
- Depending the findings and the areas it was decided to consider the NDT method as follows:
 - TE insert areas and Hoisting Points:
 - by Thermography and Ultrasonic
 - The reinforced area
 - by Ultrasonic.
 - The surface
 - By ELCH and Thermography. (Health check)

Consequences of findings on Inspections

Inspection methods & capabilities

- **ELCH – Elasticity Laminate Checker**
 - Allows detection of inner/outer skin debonding
- **Ultra Sound – Hand probe**
 - Allows detection of inner/outer skin debonding, fluid, crushed core, core filler
- **Thermography**
 - Fluid detection



Damage in Sandwich Construction

Best practices for prevention/detection

Flight Control Sandwich Structures

In Service experience

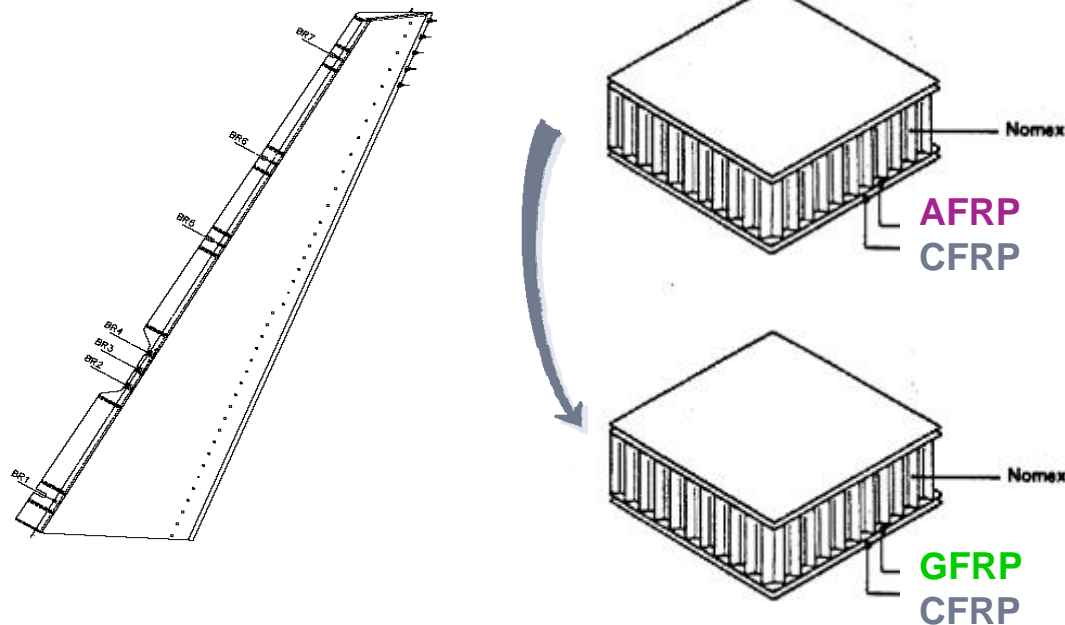
Consequences of findings on inspections

Structure improvements

Structure improvements

Rudders

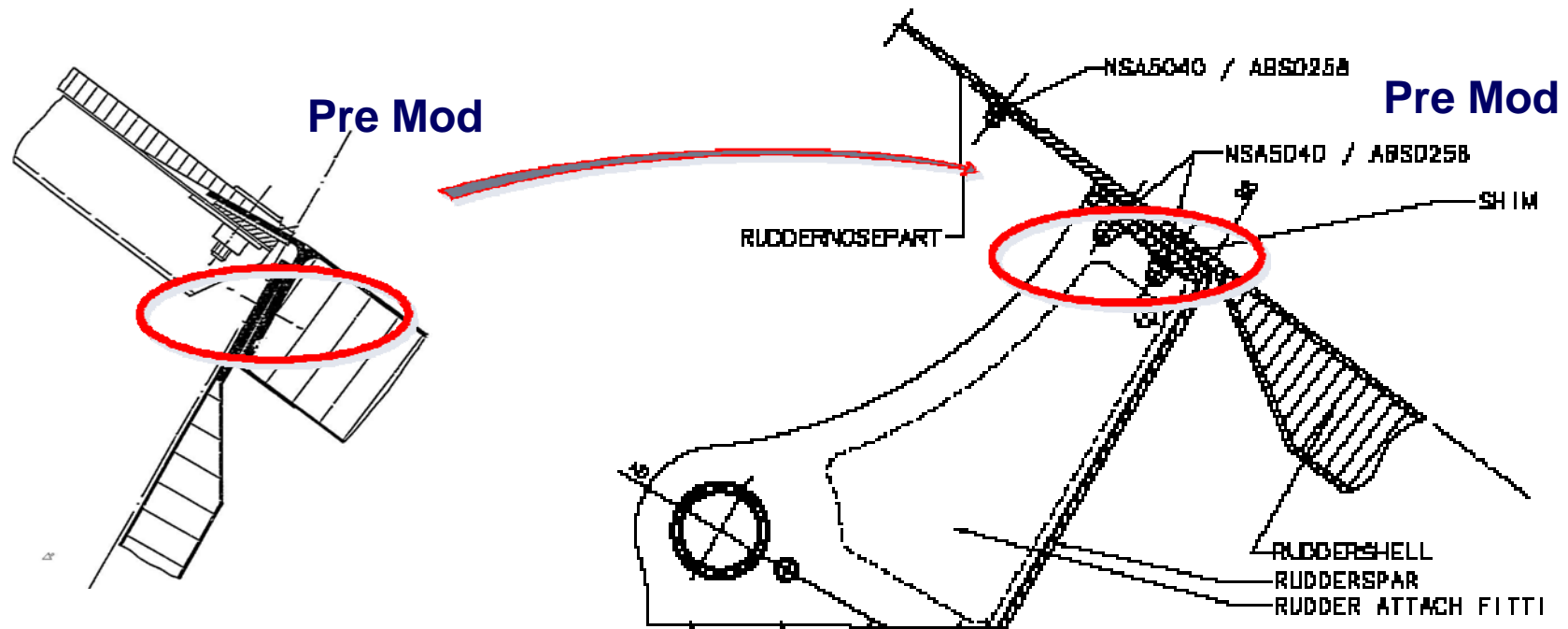
- Finding : Large debonding
- Design improvement:
 - Deletion of AFRP bridging layer and application of GFRP



Structure improvements

Rudders

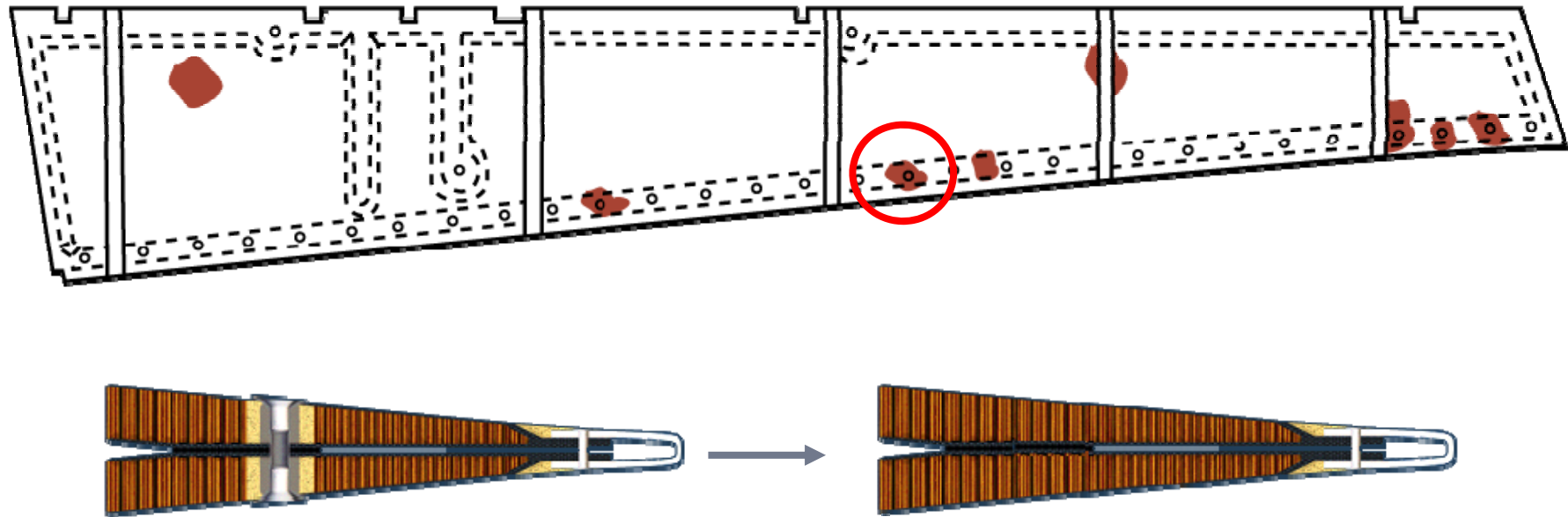
- Finding : Hydraulic fluid contamination
- Design improvement:
 - Panels (Skin and Spar) are attached through monolithic area



