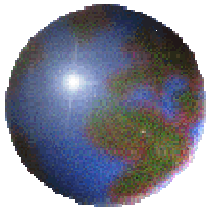


UAL PERSPECTIVES ON COMPOSITE MAINTENANCE CHALLENGES AND REGULATORY ISSUES

By Eric Chesmar, June, 2009

UNITED AIRLINES

Outline

UAL CONTEXT AND BACKGROUND

- UAL Fleet, operation

REGULATORY ISSUES

- Maintenance Regulatory Environment
- CFR Part 26 changes

PAST EXPERIENCES FOR DT COMPOSITES

- Damage Assessment
- Reparability

CONCLUDING THOUGHTS

UAL Fleet and Operation

- UAL FLEET COMPOSITION:
  - Since 2007- Reduced fleet size in response to lower demand.

			MAINTENANCE VISITS PER YEAR	
	NUMBER OF AC	Max Age	C-CHECK	D-CHECKS
A3219/320	153	15.5	107	31
737-300/500	64	22.6	26	19
747-400	24	19.9	12	5
757-200	97	19.8	49	19
767-300	35	18.1	21	4
777-200	52	14.1	31	5
TOTAL	425		245	83

UAL Fleet and Operation

- Where did we come from?
  - 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 receiving inspections in 1991
  - Rebuilding
    - 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.

UAL Fleet and Operation

- Changes of last 5 years
  - Closed 2 maintenance bases and outsourced
    - 100% of D-checks
    - 30% of C-checks
    - Aircraft Painting
  - Outsourced low-tech component work
  - Reduced all types of direct headcount – mechanics, engineers, inspectors, management
  - Created vendor management organization
  - Goal to eliminate customization of documents

UAL and Industry trends

- More out-sourcing
  - Airline maintenance:
    - Line - Fewer stations with Maintenance Technicians. Not using for receiving and pushing out the aircraft.
    - Base - UAL D-checks out-sourced
    - Component - Shop work tied to D-checks also out-sourced
    - Engineering – less feedback from OSVs. Oversight.
  - OEM subcontracting of engineering, design, fabrication. Are Lessons Learned from past being lost?
- Reduction in airline staff (engineering, inspectors, mechanics) leads to fewer specialists

REGULATORY ISSUES

Maintenance Regulatory Environment

Airline Maintenance Responsibility: 14 CFR § 121.363:

(a) Each certificate holder is primarily responsible for:

(1) The airworthiness of its aircraft, including airframes, aircraft engines, propellers, appliances, and parts thereof; and

(2) The performance of the maintenance, preventive maintenance, and alteration of its aircraft, including airframes, aircraft engines, propellers, appliances, emergency equipment, and parts thereof, in accordance with its manual and the regulations of this chapter.

(b) A certificate holder may make arrangements with another person for the performance of any maintenance, preventive maintenance, or alterations. **However, this does not relieve the certificate holder of the responsibility specified in paragraph (a) of this section.**

Maintenance Regulatory Environment

- Maintenance Program – Derived from MPD, CML, etc
- Maintenance Program under continuous review and modification to:
  - Reflect changes in regulatory requirements
  - Reflect increasing age of fleet and extra tasks
  - Reflect reliability and service experience within industry and UA
  - Optimize costs, such as incorporate repetitive non-routine maintenance in routine planned schedule, extensions, repackaging
- Reliability Program - Monitor/reporting of delays, cancellations, and component removals
- Service Difficulty Reports
- FAA Oversight/audits of Procedures and Specific Incidents

Maintenance Regulatory Environment

- Engineering Repair Authority
  - Delegated by Authority, per procedures approved by local regulatory office
  - Repairs beyond the MRO's authority requires Authority-approved data
- Limitations of airline engineering
  - Major Repair (for UAL) = reinforcing repair to PSE, and requires FAA-approved data for repair
  - DTA – required for reinforcing repairs beyond SRM for PSE, and for Fatigue Critical Structure (FCS)

Maintenance Regulatory Environment

Off-wing Component Repair Responsibilities:

- Airline determines maintenance program and documentation, whether inside or vendor
- QA approves vendors and has oversight
- Engineering responsible for authorizing repair documents beyond OEM on airline's parts
- Repair Station responsible for accomplishment per the document – on a 8130-3 or Form One tag
- Airline receives part, inspects and installs on aircraft
- Airline and Repair Station stores records of maintenance which documents repair.
- Local regulatory office oversees airline and approves airline policy that governs how all the above are accomplish

Maintenance Regulatory Environment

Off-wing Component Repair Responsibilities:

After the Repair – Continued Airworthiness when installed on an aircraft

- Aircraft has maintenance program which includes off-wing component maintenance
- Airline has Continuous Airworthiness Maintenance Program - surveillance of aircraft and reliability program.
- SDR Reporting – certain in-service failures must be reported, and root cause identified. Internal QA requires preventative measures implemented.

