

Presented by
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FAA Workshop for Composite Damage Tolerance and Maintenance
June 4-5, 2009
Tokyo

Flight Control Sandwich Structures and Inspections

Flight Control Sandwich Structures & Inspections

Background

Scheduled maintenance

Un scheduled maintenance

Recommendations & Improvements

Revised Rudder WB SSI

Key messages

Flight Control Sandwich Structures & Inspections

Background

Background

Workshop in Amsterdam

- **Elevators**

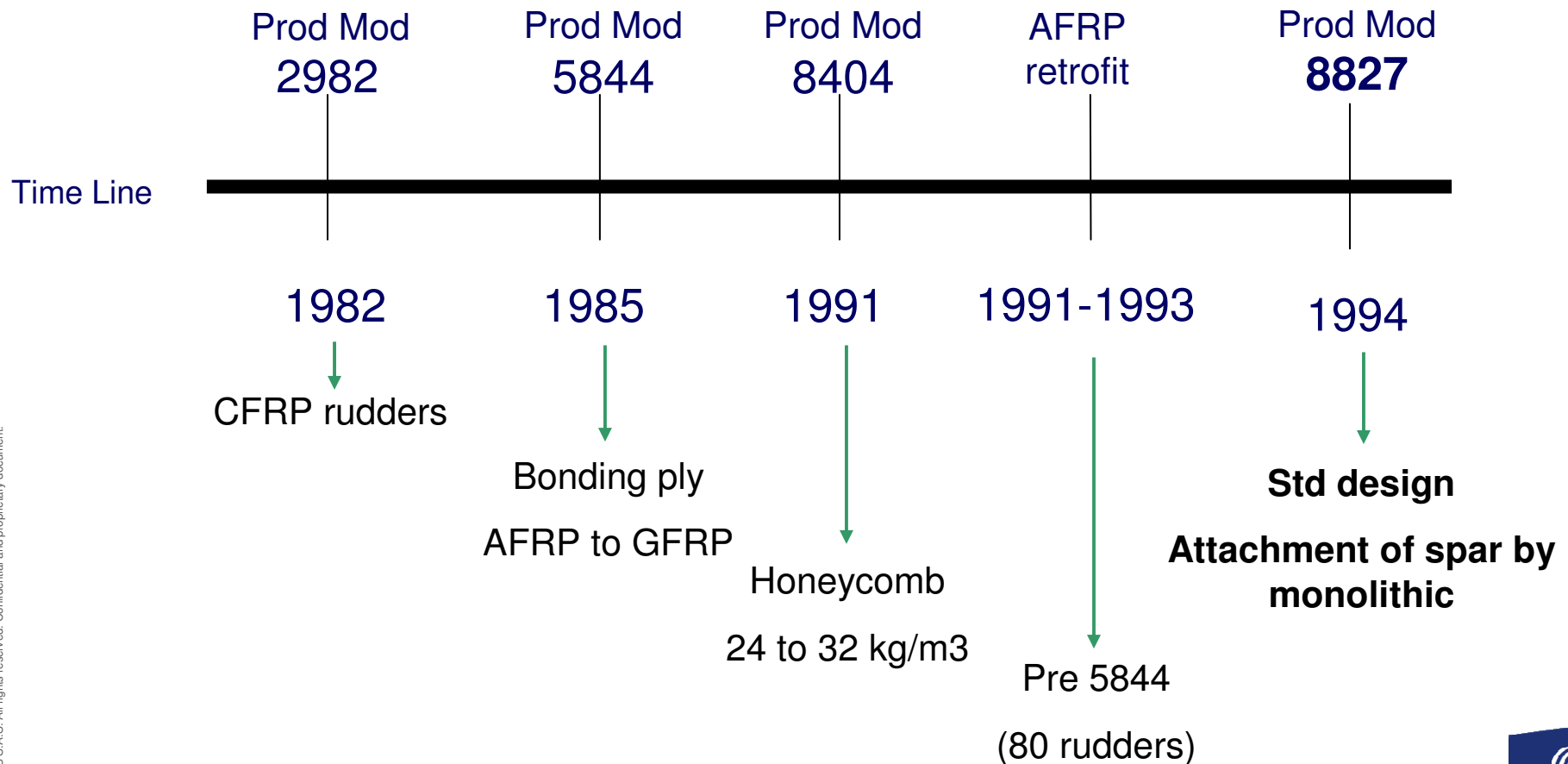
- ▶ Water cannot be left unrepaired on elevator composite sandwich primary structure
- ▶ Mandatory repeated thermography inspection is required
- ▶ Deep change in design have been introduced

- **Rudders**

- ▶ Until March 2005, rudders showed satisfactory in-service experience (except Aramid early design – unfit to fly)
- ▶ Recent experience showed unexpected rudder damage types:
 - Disbond (skin to core)
 - Fluid ingress & skydrol contamination
 - Incorrect repairs, maintenance
- ▶ Need to improve the inspection program and the associated NDT technique to cover invisible damages
 - ELCh, ultrasonic, ...

