UNITED AIRLINES MAINTENANCE EXPERIENCE: Context, Past Issues, and Trends

By Eric Chesmar
Outline

CONTEXT
- Maintenance Regulatory Environment Summary
- UAL Fleet, our Structures and Workforce to be trained

PAST EXPERIENCES
- Damage Assessment
- Repairability

TRENDS
- Human Factors and Maintenance trends
- Conclusions
Maintenance Program – Derived from MPD, CML, etc

Summary, in general:
- Walk-around at A-Check (monthly), B-check (6 month)
- Visual inspection at C-check (1-year), D-check (5-year)

Very few composite parts with overhaul programs or routine NDI

Maintenance Program under continuous review and modification to:
- Reflect changes in regulatory requirements
- Reflect increasing age of fleet and extra tasks
- Reflect service experience within industry and UA
- Optimize costs, such as incorporate repetitive non-routine maintenance in routine planned schedule
Maintenance Regulatory Environment

- Reliability Program - monitor/reporting of removals, causes of delays and cancellations
- Service Difficulty Reports
  - Feedback mechanism to FAA
  - For flight interruptions, corrosion reporting, EES failures, etc
  - SFR36 Major Repairs
- Engineering Requests to OEM
- Oversight/audits of Procedures and Specific Incidents
  - Local FAA Principal Maintenance Inspectors
  - Internal QA and Flight Safety investigations
Maintenance Regulatory Environment

- Instructions for Continued Airworthiness
  - Structural Repair Manual
  - Configuration Dispatch List, Minimum Equipment List

- Engineering Repair Authority
  - Delegated by Authority, per MRO approved procedures
  - Repairs beyond the MRO’s authority requires Authority-approved data
Airlines/MRO Experience Levels

UAL FLEET COMPOSITION:

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Number of AC</th>
<th>Max Age</th>
<th>C-CHECK</th>
<th>D-CHECKS</th>
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<td>153</td>
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<td>107.1</td>
<td>30.6</td>
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<td>15.7</td>
<td>37.6</td>
<td>28.2</td>
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<td>777-200</td>
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<td>461</td>
<td>15.7</td>
<td>260.4</td>
<td>92.9</td>
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## Airlines/MRO Experience

- Composite PSE increasing vs. Secondary structure
- Secondary structure majority of work for inspectors, mechanics, engineers

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<th>ATA Chapter</th>
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<th>737-300/500</th>
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**Notes:**
- Sub-components
- Color Code
  - 1 Spar = Graphite
  - 2 Skin = Fiberglass
  - 3 Ribs = Metalbond
  - 4 Fittings = Sheetmetal
  - 5 Nose cap = RED FONT = PSE
  - 6 TE Wedge
  - 7 Main box
  - 8 Tab
Airlines/MRO Experience Levels

- Most inspectors, mechanics, and engineers for structures do not deal with composites very much. We are mostly generalists.
- Engineers - UAL has about 250 (about 50% reduction from 2002)
  - 40 Structures engineers, 20 fleet-specific and 20 Line/Dock/Shop support
  - 3 engineers with composite experience, some from composite OEMs.
  - Those 3 deal with most of the repairs to PSE beyond SRM requiring 8100-9/RAS and therefore DTA. About 20 times/year. Does not include rebuilds.
- Inspectors - Primarily at UAL SFO Maintenance base
  - 40 total to cover the whole AC
  - 15 with NDI qualifications, for metals and composites
  - Composite NDI infrequently performed
Airlines/MRO Experience Levels

Levels of training and experience on composites corresponds to work planned, and performed frequently enough to keep up skill level via on-the-job training:

1st Level - Line Station: Supporting through flights, performing overnight service, A-checks, B-checks, troubleshooting delays and cancellations.

- Mechanics -
  - Capability Room temp wet layup. No training beyond A&P school.
  - 67% of Line repairs are room temperature wet layup

- Inspectors - none usually.
  - NDI equipment brought for specific task on one aircraft

- Engineers - none on-site
  - Remote Engineering, via photos or field trips.
Airlines/MRO Experience Levels

2nd level of capability - Hanger for Scheduled checks

- Mechanics -
  - Part of sheetmetal crew. Typical dock crew for a C-check has about 8-10 sheet-metal technicians per shift
  - About 20% of Sheetmetal technicians also trained for composite wet layup repairs.
  - Only do a wet layup about 10 times per year.
  - Internal UAL 5 days training, annual recurring.

- Inspectors -
  - Covers whole aircraft.
  - NDI equipment generally only for specific tasks

- Engineers -
  - 24 hour support
  - OEM Customer Service on-site and 24-hour AOG desk.
3rd level of capability - Repair station

- Composite Prepregs and Metalbond processes. Autoclave and hotbond repairs, PAA line, mechanical and chemical testing capability, tooling, etc.

- Mechanics -
  - Specialist, but usually transfers from elsewhere. Typical Shop mechanic has about 15 years seniority, and between 5 to 25 years experience in the shop. Some not A&Ps but worked for composite OEMs.
  - Shop technicians support hanger and line operations.
  - Two week training plus OJT and probation period.

- Inspectors -
  - 24 hour support for pre-inspect, in-process checks, post-repair inspections
  - NDT common and routine (ultrasound, X-ray, thermography).