CFR Part 26 - Damage tolerance

Implements new requirements, including

- Identification of additional Fatigue Critical Structure
- Survey to cover existing repairs are DT
- Future repair approval for DT beyond SRM
  - Stage 1 - immediate for static strength
  - Stage 2 - permanent within 24 months
- Threshold for Supplemental Inspections

CFR Part 26 - Damage tolerance

Component Principal Structural Elements						
Name	747-400	737-300/ 500	757-200	767-300	A320	777-200
Elevator			X		1,2,4	4,7
Rudder			1,2,3,4		1,2,3,4	4,7,8
Spoilers					2,3	
Aileron					4	
OB Flap	7	7	7	7	1,2,4	X
IB Flap	7	7	7	7	1,2,3,4,5,8	X
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					

- OLD CHART FROM 2007 WORKSHOP
- Composite PSE increasing on newer designs.
- Components are where we have most of our composite repair experience

CFR Part 26 - Damage tolerance

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

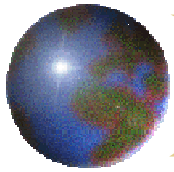
Notes:	Sub-components	Primary Material Color Code		
1	Spar	=	Graphite and hybird	
2	Skin	=	Fiberglass	
3	Ribs	=	Metalbond	
4	Fittings	=	Sheetmetal	
5	Nose cap			
6	TE Wedge			
7	Main box			
8	Tab			
x	= PSE, blank is not			

***Red* = added for FCBS**

- More Composites are FCBS than PSE and therefore much more OEM support will be needed

CFR Part 26 - Damage tolerance

- Survey to cover existing repairs
  - Determine if complies with SRM by:
    - review of documentation, or evaluation of repair
  - Do we need repair evaluation guidelines for composites?
- Spares?
  - Documentation not adequate currently
  - DER Repairs need to state compliance with DTA.
- Threshold for Supplemental Inspection: need history of hours/cycles accumulated component
  - Why not known
    - No tags – depart, or illegible
    - No history of which aircraft installed originally on
  - Hours and cycles – if not known, then what?
    - Default: Use highest hours/cycles in world fleet
    - How about: use date of manufacture stamped on a sub-component?



PAST EXPERIENCES FOR DAMAGE TOLERANT COMPOSITES
- Damage Assessment

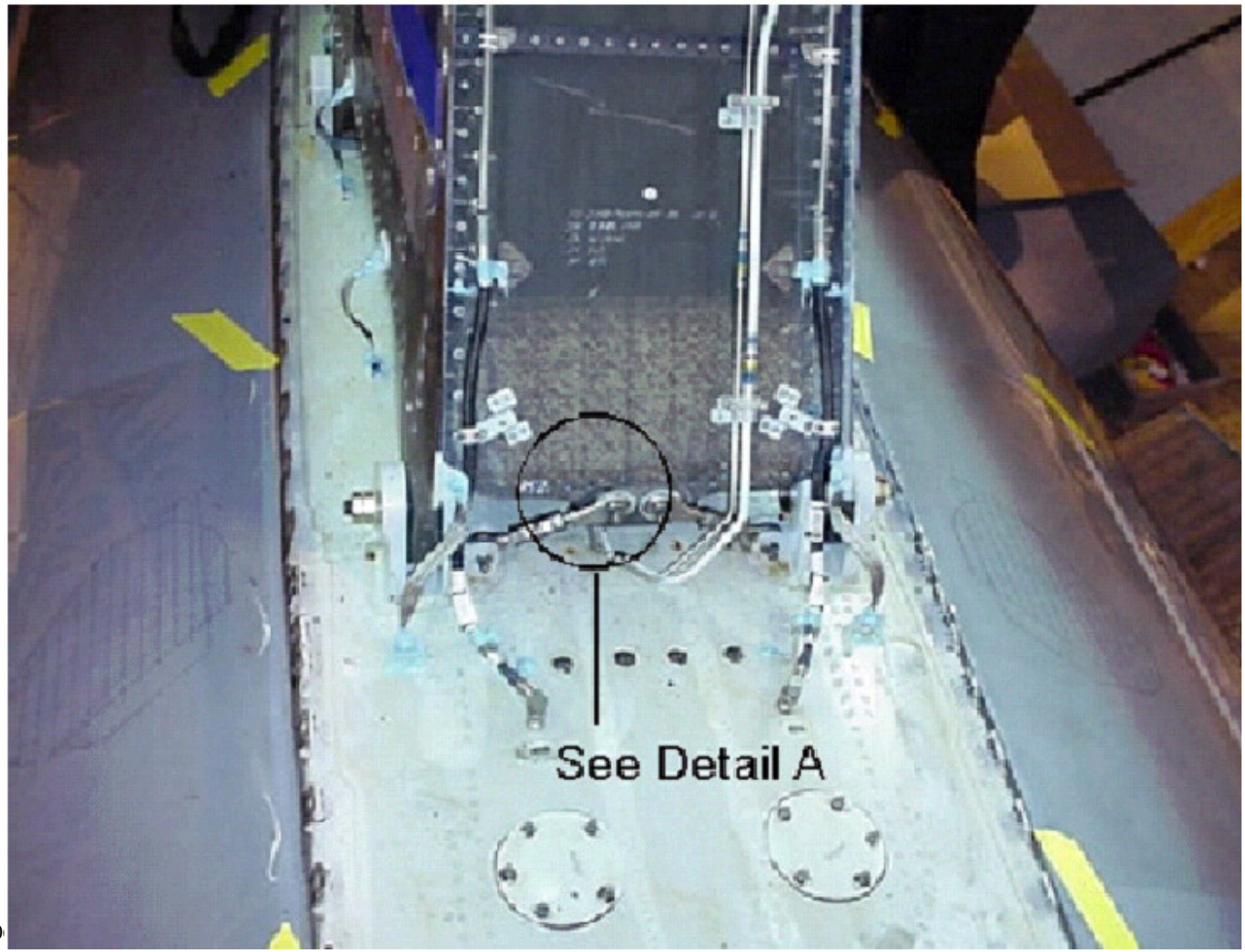
Damage Assessment Process

- 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. Reference standards should be defined by drawing for local manufacture, or use industry standards
- Defects types
  - Defect definition not well documented in SRM
  - Defect types not complete in SRM
    - 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 in SRM
    - 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