Background

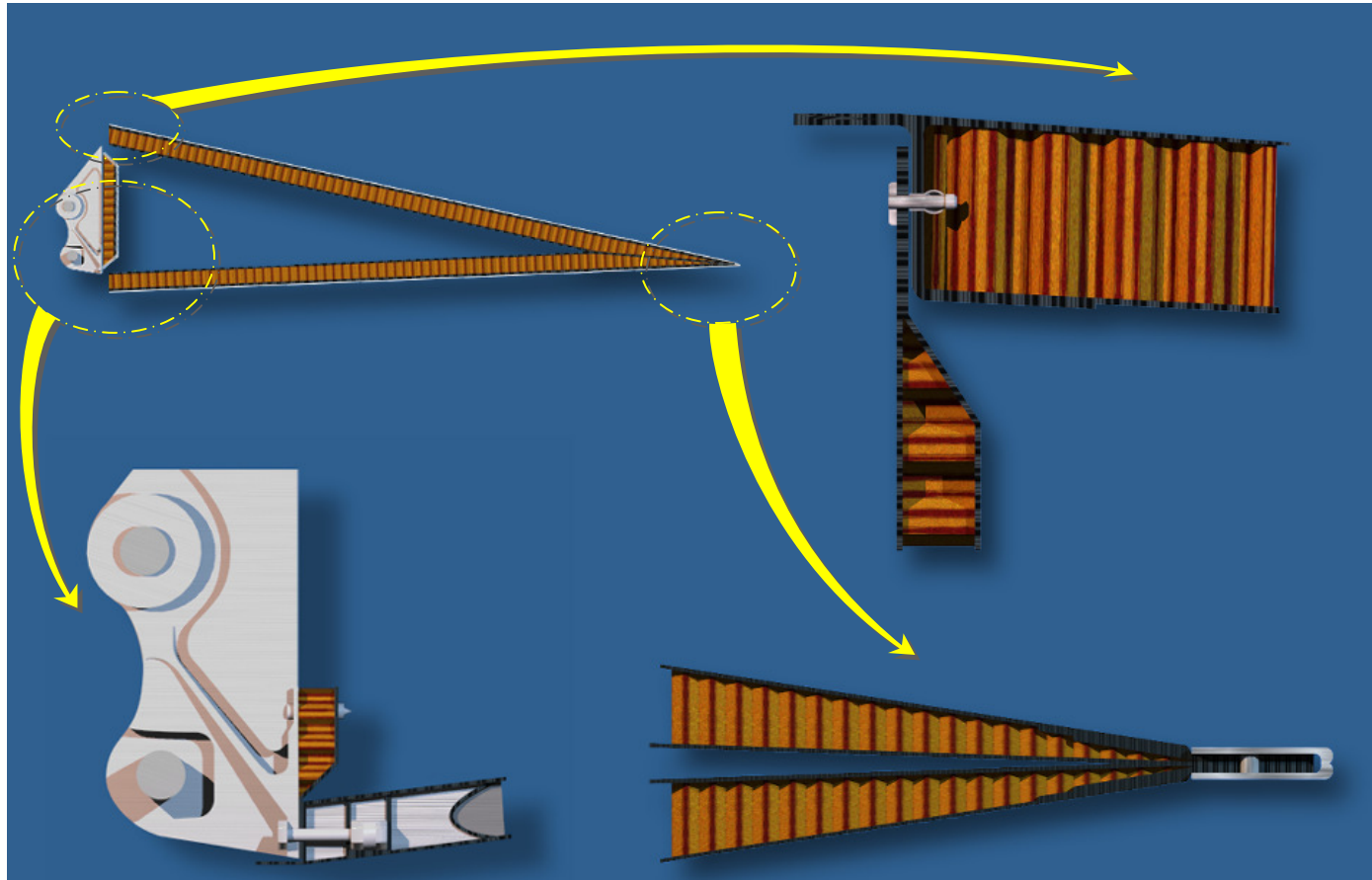
Composite WB Rudder modification evolutions



Background

Composite WB Rudder modification evolutions

▶ Mod 2982

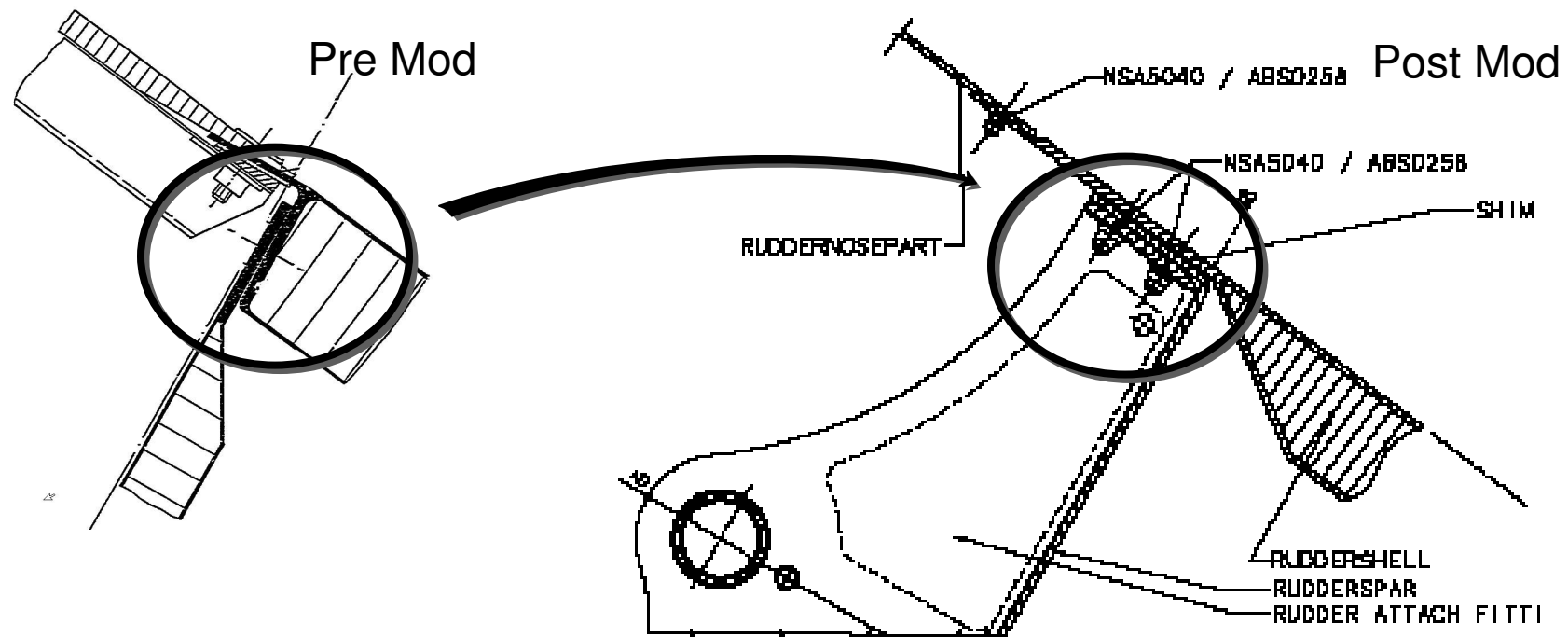


Background

Composite WB Rudder modification evolutions

► Mod 8827

Panels (Skin and Spar) are attached through monolithic area



Flight Control Sandwich Structures & Inspections

Background

Scheduled maintenance

Scheduled maintenance – WB Rudders

The initial scheduled maintenance for WB rudder consisted of the following tasks:

Walk around visual inspection of the rudder -GVI	Pre flight check
General visual inspection of the rudder from arm length distance -GVI	2C-check
Rudder hinge free-play measurement	4C-check
Detailed visual inspection (DVI) of rudder hinge fittings	5-years
DVI of rudder spar	5-years
Special Detailed Inspection of rudder side panels according NTM procedure (Tap Test)	5-years

Scheduled maintenance – WB Rudders

NTM rudder side panel tasks

- **Before MOD8827**
 - ▶ **SSI 55-40-04**
 - Glass block inspection
 - Ultrasonic
 - MPD Interval: 5 years
 - ▶ **SSI 55-40-05**
 - Special detailed inspection of rudder skin panel:
 - tap test
 - Areas
 - 40mm strip, 100mm aft of the leading edge
 - 40mm strip, 400mm forward of the trailing edge
 - around hoisting points
 - MPD Interval: 5 years

Scheduled maintenance – WB Rudders

NTM rudder side panel tasks

- **After MOD8827**
 - ▶ **SSI 55-40-05**
 - Special detailed inspection of rudder skin panels
 - Ultrasonic
 - Resonance frequency (Tap test, Bondmaster)
 - Areas:
 - 40mm strip, 100mm aft of the leading edge
 - 40mm strip, 400mm forward of the trailing edge
 - Around hoisting points
 - MPD Interval: 5 years

Flight Control Sandwich Structures & Inspections

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Un scheduled maintenance

Un scheduled maintenance – WB Rudders

Chronology for inspections

- ▶ 2005: In flight event
 - external tap test + visual One time inspection
 - OIT 996.0080/05 about Pre Mod

- ▶ 2006: Debonding
 - internal tap test + visual One time inspection
 - OIT 999.0027/06 & TFU 55.40.00.002 about Pre Mod

- ▶ 2007: issue of two SBs
 - “Z-profile” UT inspection about Pre Mod
 - A300-55-6043 & A310-55-2044 (Repetitive)
 - “TE & HP” thermo + UT inspection about Pre Mod
 - A300-55-6044 & A310-55-2045 (One time)

Un scheduled maintenance – WB Rudders

Z-profile area inspection along complete profile

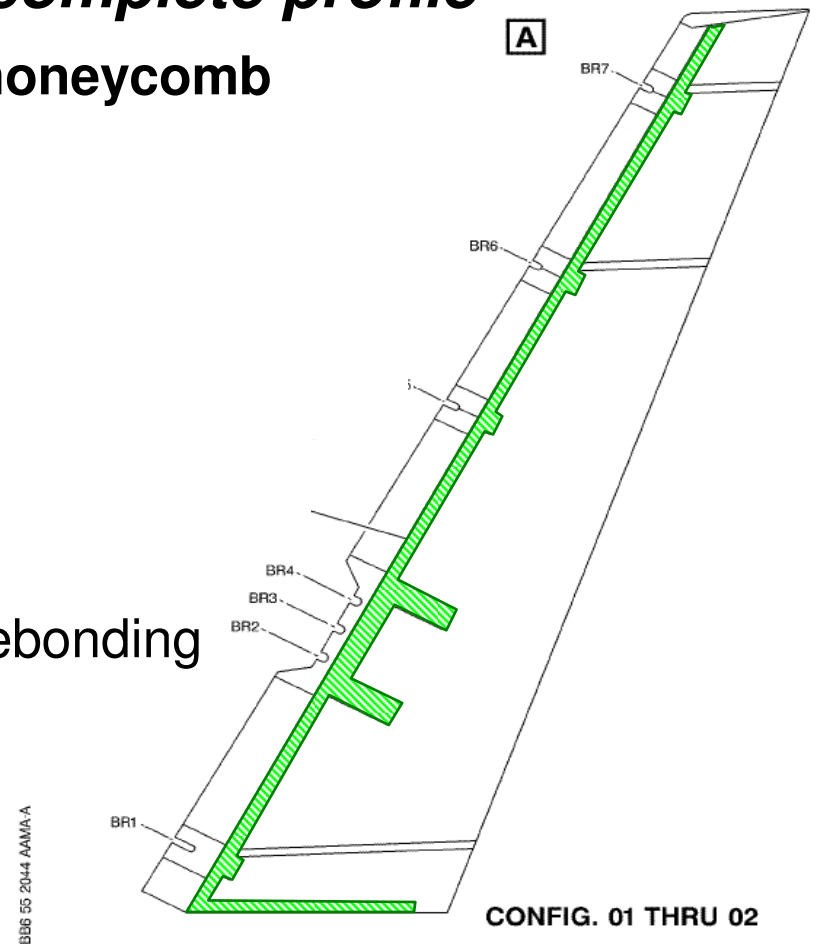
▶ Check bonding of both skins / honeycomb

- ISBs issued end July 07
- AD 2007-0266 issued

– Inspection method capability

- Ultrasonic

- ▶ Outer skin delamination
- ▶ crushed core
- ▶ inner/outer skin to core debonding
- ▶ water ingress

