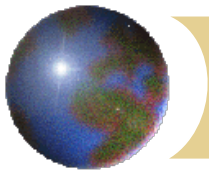


*UNITED AIRLINES
MAINTENANCE
EXPERIENCE:*

*Context, Past Issues, and
Trends*

By Eric Chesmar



Outline

CONTEXT

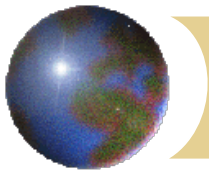
- ✦ Maintenance Regulatory Environment Summary
- ✦ UAL Fleet, our Structures and Workforce to be trained

PAST EXPERIENCES

- ✦ Damage Assessment
- ✦ Repairability

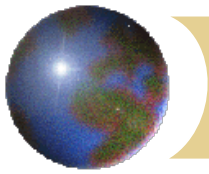
TRENDS

- ✦ Human Factors and Maintenance trends
- ✦ Conclusions



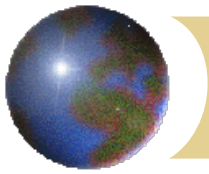
Maintenance Regulatory Environment

- ✦ 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



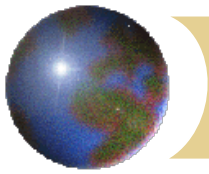
Maintenance Regulatory Environment

- ⊕ 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

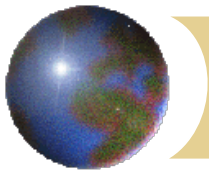
- ✦ Instructions for Continued Airworthiness
 - ✦ Structural Repair Manual
 - ✦ Aircraft Maint. Manual., Component Maint. Manual, NDT Manual, Service Bulletin, Service Letters, etc.
 - ✦ Configuration Dispatch List, Minimum Equipment List
- ✦ Engineering Repair Authority
 - ✦ Delegated by Authority, per MRO approved procedures
 - ✦ Repairs beyond the MRO's authority requires Authority-approved data



Airlines/MRO Experience Levels

✦ UAL FLEET COMPOSITION:

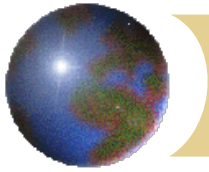
			MAINTENANCE VISITS PER YEAR	
	NUMBER OF AC	Max Age	C-CHECK	D-CHECKS
A3219/320	153	8.7	107.1	30.6
737-300/500	94	15.7	37.6	28.2
747-400	30	13.1	15.0	6.0
757-200	97	12.9	48.5	19.4
767-300	35	11.3	21.0	3.5
777-200	52	7.2	31.2	5.2
TOTAL	461	15.7	260.4	92.9



Airlines/MRO Experience

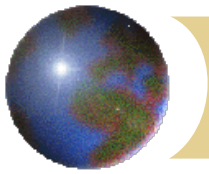
- ❖ Composite PSE increasing vs. Secondary structure
- ❖ Secondary structure majority of work for inspectors, mechanics, engineers

ATA Chapter	Name	737-300/500	747-400	757-200	767-300	A320	777-200	
53	Fuselage	X	X	X	X	X	X	
55	Fixed Empennage					X	X	
55	Elevator			X		1,2,4	4,7	
55	Rudder			1,2,3,4		1,2,3,4	4,7,8	
57	Spoilers					2,3		
57	Aileron					4		
57	OB Flap	7	7	7	7	1,2,4	X	
57	IB Flap	7	7	7	7	2,3,4,5,8	X	
57	LE Devices			X	X	2,6		
<u>Notes:</u>	<u>Sub-components</u>					<u>Color Code</u>		
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 -**

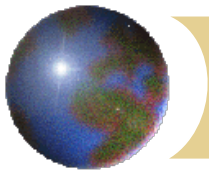
- ✚ Capability Room temp wet layup. No training beyond A&P school.
- ✚ 67% of Line repairs are room temperature wet layup

✚ **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 -

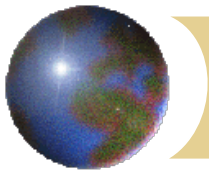
- ✦ Part of sheetmetal crew. Typical dock crew for a C-check has about 8-10 sheet-metal technicians per shift
- ✦ About 20% of Sheetmetal technicians also trained for composite wet layup repairs.
- ✦ Only do a wet layup about 10 times per year.
- ✦ Internal UAL 5 days training, annual recurring.