(VIEW 1)



Damage Assessment Process

Example:

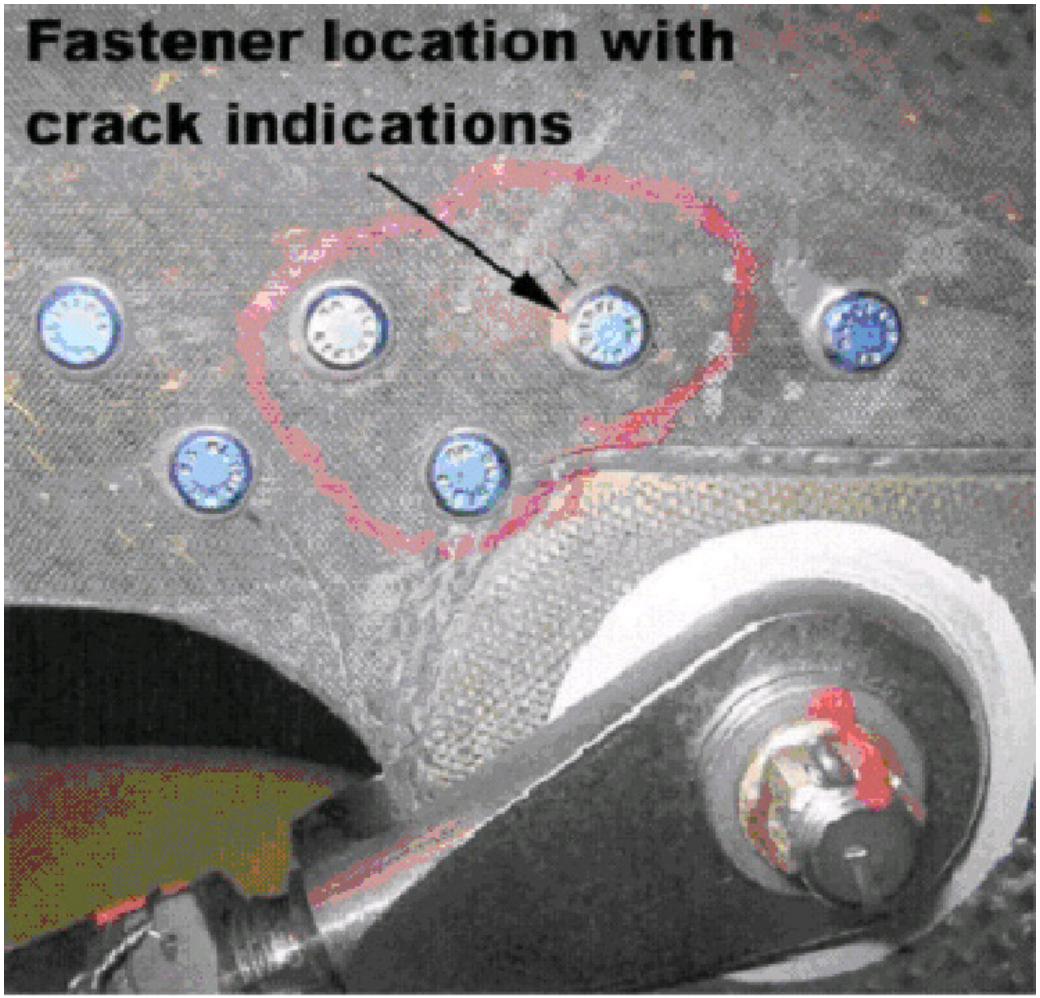
Vert. Fin

Front

Spar

DAMAGE:

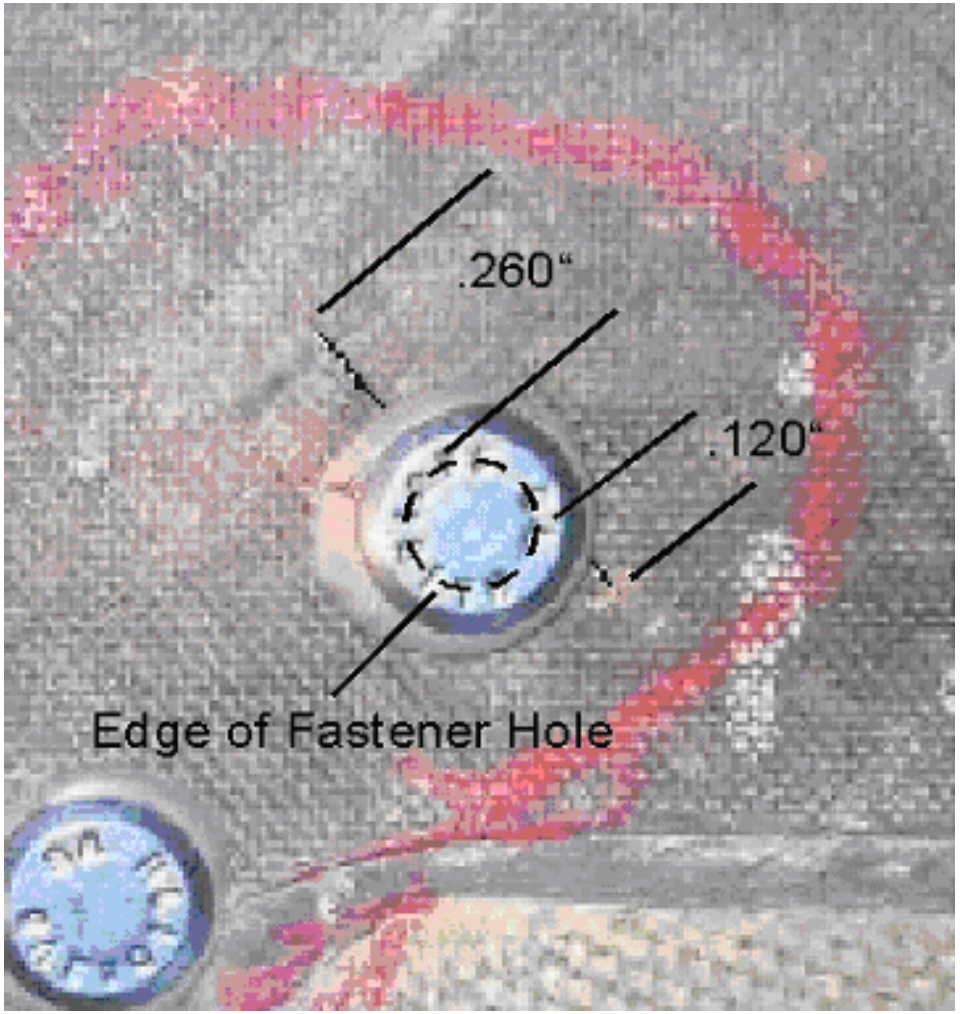
"Crack" 0.25 inch with 1 ply delam



Damage Assessment Process

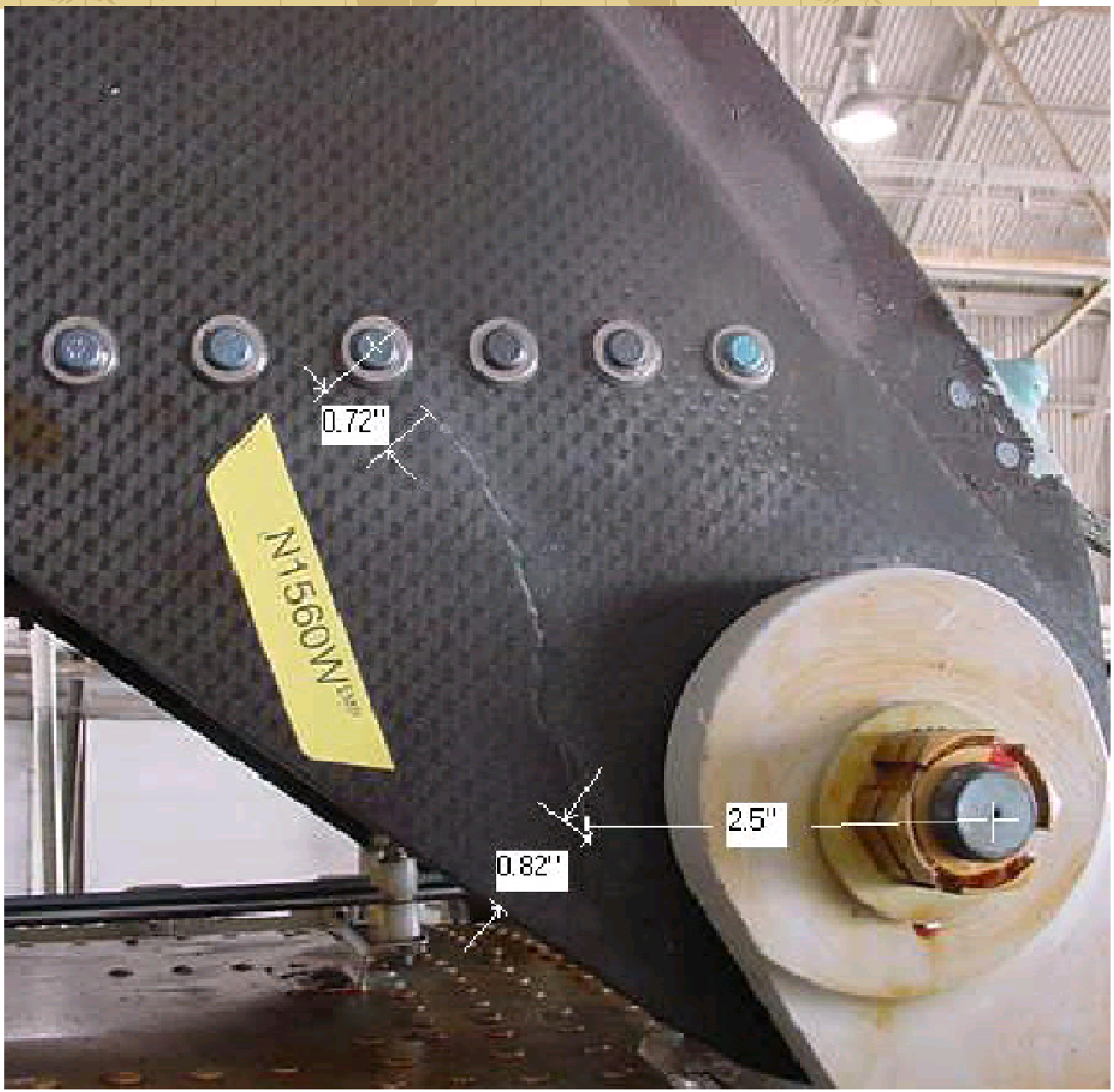
Example: Vert. Fin, Front Spar Close-up

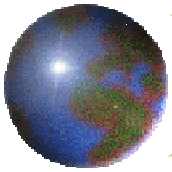
- "Crack" enhanced for this picture.
- Breakout on 1 ply
- To find allowable damage limits takes 15 pages, jumps to 5 SRM chapters. Not covered.
- Resolved after 4 telexes, 3 days, removal of fastener and NDT, and "repair" with resin.