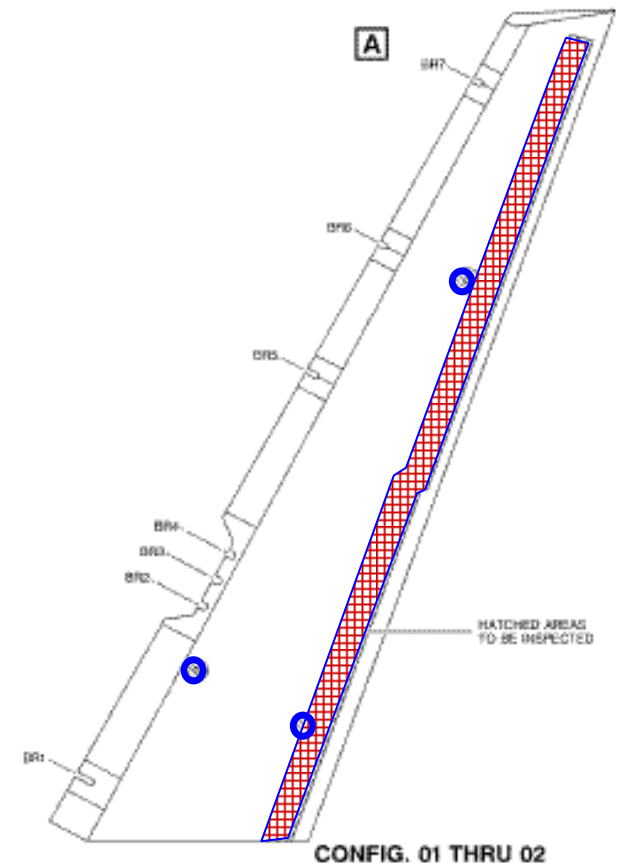


Un scheduled maintenance – WB Rudders

Hoist points & trailing edge screw areas inspection

- ▶ **Check for water contamination**
 - ISBs issued end July 07
 - AD 2007-0266 issued
 - New ‘combined’ ultrasonic & thermographic procedures

- Inspection method capability
 - Thermographic
 - ▶ Water ingress
 - Ultrasonic
 - ▶ Outer skin delamination
 - ▶ Crushed core, inner/outer skin to core debonding
 - ▶ Water ingress



Un scheduled maintenance – WB Rudders

Today's status

- ▶ The concerned fleet have been inspected.
- ▶ SB about the Z profile
 - Around 10% of the inspected Rudders are with finding
 - only fluid - no disbond
 - These findings are eliminated by the Mod 8827 (WB)
- ▶ SB about water ingress
 - Around 50% are with fluid ingress findings
 - only fluid - no disbond
 - These findings are not addressed by the Mod 8827 (WB)
 - The designs in the area of Trailing Edge inserts and the Hoisting Points are common between WB/LR (pre and post mod) and the SA rudders. Common means that if there are few differences between the design features they are recognized as having no influence of the liquid tightness.

- ▶ All findings are airworthy.

Flight Control Sandwich Structures & Inspections

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Maintenance Program Improvements

Maintenance Program Improvements

Reason for maintenance task improvement

- ▶ Based on the findings the current **maintenance manual** for all Airbus sandwich rudders is considered **not optimised** and therefore should be improved.
- ▶ The improvement is related especially to rudder structure discontinuities at hoisting points and trailing edge screw area to detect water ingress and/or debonding and generally to the overall sandwich panel to find defects.
- ▶ With reference to the here above and the commonality between all the designs, it is possible to get on all the fleets of all programs the same type of findings. The recommendation is therefore to inspect all these rudders.
- ▶ Maintenance programs, is already applied to the Pre mod Rudders (WB) and considered to the Post mod designs for WB.

Maintenance Program Improvements

Way forward

- ▶ The **threshold** as well as the **interval** have to be **justified by the numerous available data** obtained by the existing SBs which have shown that all damage are airworthy.
- ▶ In order to cover all Rudder areas inspected by thermography and Ultrasonic through the SBs for the Pre Mod design such as
 - TE insert areas.
 - Hoisting Point.
- ▶ it is recommended to also inspect:
 - the surface with ELCH and Thermography.
 - the reinforced area with Ultrasonic.

Maintenance Program Improvements

WB Rudder side panel maintenance

- ▶ The NTM Part 1 General SSI 55-40-05 is affected by the ISBs and the inspection procedure to be introduced after the application of the one time inspection in the frame of regular maintenance.

- ▶ For **Pre**-mod 8827 rudders the NTM has to be revised.
 - The inspection at the rudder LE is superseded completely by ISB no. A310-55-2044 and A300-55-6043
 - The inspection at the TE screw line and hoisting points is superseded the procedure requested by ISB A310-55-2045 and A300-55-6044 and shall be performed every 6 years.

Maintenance Program Improvements

WB Rudder side panel maintenance

- ▶ For **Post**-mod 8827 rudders the NTM should also to be revised.
 - The inspection procedure concerning the hoisting points and the TE screw line should be updated to the contents of the one time inspection as required by ISB A310-55-2045 and A300-55-6044 and shall be performed every 6 years.
 - Inspection behind rudder bearing fittings shall be performed exclusively by Ultrasonic every 6 years.
 - In addition, the inspection as performed by the one time ISB should be completed by an ELCH -inspection and introduced as regular maintenance task (interval 5 years) for the panel of all rudders.