Structure improvements

Elevators

- Finding : Water ingress in the skin panels
- Improvements of design
 - By deleting the Trailing edge insert

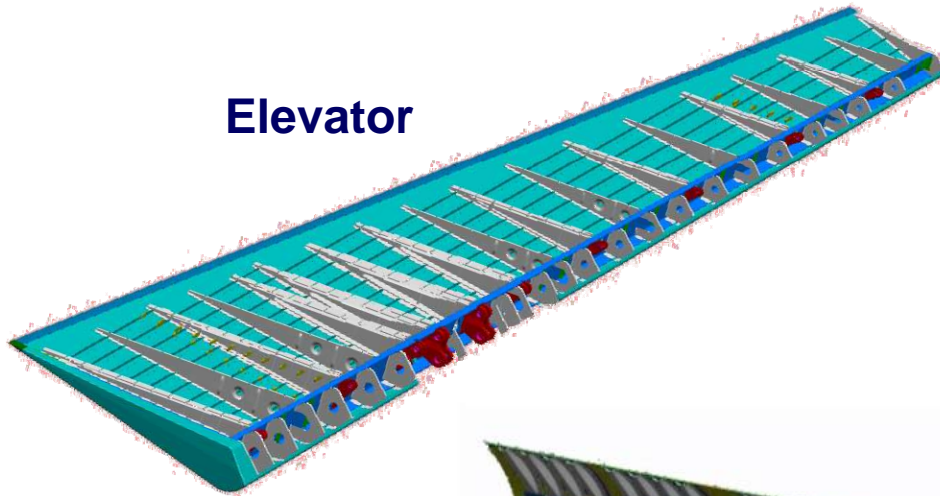


Structure improvements