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





AIRLINE EXPERIENCES FOR DAMAGE TOLERANT COMPOSITES

- Reparability

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, but ...

Common damage with difficult SRM repair

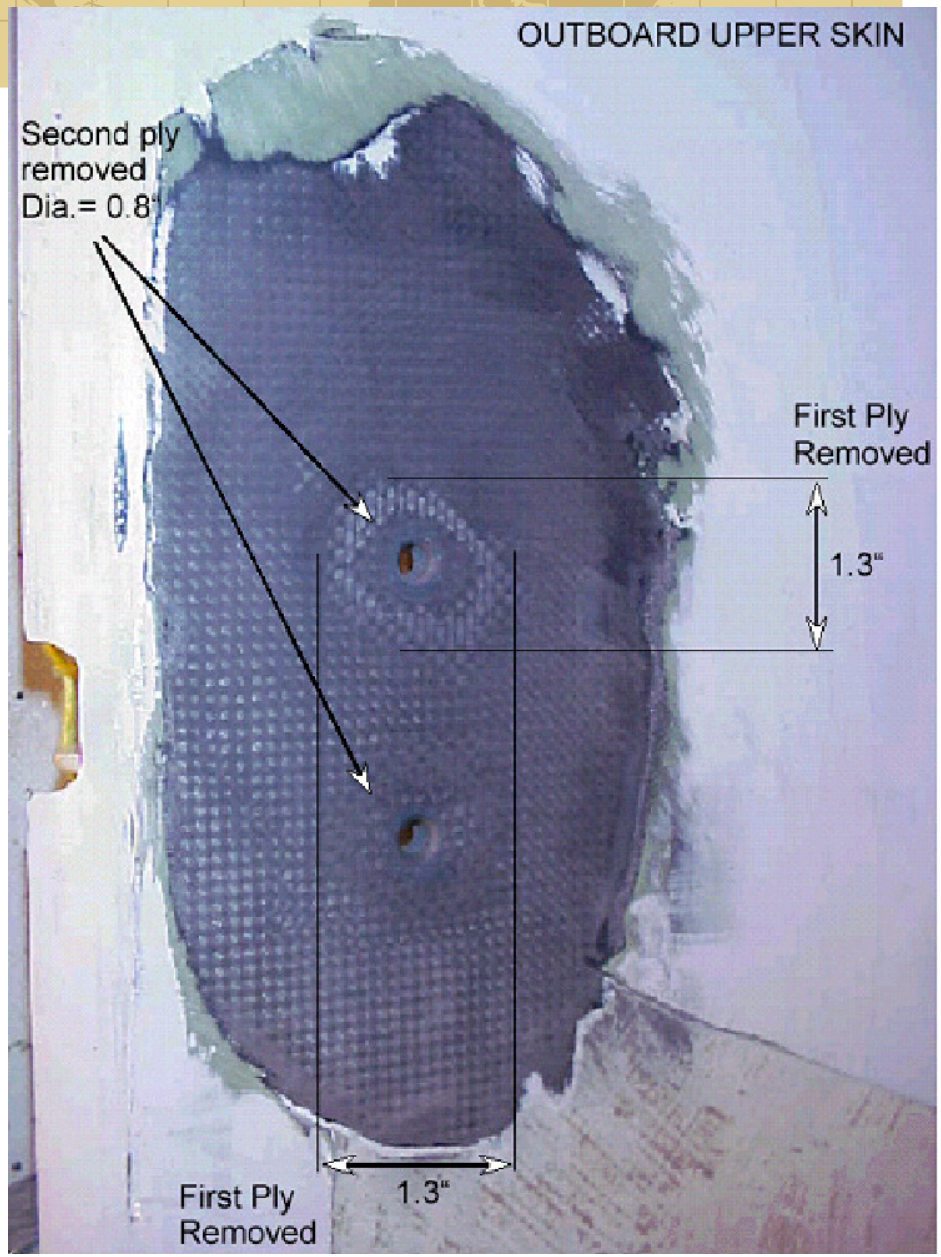
Rudder

- Lightning burn at trailing edge, where 2 panels are fastened
- 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.
- Common to have 1 or 2 plies burned
- No SRM repair - “Contact OEM”