Maintenance Program Improvements

SA and LR sandwich rudders

- ▶ The inspection at the trailing edge screw line and hoisting points should be modified/ replaced by the procedure applied to WB/LR Post-MOD 8827 and 40904 rudder one time inspection (e.g. ISB A310-55-2045).
- ▶ Inspection behind rudder bearing fittings shall be performed exclusively by Ultrasonic every 6 years.
- ▶ Complete surface inspection by ELCH and reinforced area with Ultrasonic
- ▶ Interval: 5 or 6 years depending on the A/C related MPD

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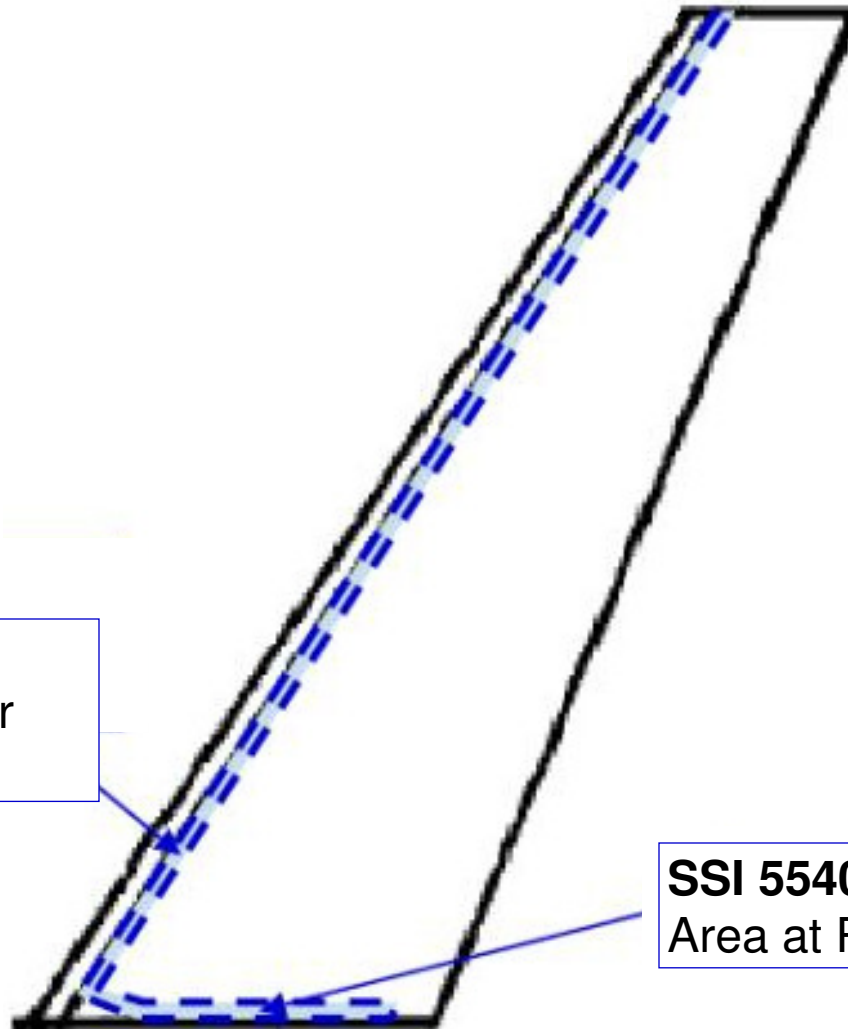
Maintenance Program Improvements

Revised Rudder WB SSI

Revised WB Rudder SSI

Tap test

SSI 554009
Area at Front spar
(Pre 8827)



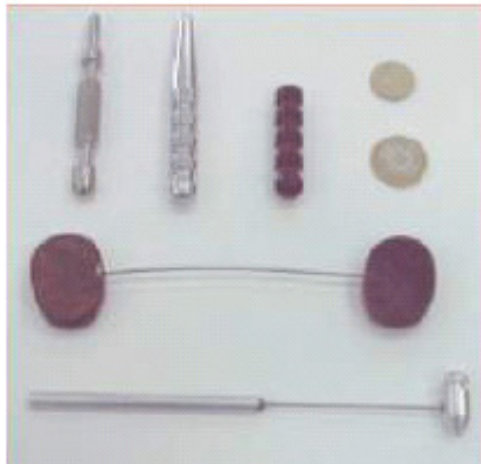
SSI 554009
Area at Rib 0 (Pre 8827)

Revised WB Rudder SSI

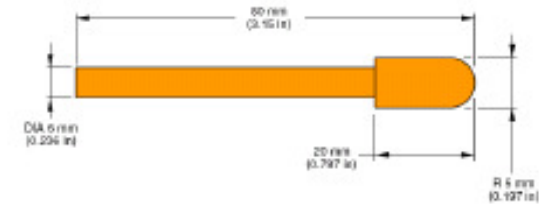
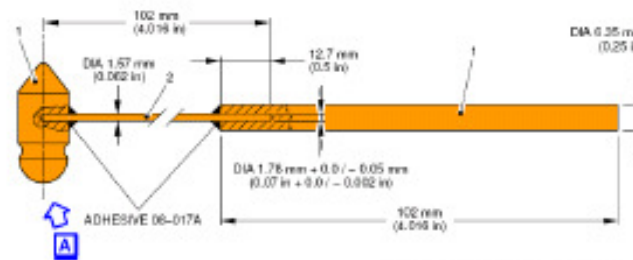
Tap test

► Detection of Outer skin debonding

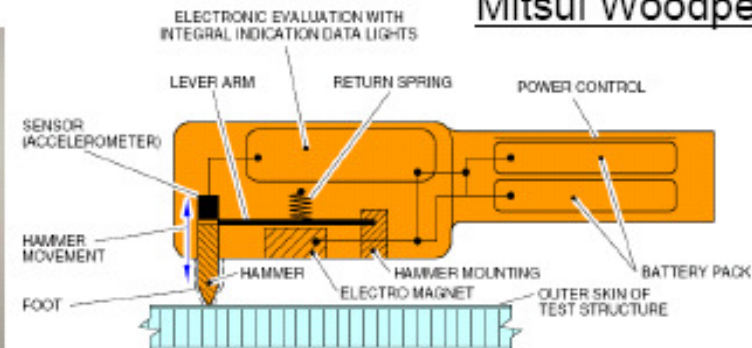
- Min. detectable damage size: 25x25mm depending on sandwich configuration (face sheet thickness up to 1.8mm)