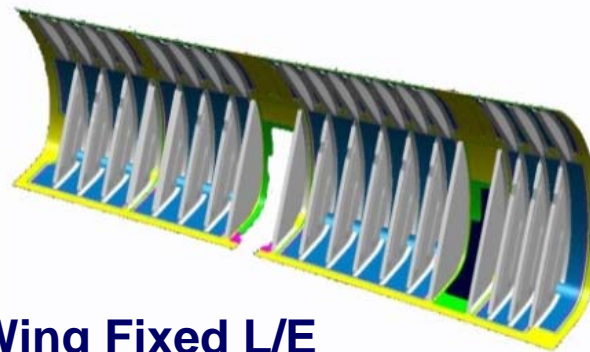
Sandwich to Monolithic

- **A340-500/600**

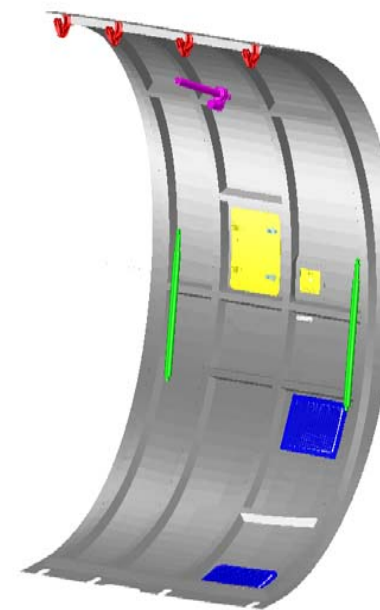
Elevator



Wing Fixed L/E



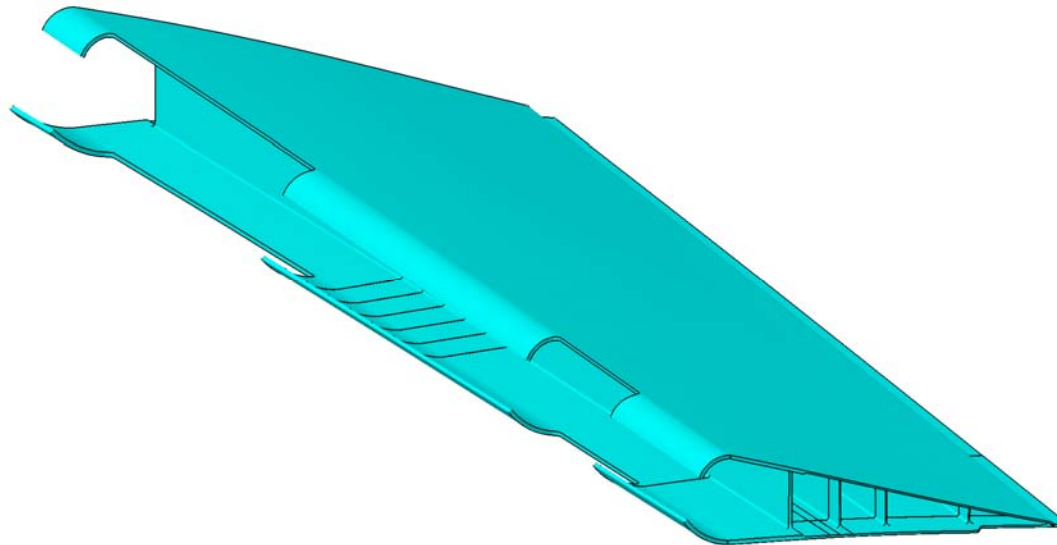
Fan Cowl Door



Structure improvements

