Operator Field Experiences and Future Perspectives

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A STAR ALLIANCE MEMBER

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Topics

Field Experiences

- **Bonded FCBS structures**
- **Monolithic versus Honeycomb repairs**

Future Perspectives -

- **Regulatory**
- **Industry standardization**
- **Airline / OEM exchange**

Field Experiences – Context

FCBS Structure:

- Added by Part 26 Aging Aircraft rule
- Parts not PSE but are FCBS
- Major Repairs requiring FAA-approved data

Component PSE and FCBS						
Name	747-400	737-300/ 500	757-200	767-300	777-200	A320
Elevator		1,2,3,4,8	X	1,2,3,4	4,7	1,2,4
Rudder		1,2,3,4	1,2,3,4	1,2,3,4	4,7,8,1,2	1,2,3,4
Spoilers						2,3
Aileron						4
OB Flap	7	7	7	7	X, 7	1,2, 3, 4
IB Flap	7	7	7	7	X, 7, 3	1,2,3,4,5,8
LE Devices			X	X		2,6
Notes:	Sub-components		Primary Material Color Code			
1	Spar			=	Graphite and hybird	
2	Skin			=	Fiberglass	
3	Ribs			=	Metalbond	
4	Fittings			=	Sheetmetal	
5	Nose cap					
6	TE Wedge					
7	Main box					
8	Tab					
x	= PSE, blank is not					
Red = added for FCBS						

Field Experiences

- Composite experience at airlines is resides in shops
- UAL Composite repair history -
  - Composite shop capabilities evolved
    - 1st autoclave in 1960s for metalbond repairs on DC10, 727, etc.
    - PABST program
    - 2nd Autoclave in 1974, with PAA line, bond room, etc.
    - Bigger freezer in 1990s for prepregs
    - Mechanical test lab and receiving inspection program in 1991
  - Rebuilding / Skin and core replacement
    - Flaps, Slat Wedges, Wing panels
    - Metal-bonded parts before corrosion-inhibiting primers and better anodizing
    - Large damage due to trucks, FOD, etc.
    - Fleet campaigns to fix design problems such as 757 Spoilers, Slat Wedges, Graphite fan Cowls with aluminum honeycomb, moisture ingression
  - Support of hanger checks
    - Heat blanket repairs to minimize disassembly and exposure to heat
    - Parts sent to shop
    - Mechanics sent to airplane for on-wing repairs

Field Experiences

FCBS Repairs –

- See past examples from Todd Harrington in ATL 2009, and myself in Tokyo Workshop 2009:
  - Elevator, Ailerons – large repairs from ground equipment damage
  - Rudders – spars spliced
  - Flaps – reskin of aluminum honeycomb skin panels
- Non-FCBS: Primary and secondary structures:
  - Authorized by SRM, SBs, with approval/help of OEM
    - 757 spoiler SB – over 500 Spoilers re-skinned.
    - 747/757/767 Inlet cowl SB and Rework Drawing - Outer Barrel Kevlar removal
  - Nacelles – large damage and repairs
    - Sources is heat, trucks, burst ducts, boroscope plugs left out, engine fires, engine temps higher than design objectives.
    - Highest cost structural component make repair a economic necessity and able to justify large investments
  - Fan Cowls
    - Pre-cured graphite skins secondarily bonded to alum honeycomb
    - Developed in-house a FAA-approved Reskin procedure, with little assistance from OEM.
    - At worst, we were seeing over 120 removals per year for fleet of 620 Fan Cowls
    - Over 200 Reskins to date