Manual Tap Test

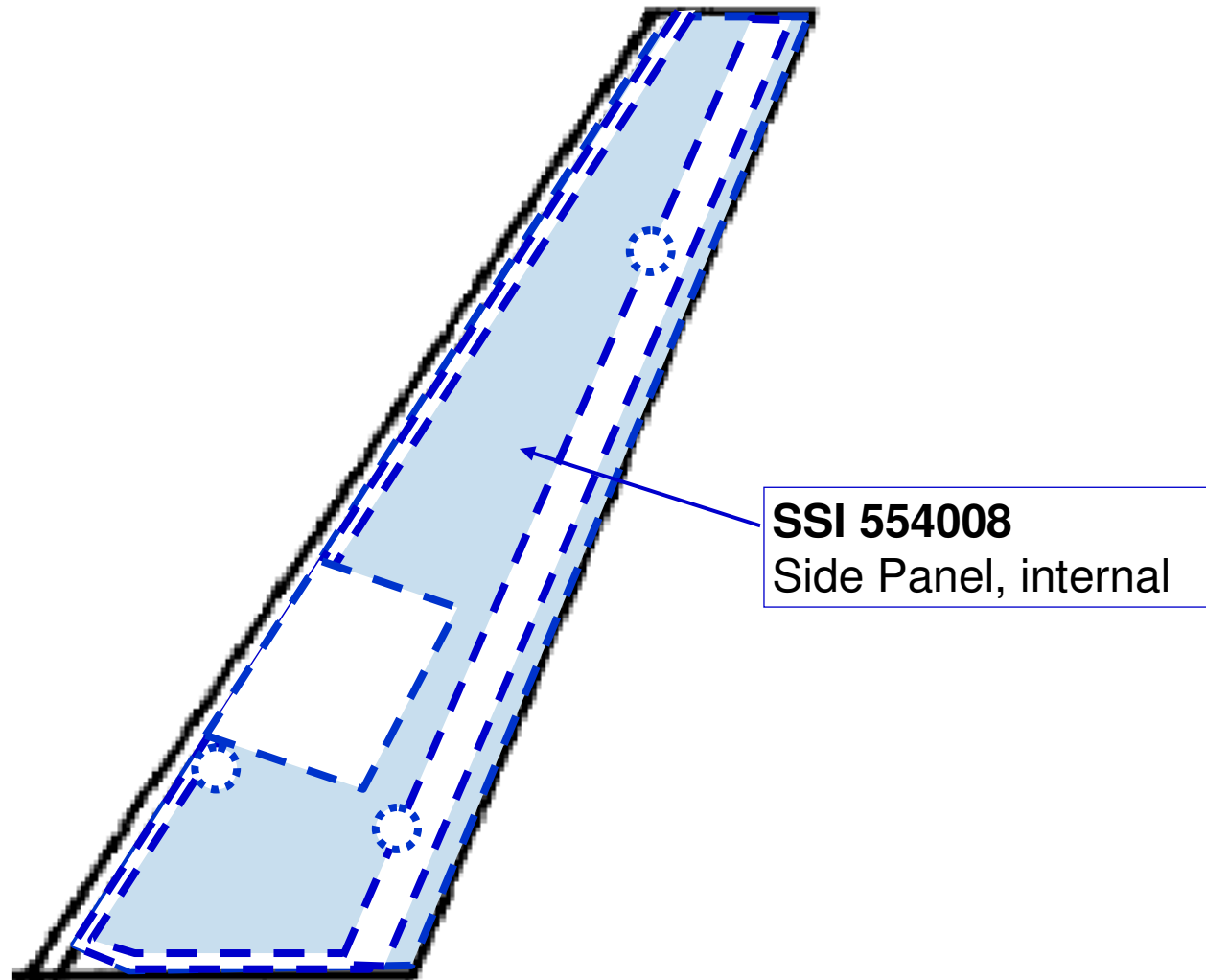


Mitsui Woodpecker



Revised WB Rudder SSI

ELCH

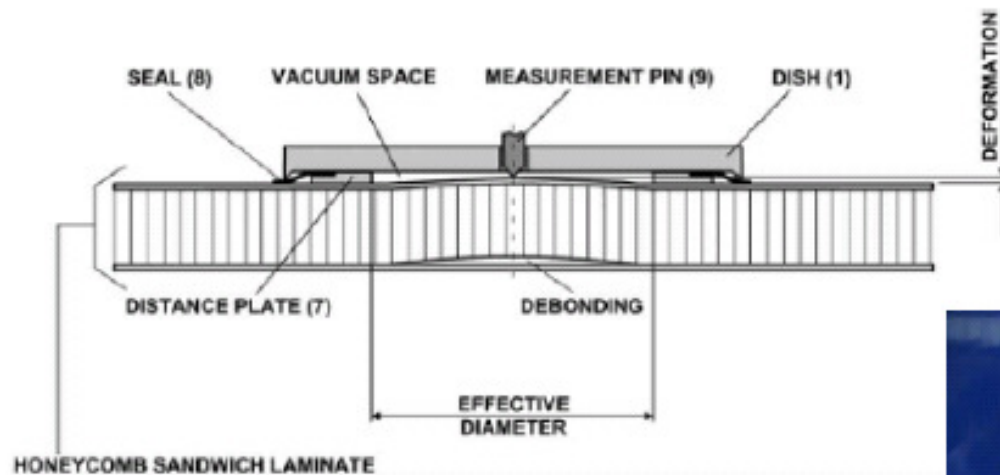


Revised WB Rudder SSI

ELCH (Elasticity Laminate CHecker)