Sandwich to Monolithic

- **A320 Aileron**

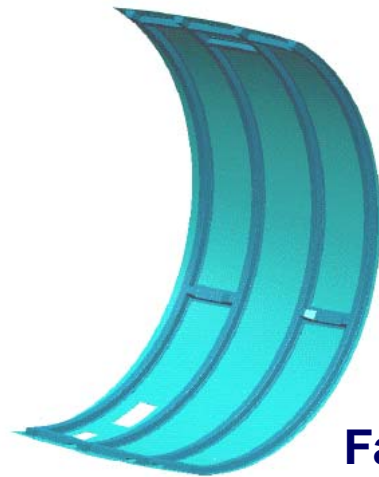


Structure improvements

Sandwich to Monolithic

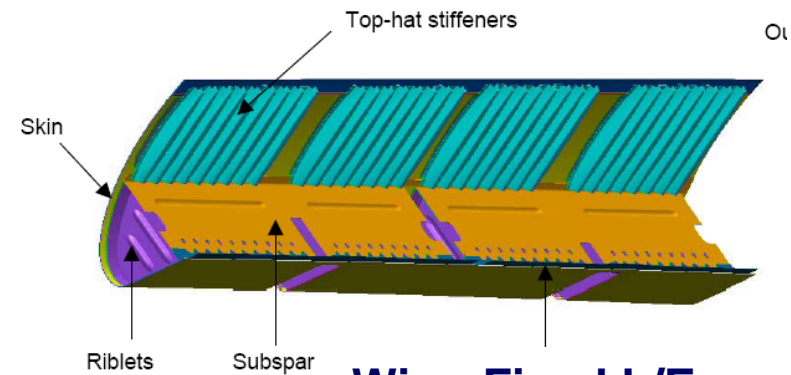
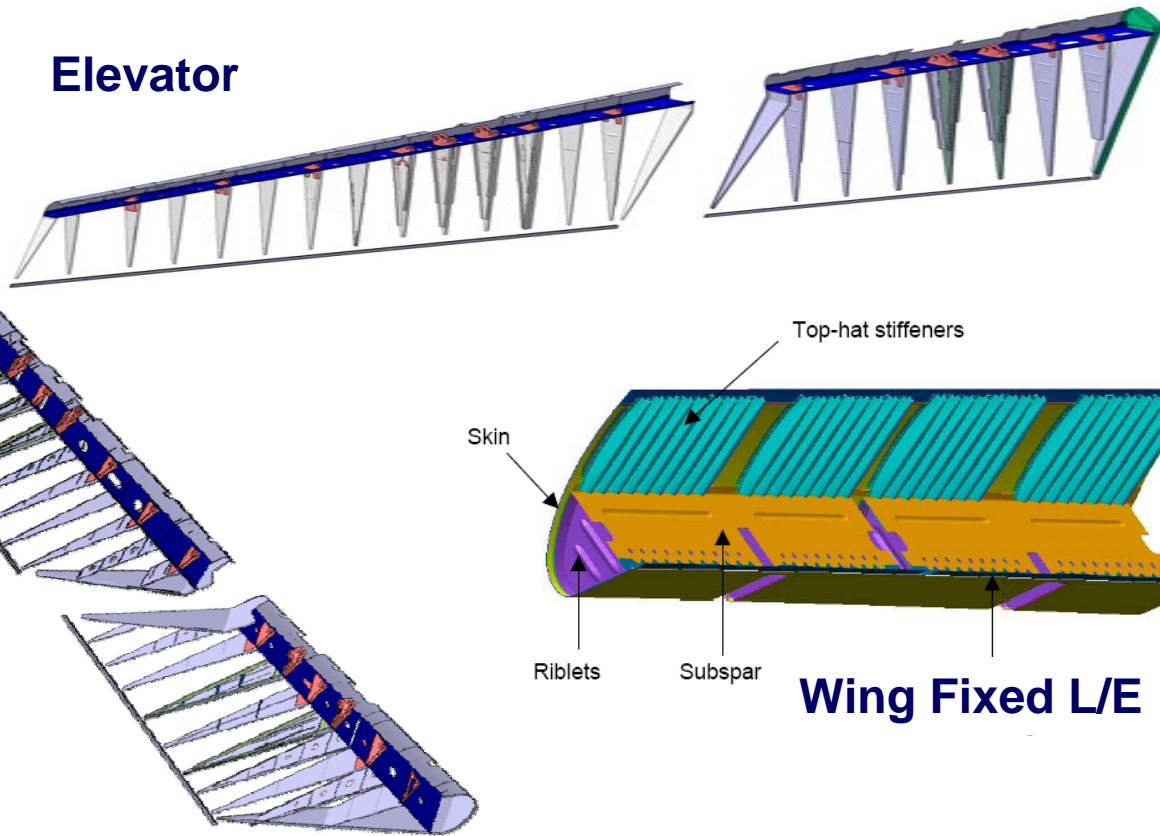
- **A380**