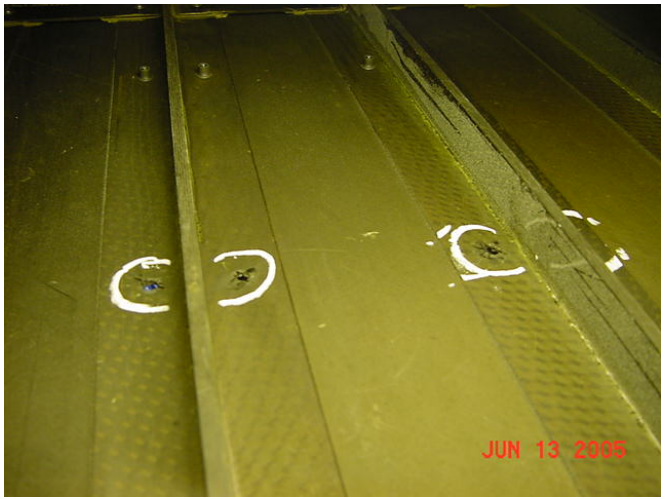
Field Experiences

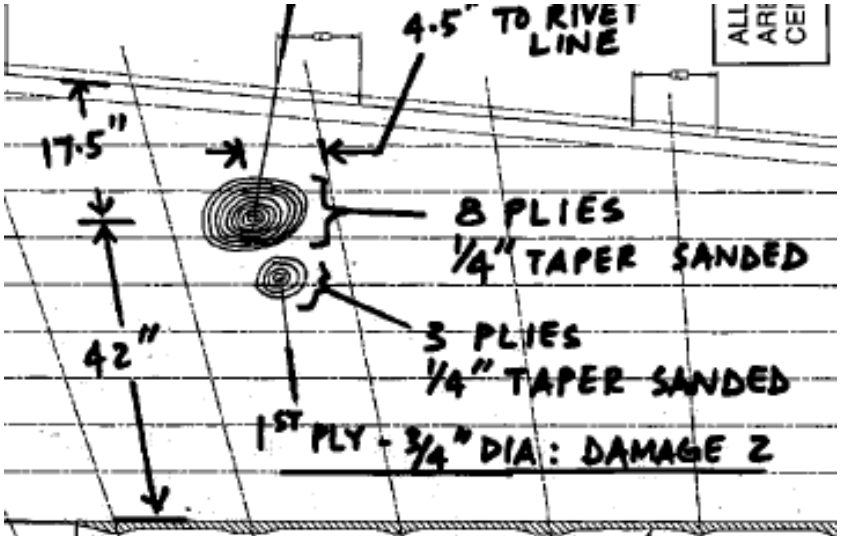
Monolithic FCBS includes:

- A320 and 777 Flaps - Main Box
- A320 and 777 Horizontal and Vertical Stabilizer

On-wing field repairs repair options:

- Bonded repairs – not many published to restore original strength – and limited in size
- Add fasteners – disbonded stringers, or at risk of disbond
- Bolted patch with graphite autoclave cured repair parts
- Bolted patch with metal repair parts