✦ 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.



Airlines/MRO Experience Levels

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 -

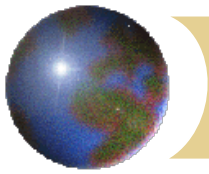
- ❖ Specialist, but usually transfers from elsewhere. Typical Shop mechanic has about 15 years seniority, and between 5 to 25 years experience in the shop. Some not A&Ps but worked for composite OEMs.
- ❖ Shop technicians support hanger and line operations.
- ❖ Two week training plus OJT and probation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



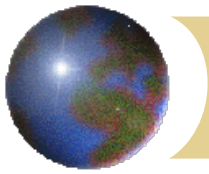
Damage Assessment Process

✦ 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

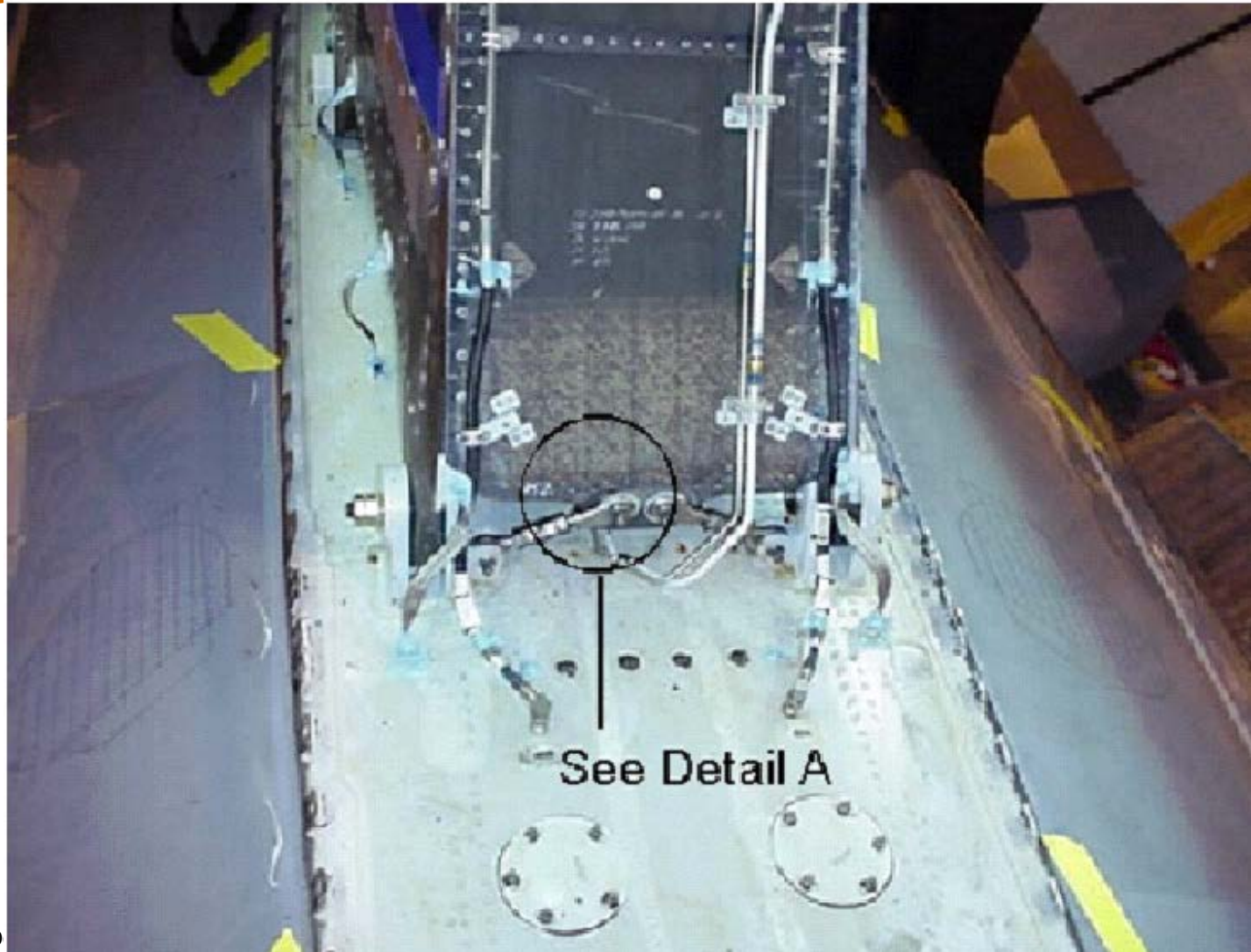
- ✦ Defect definition not well documented
- ✦ Defect types not complete
 - Burns in fiber, fiber breakout at drilled hole, resin starvation, etc,
- ✦ Depth as well as area should be covered in SRM
- ✦ Manufacturing allowables and flaws not included
 - wrinkles, surfacer, injection, ply splices, wrinkles,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