Minor damage with SRM limits & difficult repair

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

Minor damage with no SRM repair

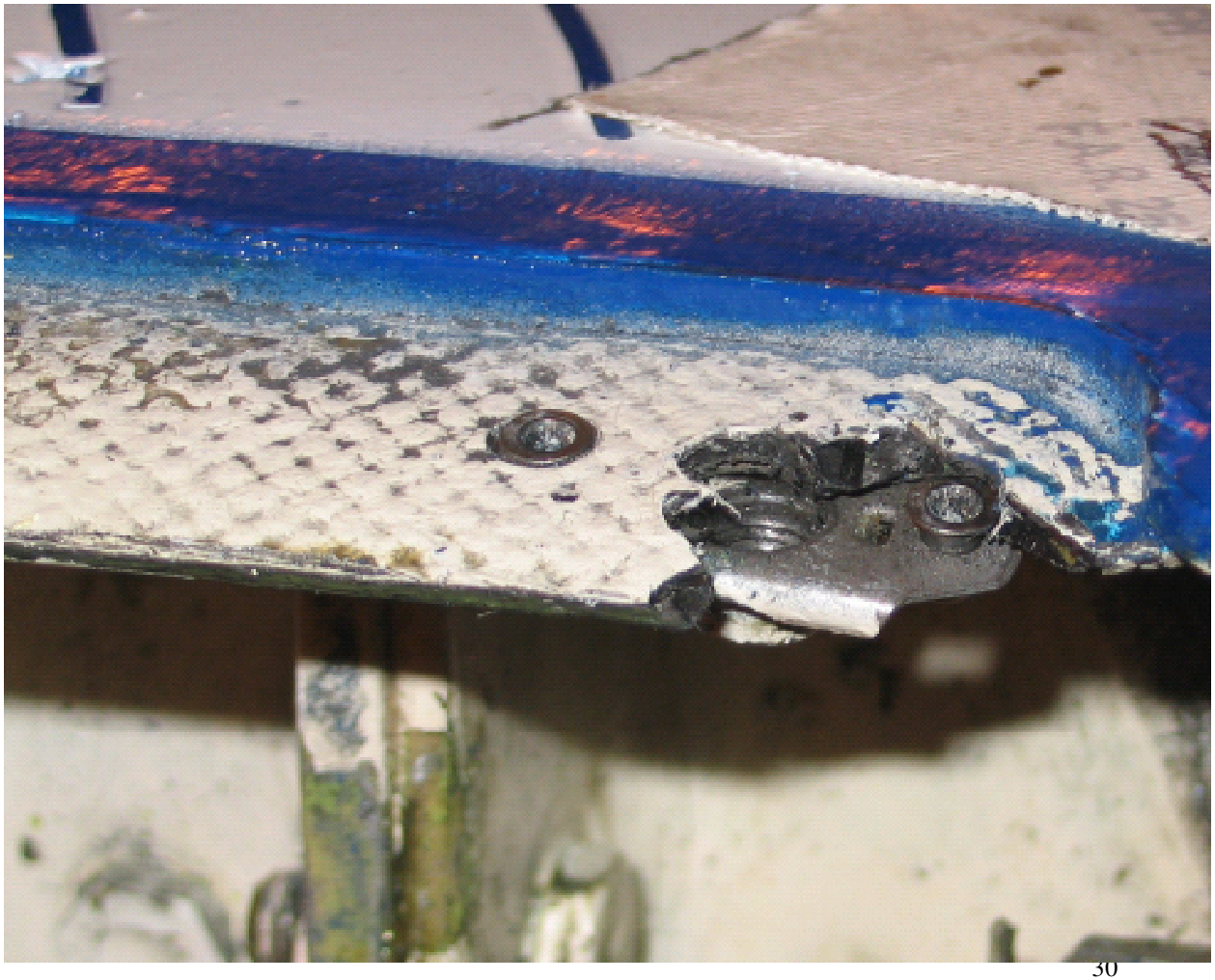
Rudder Spar

- Attach hole for LE access plate
- SRM shows in critical area. No repair. “Contact OEM”

Minor damage with no SRM repair

Rudder Spar - Close Up View

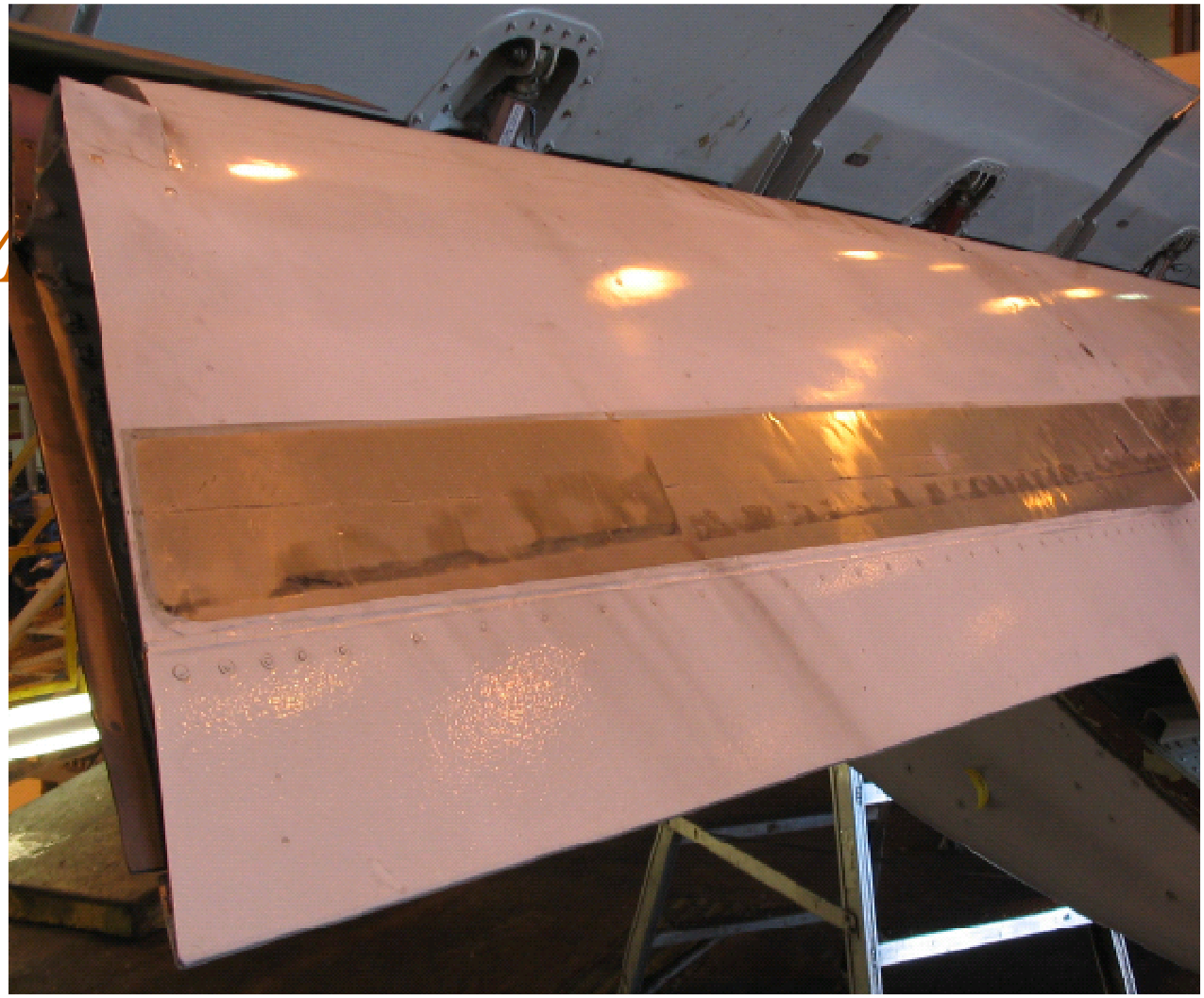
- SOLUTION: Repair with Ti doubler
- IMPACT: Rudder removed, test flight, out-of-service 4 days