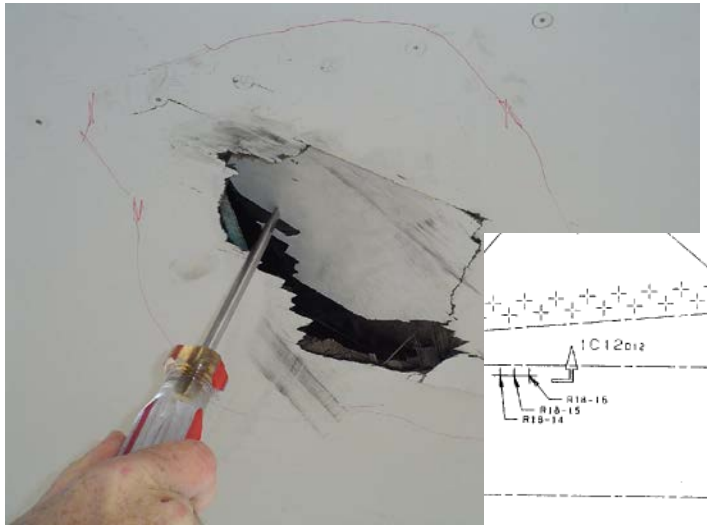
Field Experiences

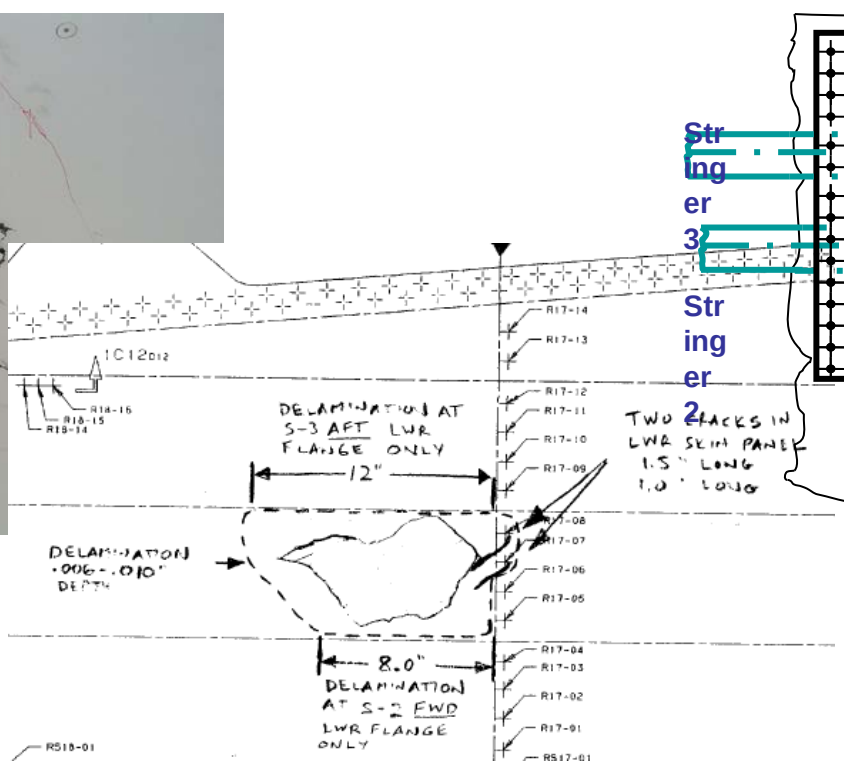
Large punctures - only options have been:

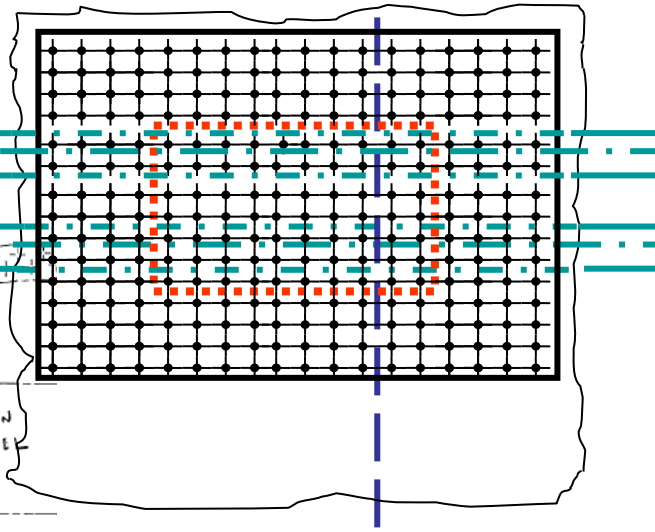
- Bolted patch with graphite autoclave cured repair parts
- Bolted patch with metal repair parts

When evaluation cycle time to make parts, metal bolted repairs

- Fasteners are difficult to procure
  - Blind composite bolts - coatings not standardized







Field Experiences - Success Factors:

Definition of success:

- Equivalent safety and risk
- Part 43.13 standard of repair = Equivalent or better to original
- Economical to operate airplane and salvage the component

Successful accomplishment of composite repairs depends on:

- Investment by Repair Station in facilities, tooling, training, materials to ensure repeatability and reliability
  - First article and Destructive testing
  - Training program – limited crew, detailed OJT, and monitoring in every step
  - In-process QC – verifilm, thermal survey, post-repair NDT
- Support from OEM to share original design info
  - Material of construction
  - Process details
  - Quality controls
  - Manufacturing allowables
  - Inspection methods and Pass/fail criteria

Future Perspectives

Future Perspectives/Opportunities within regulations

Major Repairs are Required Inspection Item (RII)

- Metal repairs have well-established in-process quality inspections:
  - Damage assessment and removal
  - NDT
  - Doubler fabrication
  - Repair layout
  - Clearance to close
  - Fastener inspection
- What would equivalent steps be in bonded repair?

FCBS are defined as Major Repairs and require FAA-approved data

- Service Difficulty Reports required for major repair accomplishment
  - Find repairs by MROs not asking for OEM assistance
- Repairs require DTA/OEM support.
  - What's required for OEM approval?
  - How much interaction, oversight, QC required?