Rudder



Fan Cowl Door

Elevator



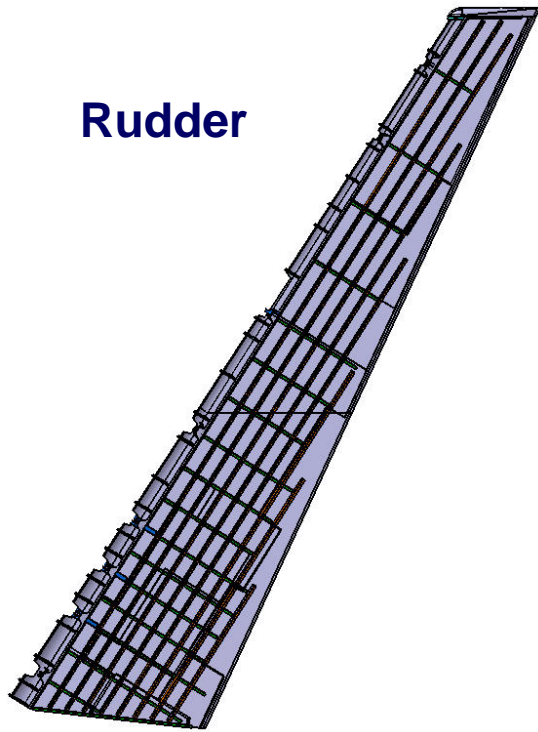
Wing Fixed L/E

Structure improvements

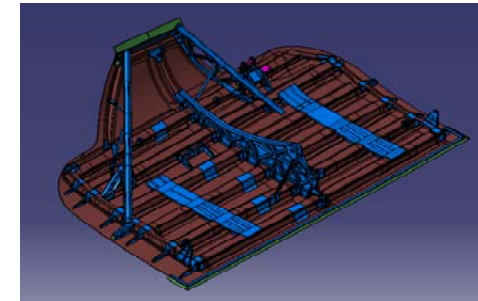
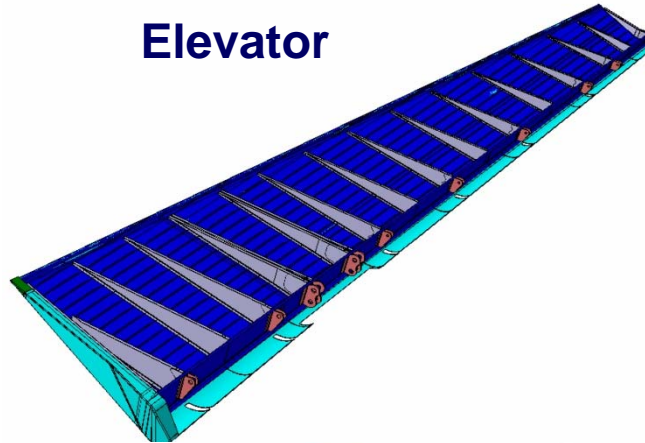
Sandwich to Monolithic

- **A350**

Rudder

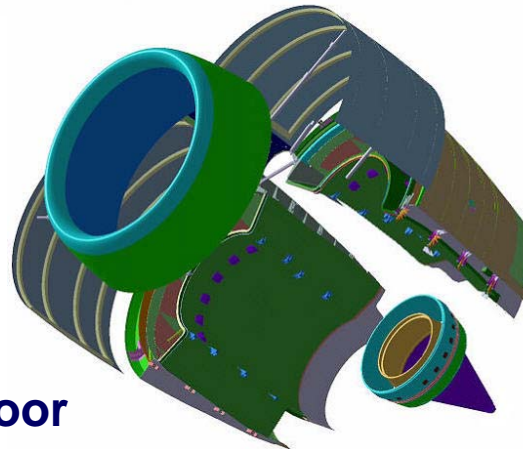


Elevator



**Main Landing
Gear Door**

Fan Cowl Door



Structure improvements

Conclusions

- Solutions exist to improve sandwich design
- But recent trade-off lead to replace Sandwich by Monolithic.

Damage in Sandwich Construction

Best practices for prevention/detection

Flight Control Sandwich Structures

In Service experience

Other experiences

Consequences of findings on inspections

Structure improvements

Key messages

Key messages

- *No fatal accident over this period can be imputed to the deficiency of a composite structure.*
- *Thus, the whole community, first of all the aircraft manufacturers, but the AA's too, 'did a good job'.*
- *However, we have to imagine that one day a fatal accident due to a composite part structural deficiency will happen.*
- ***The question is : What we will have unconsciously missed or ignored that will explain the accident ?***

By J. Rouchon



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