Operator Field Experiences and Future Perspectives

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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

<table>
<thead>
<tr>
<th>Component PSE and FCBS</th>
<th>747-400</th>
<th>737-300/500</th>
<th>757-200</th>
<th>767-300</th>
<th>777-200</th>
<th>A320</th>
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<td>X</td>
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<td>4,7</td>
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<td>2,3</td>
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<td>Aileron</td>
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<td></td>
<td>4</td>
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<td>OB Flap</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>X,7</td>
<td>1,2,3,4</td>
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<tr>
<td>IB Flap</td>
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<td>7</td>
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<td>2,6</td>
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Notes:
- Sub-components:
  1. Spar
  2. Skin
  3. Ribs
  4. Fittings
  5. Nose cap
  6. TE Wedge
  7. Main box
  8. Tab
- Primary Material Color Code:
  - Graphite and hybrid
  - Fiberglass
  - Metalbond
  - Sheetmetal

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 ingestion
  - 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?
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.
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)
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
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
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?