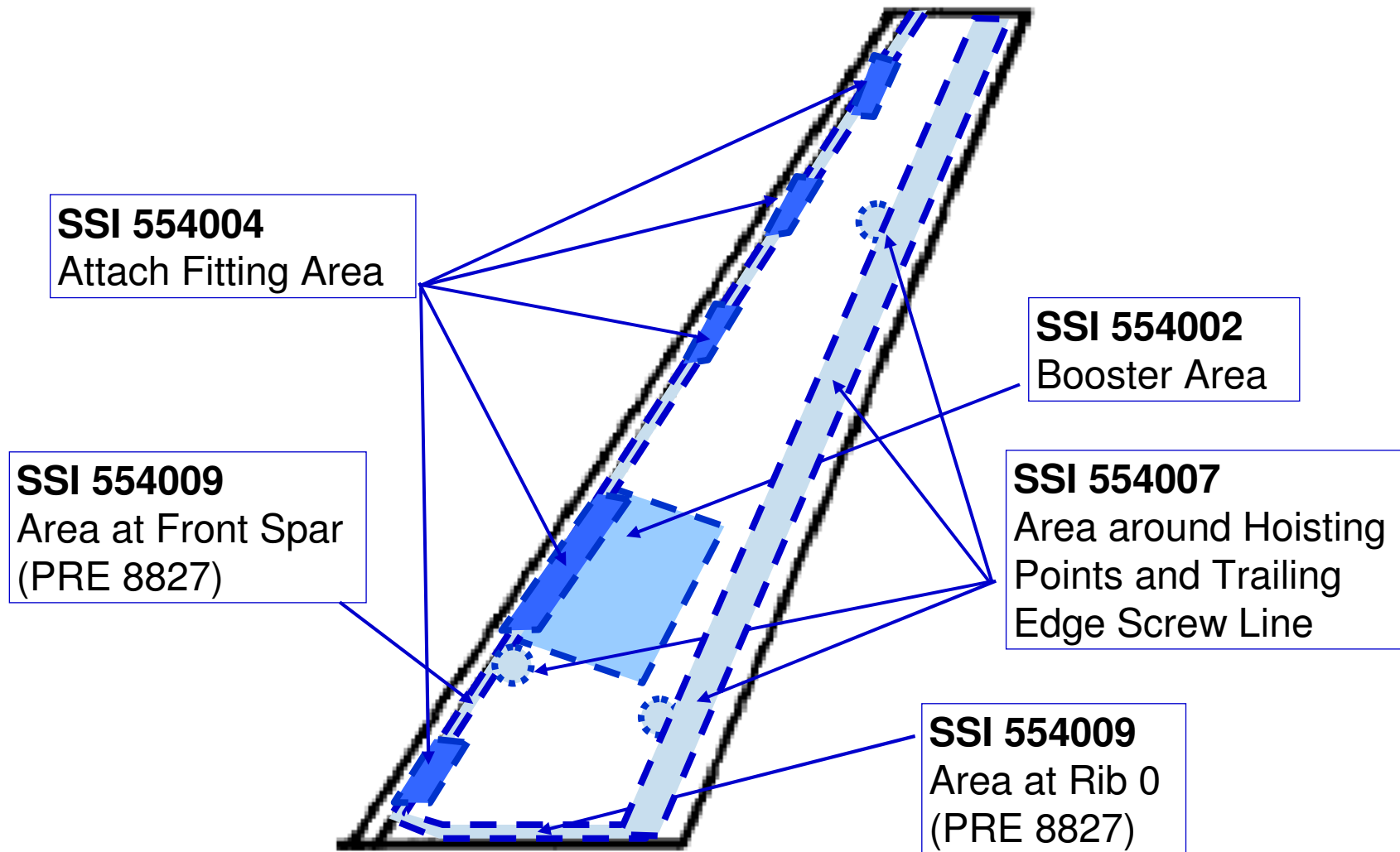
▶ Detection of Outer and inner skin debonding and core fracture

- Min. detectable damage size: $D=100\text{mm}$ depending on sandwich configuration (face sheet thickness and core height, density)
- The test unit operates to the principle of deformation measurement of a sandwich structure under vacuum