- Engineers -
  - Composite specialists for repairs.
  - Engineering support for repairs and process specs.
Damage Assessment Process

- **Type of Assessment**
  - Visual Inspection method is primary
  - Human factors – eyesight standards, painted vs. unpainted, use of magnifying glass.
  - NDI methods - usually used to prove no defects or extent of defect

- **Defects types**
  - Defect definition not well documented
  - Defect types not complete
    - Burns in fiber, fiber breakout at drilled hole, resin starvation, etc.
  - Depth as well as area should be covered in SRM
  - Manufacturing allowables and flaws not included
    - wrinkles, surfacer, injection, ply splices, wrinkles, inclusions, waviness, tool markoff, resin rich porosity, etc.
    - One-time concessions or MRB action not in Rework Log
Damage Assessment Process

Example:
Vert. Fin
Front Spar, at lower attach lug

See Detail A

(VIEW 1)
Damage Assessment Process

Example:
Vert. Fin
Front
Spar

DAMAGE:
“Crack” 0.25 inch with 1 ply delam
Damage Assessment Process

Example: Vert. Fin, Front Spar Close-up

- “Crack” enhanced for this picture.
- To find allowable damage limits takes 15 pages, jumps to 5 SRM chapters
- Resolved after 4 telexes, 3 days, removal of fastener and NDT, and “repair”
**Example: Vert. Fin Lug**

- “Wrinkle” filled with grey stuff
- Not documented in Rework Log
- Uncertain if it was undocumented damage
- Resolved after 8 telexes, 10 days, NDT, 30 hours engineering time
- “OK as is” - approved during manufacturing

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Example:

Horizontal Stab. Non-routine event

- Actuator changed.
- Removal tool was installed from the Horiz. Stab to the lower fuselage skin to allow the Actuator to be unloaded.
Example: Horiz. Stab. Tool pad connection on fuselage skin which cracked brackets and pulled up the skin.
Example:
Horizontal Stab. Non-routine event
Non-routine event - Horizontal Stabilizer Actuator

"OK as is"
Repairability
Airline Experience

- Airlines understand the concept of out-of-service for repair of non-routine and large damage
Airline Experience

Obvious damages are not safety issues but repair and economic issues
Common damage with difficult SRM repair

Rudder

- Lightning burn at trailing edge
- SRM Requires 350F prepreg repair and disassembly
- Days out of service
Common damage with no SRM repair

Aileron

- Lightning burn around fasteners which are in a critical area
- No SRM repair - “Contact OEM”
Minor damage with SRM difficult repair

737 Elevator Upper skin

- Hole in upper skin, 0.5 inch diameter.
- Not in a critical area, but “Note: no wet-layup repair within 6 inch of edge”
- 350F prepreg repair

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Minor damage with no SRM repair

737 Rudder Spar

- Attach hole for LE access plate
- SRM shows in critical area. No repair. “Contact OEM”
737 Rudder Spar - Close Up View

- **SOLUTION:** Repair with Ti doubler
- **IMPACT:** Rudder removed, test flight, out-of-service 4 days
Common damage with difficult SRM repair

PROBLEM: Flap CRES Rubstrip delaminates.
Flap skin gouged during rubstrip trimming
SRM Repair

DAMAGE: Gouges .005 to .050” deep, 6” long (70% of skin thickness)

SRM REPAIR: No bonded repair - bolted only

Locally fabricate angles and doublers from original material, with prepreg on-hand

RESULT: 8 Days out of service

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**Repairability**

- “Airline maintenance operations live and die by the Structural Repair Manual”
  - Allowable damage, Identification, Repair Options.
- Repair requirements need to be provided for during initial design. Including interim/ferry flight.
- Not all parts are covered or covered completely.
- PSE definition often too general
- Lack of optional materials or standard repair materials, including fasteners and doubler materials
- Repair Approval - Repairs for PSE requires DTA by OEM. Airlines engineers can design repair for Sheetmetal based on static strength and get OEM DTA approval within 18 months.
UAL and Industry trends

- More out-sourcing
  - Airline maintenance:
    - Line - Fewer stations with Maintenance Technicians
    - Base - UAL D-checks out-sourced
    - Component - Shop work tied to D-checks also out-sourced
    - Engineering - more difficult to get feedback from OSVs
  - OEM subcontracting of engineering, design, fabrication.
    Are Lessons Learned from past lost?
- For the airlines that are out-sourcing, OSVs are also handling the shop work to support checks, and the engineering
- Reduction in Airline engineering and less specialization
Commercial Aircraft Composite Repair Committee (CACRC)

Forum and feedback for addressing industry-wide issues

Goal to reduce maintenance costs by standardizing:
  - Repair Techniques
  - Training Curriculums
  - Design Guide
  - Airline Conditions (facilities, locations, repair types)
    - Materials
    - Analytical Techniques
    - Maintenance Cost

Specifications available to purchase from SAE

See website www.sae.org to join

Next meeting Oct 2006 in Ohio, USA

NEED MORE OSV INvolvEMENT and IMPLEMENTATION AT OEM
Conclusions

Safety Issues
- Maintenance lives by the letter of the Manual
  - More detail always better - allowable structural vs cosmetic
  - Criticality of parts -
- If not covered by the manual, then must be conservative
  - Uncertainty equals NO GO and grounded aircraft
  - Fear of a Safety Risk results in economic cost
  - High economic costs results in bias against composites

Human Factors
- Uncertainty widespread among non-composites people
- Non-composites people are the majority in Maintenance
- What they do hear - Marketing vs Engineering vs. Media
- Economic issues need to be addressed to reduce the incentive of turning into safety issues, either by not reporting damage or not repairing properly