Common damage & 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

SRM Repair DAMAGE: Aileron Puncture 6” long

SRM Repair

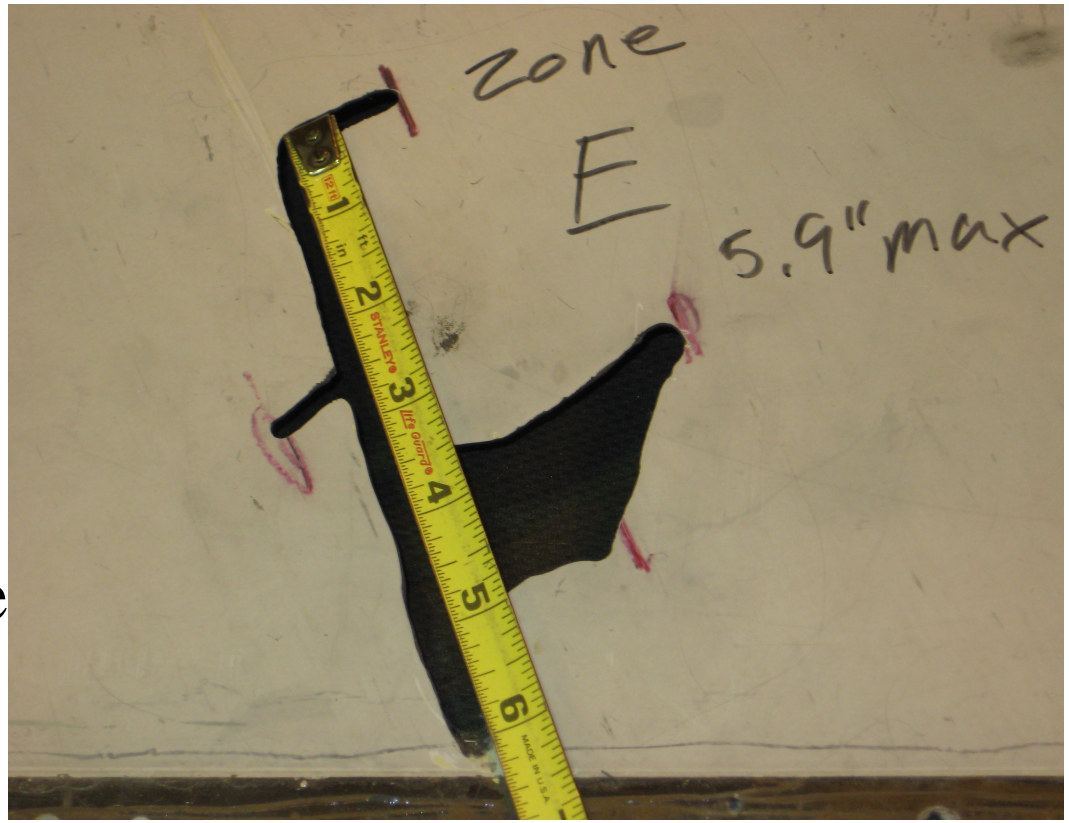
DAMAGE: Aileron,

Puncture 6” long

SRM REPAIR: no repair

RESULT:

- Scrap or send to OEM.
- Estimated out-of service 6 months.
- Spare needed to be purchased.