Revised WB Rudder SSI

Ultra Sound

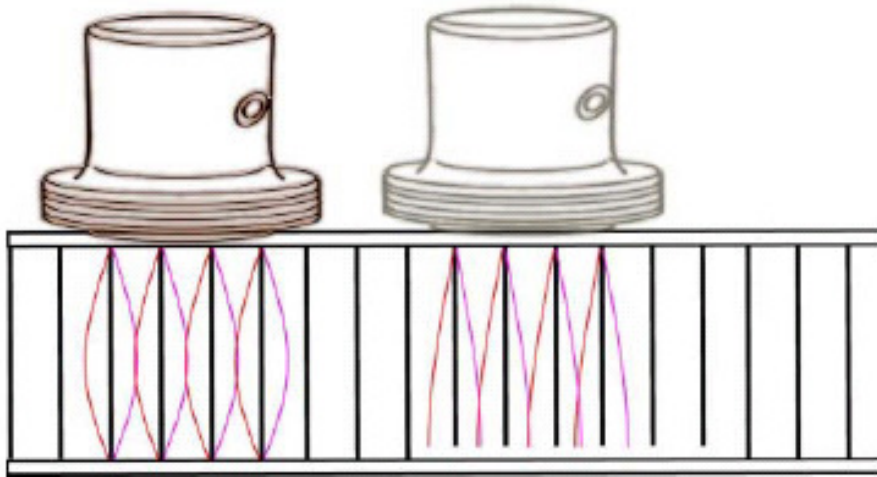


Revised WB Rudder SSI

Ultra Sound

► Detection of debonding, core fracture and fluids

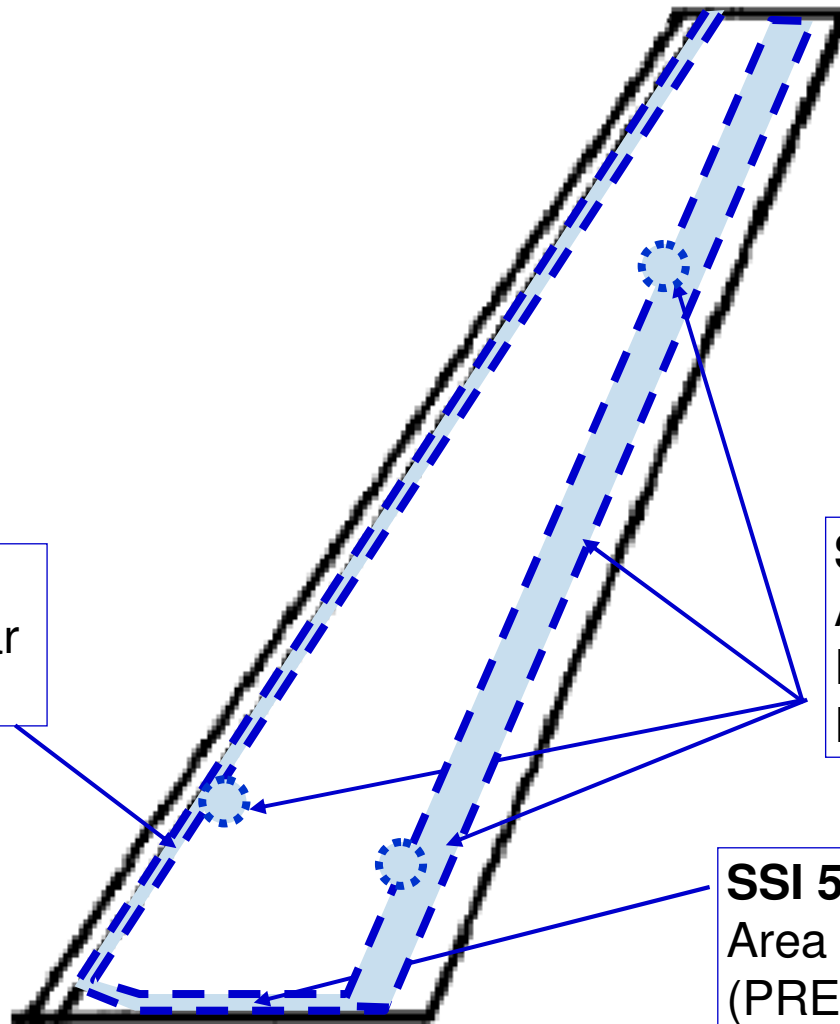
- Min. detectable damage size: 40x40mm
- The UT Procedure uses kind of guided wave. System must be tuned to core height (membrane length = $\frac{1}{2} \lambda$)



Revised WB Rudder SSI

Thermography

SSI 554009
Area at Front Spar
(PRE 8827)



SSI 554007
Area around Hoisting
Points and Trailing
Edge Screw Line

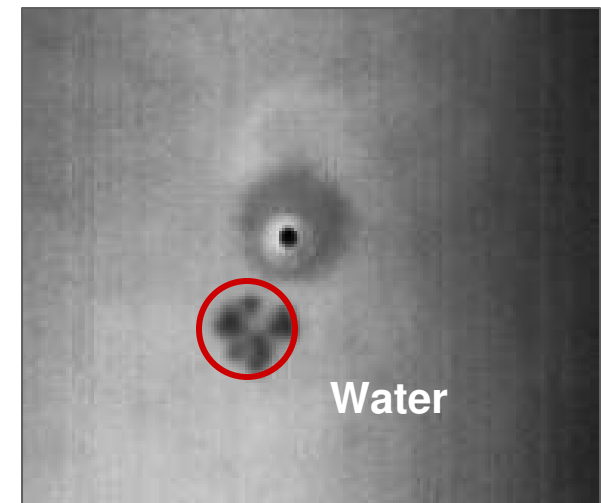
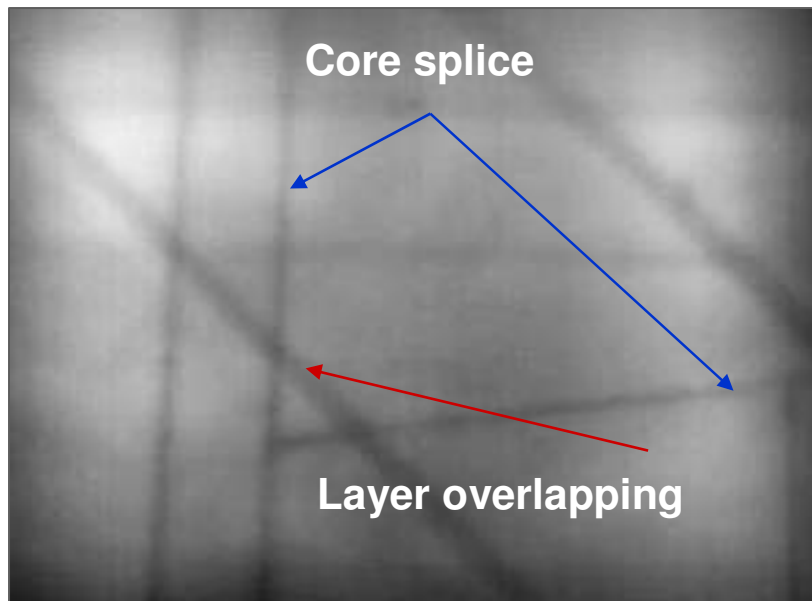
SSI 554009
Area at Rib 0
(PRE 8827)

Revised WB Rudder SSI

Thermography

► Detection of fluids

- By measurement of temperatures difference on the surface, following thermal excitation with hot air gun.
- Performance
 - Few millimeter Penetration
 - Honeycomb cells containing more than 50% of trapped fluid per cell in areas equal to or greater than 100 mm² in size.



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Recommendations & Improvements

Revised Rudder WB SSI

Key messages

Key messages

- In service occurrences (water ingress,...) within sandwich flight control structures such as Rudder, Elevators.
- SB have been issued to ensure continued airworthiness.
- Heavy change taking into account the experience have been introduced within the Maintenance program.
- In the same time deep change in the design have been considered.
- Implementation of new inspection means
- Recent trade off lead to the selection of Monolithic design replacing sandwich on Rudder and Elevators.

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