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Future Perspectives/Opportunities – OEM Support

Example of Elevator repair to both panels and rib – critical areas – no SRM repair

Finished repair - OEM support included 22 messages over 2 months, pre- and post-repair NDT, contour measurements, tool fab, cure verification, etc.

Classified as CAT A – permanent.

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Future Perspectives/Opportunities – OEM support

Opportunities for improvement via airline/OEM exchange

- Successful maintenance and repair (defined as equivalent or better than original) depends on:
  - OEM planning for repair during certification to account for reparability
    - Test materials for exposure to multiple cure cycles to allow repair at original cure temperatures
    - Plan for disassembly
    - Sell replacement parts
    - Plan for superseded or replacement materials over lifetime
  - Support from OEM to share original design and process controls
  - Feedback by airlines to OEMs

Future Perspectives/Opportunities – via standardization

- SAE/CACRC – charter is to reduce cost of ownership while enhancing safety
- Comprised of industry experts from airlines, MROs, OEMs, Regulators, Academia, etc.
- Specialized Task Groups to write standards in areas including:
  - Training
  - NDT
  - Design
  - Materials
  - Repair Techniques
  - Analytical Techniques
  - Procedures - Repair Guidelines for large damage.
    - Metalbond Guidelines published - AIR 6291
    - Composite Guidelines in-process

Future Perspectives/Opportunities – via standardization

SAE documents - 22 published and 9 in draft:

- Repair Techniques
  - ARP 4977 – Drying of Thermosetting Comp. Mat.
  - ARP 4916 – Masking and Cleaning of Epoxy…
  - ARP 5144 – Heat application
  - ARP 5143 – Vacuum bagging
  - ARP 5367 – Machining
  - ARP xxx – Clean Room
  - ARP 5701 – Handling and storage
- Analytical TG
  - Development of allowable
  - Implementation in substantiation possible
- Material TG
  - AMS 3970 – Carbon prepreg material specification
  - AMS 2980 – Wet lay up material
- Design TG
  - AIR 5416 – Life cycle cost model
  - AE-27 – Design of Durable, Repairable, and Maintainable Aircraft Composites
- Training TG
  - AIR 4938A – Composite and Bonded Structure Technician/Specialist: Training Document
  - AIR 5279 – Composite and Bonded Structure Inspector: Training Document
  - AIR 5278 – Composite and Bonded Structure Engineers: Training Document
  - AIR 5719A – Teaching Points for an Awareness Class on "Critical Issues in Composite Maintenance and Repair"
  - ARP 6262 – Basic composite Qualification certificate
- Inspection TG
  - ARP 5605A - Solid Composite Laminate NDI Reference Standards
  - ARP 5606A - Composite Honeycomb NDI Reference Standards
  - ARP 5089 – Composite Repair Ndt/Ndi Handbook
- Procedures (was Airworthiness) TG
  - CACRC10AA - Guidelines for Repair Process Evaluation of Aluminum Bonded Structure (work in progress)

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Future Perspectives/Opportunities – via standardization

Repair Guidelines for Process Evaluation of Aluminum Bonded Structure

- 80+ page report
- Purpose:
  - Integrate Repair techniques in process flows, with QC recommendations
  - Institutionalize industry best practices
  - Provide guidance to MROs
  - Info that non-experts can use to evaluate MROs

SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR6291

Issued

Guidelines for Repair Process Evaluation of Aluminum Bonded Structure

RATIONALE

This document is intended to satisfy the need for a checklist of best practices in implementation of tooling, process steps, and quality controls that help to make sure that a previously substantiated repair design and process requirements are met.