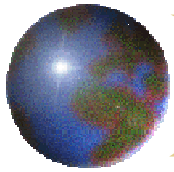


Reparability Summary

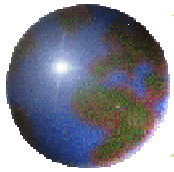
- "Airline maintenance operations live and die by the Structural Repair Manual"
  - Contains: Allowable damage, Identification, Repair Options.
- Repair requirements need to be planned for during initial design. Including for interim repairs and ferry flights, replacement of sub-components, spares availability, availability of large repair supporting data.
- SRM does not include all parts, or complete descriptions
- PSE definition often too general – should have zones
- Lack of optional materials or standard repair materials, including fasteners and doubler materials

Commercial Aircraft Composite Repair Committee

- Forum and feedback for addressing industry-wide issues
- Goal to reduce maintenance costs by standardizing:
  - Repair Techniques - Materials
  - Training Curriculums - Analytical Techniques
  - Design Guide - Maintenance Cost
  - Airline Conditions (facilities, locations, repair types)
- Standards available to purchase from SAE
- See website www.sae.org to join
- **To respond to industry trends, need more participation by 3rd parties – OSVs, suppliers**
- **Still need more implementation at OEM**



Concluding Thoughts



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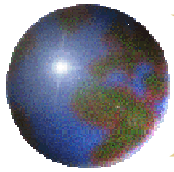


Conclusions

- Safety message
  - Consistent message for all models of aircraft, and entire aircraft and all structures
  - Needs to be prioritized

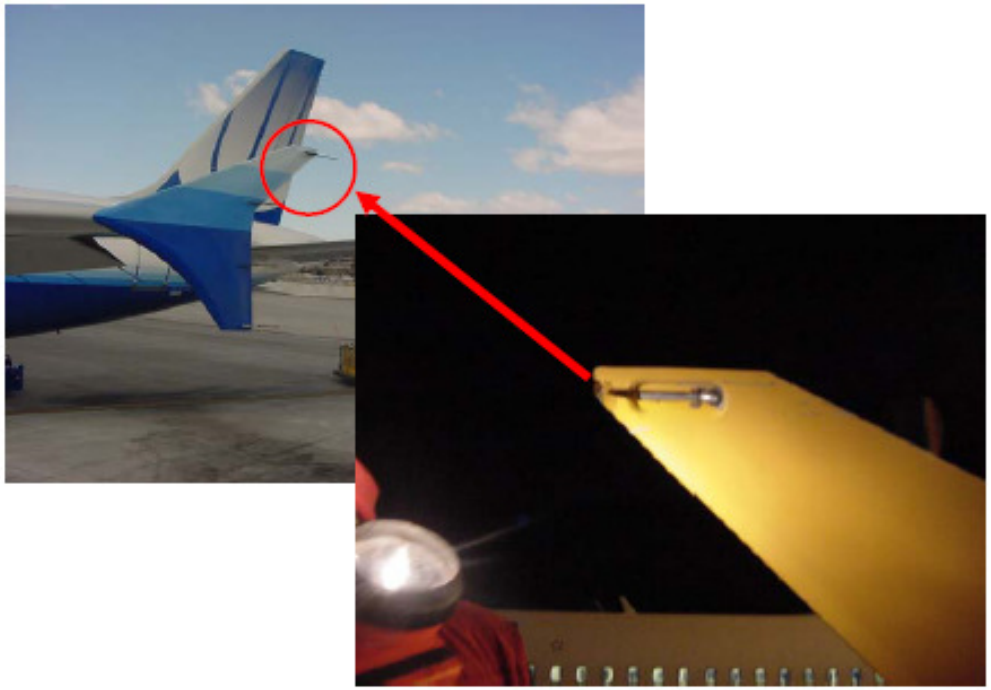
Notable Safety Events and Issues

Week of April 3rd, 2009

The Dangers of Not Reporting Damages

The Situation:
During the dispatch of an A319 and A320 the wingtips of each aircraft made contact. Not seeing any visible damage from the ground, two employees involved in the dispatch released the aircraft without notifying a supervisor or maintenance.

Both of these aircraft were found damaged later that day. The investigation reveled how the damaged occurred.



Pictured is the top portion of the fence (winglet) of aircraft 4846 (A320). This incident resulted in a crack in the fence, scratches, and a missing static wick.

Lessons Learned

- **All damages, no matter how small, must be reported.**
  - Unreported damages put our passengers, co-workers, families, and equipment at risk.
  - Small damages that are not checked out by a certified aircraft mechanic have the possibility of deteriorating and becoming much worse in flight.
  - Unreported damages could lead to higher repair cost
  - Unreported damages could result in an emergency situation.

Reference: Ground Safety Manual (GSM) Chapter 3, Section 2 – Aircraft Damage states "All aircraft damages must be reported when found, regardless of cause, location on aircraft, nature or severity."

If you have any questions, please contact your Corporate Ground Safety Representative

Conclusions

- Safety message to Ramp personnel
  - **REPORT EVERYTHING**
- Safety message to Mechanics
  - **FOLLOW THE MANUALS**
  - **MUST BE TRAINED FOR THE TASK**

Lessons Learned

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Conclusions

- Safety vs. Economics message
  - Maintenance lives by the letter of the Manuals
    - More detail always better - allowable flaws: structural vs cosmetic
    - Criticality of parts – add zones for non-critical areas of PSE
  - If not covered by the manual, then we must be conservative
    - Uncertainty equals NO GO and grounded aircraft
    - Fear of any safety risk results in unnecessary economic cost
    - High economic costs results in bias against composites
  - Avoid publishing limitations in SRM based on economic considerations
    - Monopolies should not result in a limitation in a technical manual
    - If certain capabilities are required, or more details, need a path to ensure airworthiness. Like engines - source substantiated
    - Spares – make piece parts available

Conclusions

- Life Cycle Cost
  - Design for safety, but include maintenance, repair, and durability
  - Sales pitch - “cost of maintenance will lower”
    - Might be true for the aircraft overall, not for every component
    - Help airlines continue manage costs, and consider past experience and capability

- Common goals
  - Safe and airworthy operation
  - Economic viability
  - Work together to achieve long-term success for airlines and OEMs