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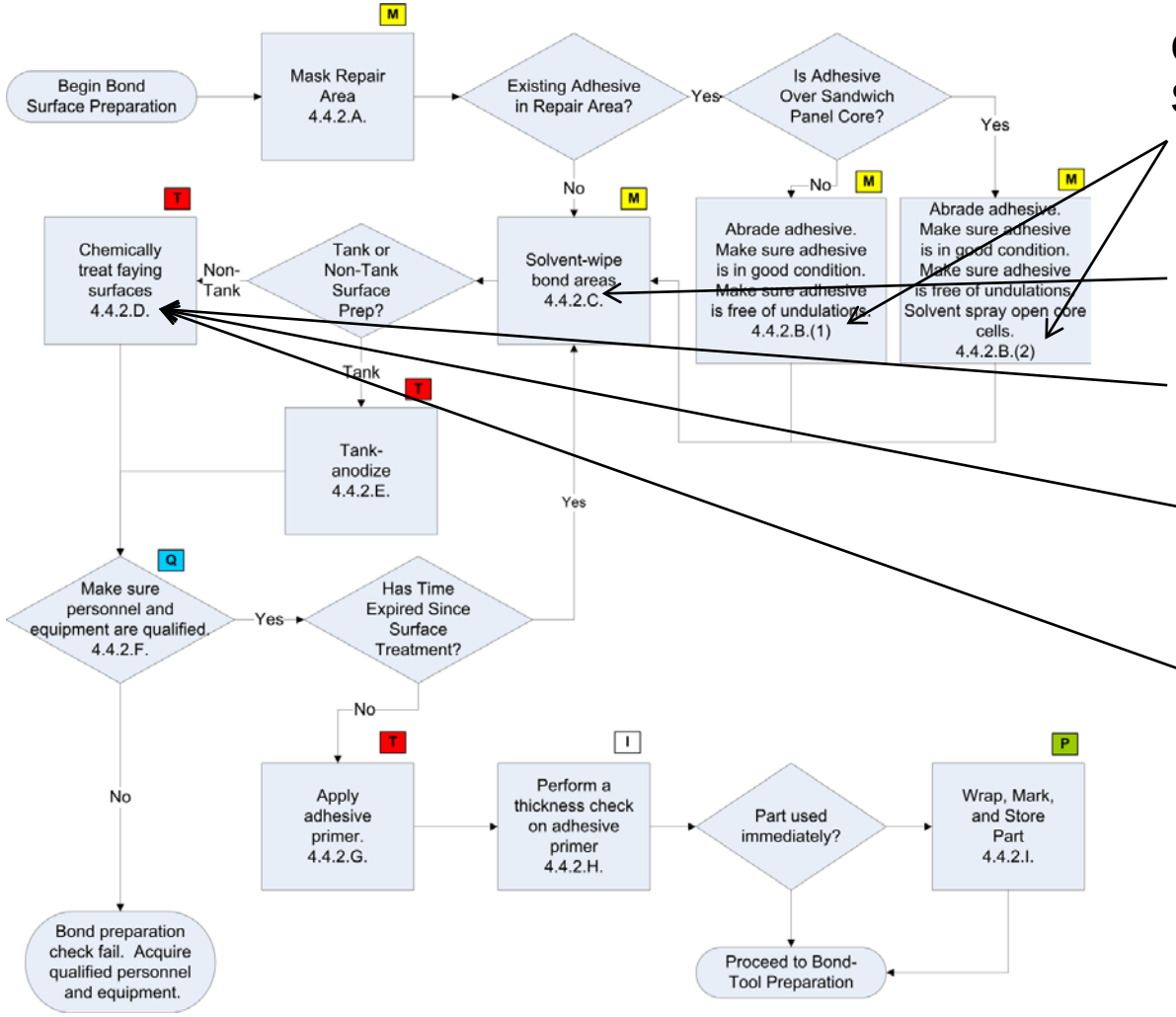
Future Perspectives/Opportunities – via standardization



Checklist items for Prepare Surfaces for Bonding

INSPECTION

- If core is not replaced, confirm that there is no discoloration of residual adhesive.

ADHERE TO SURFACE PREP INSTRUCTIONS

- Confirm that bond surfaces have been cleaned according to the Repair Document.
- Confirm that abraded surfaces have been prepared only using the process and materials in the Repair Document.
- Confirm that cleanliness requirements of Repair Document have been followed.

APPROVED CHEMICALS FOR SURFACE PREPARATION

- Confirm that surface preparation only uses the chemicals approved by Repair Document

FIGURE 21 - PREPARE SURFACES FOR BONDING FLOW

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Future Perspectives/Opportunities – via standardization

Implementation:

- Airlines –
  - Training for QA and repair station auditors
  - Guidance for Engineers reviewing repairs and failures
  - Managers of internal shops
- OEMs
  - Repair engineers can refer it to MROs
  - Refer to AIR in SRMs for autoclave repair guidance
- MROs
  - Managers of can implement internally
  - Quality control

Thank you for your attention

- Questions?

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