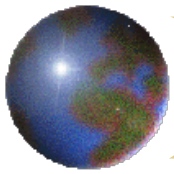


Damage Assessment Process

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

(VIEW 1)





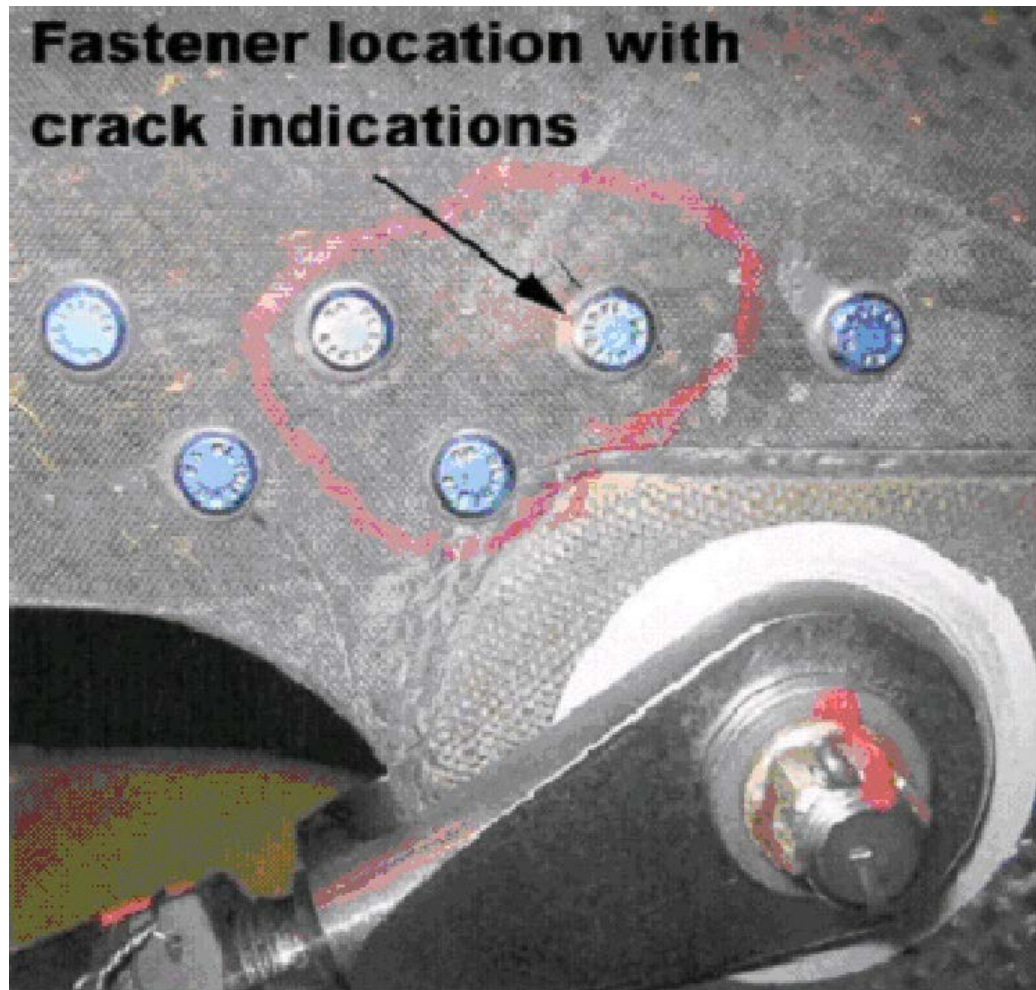
Damage Assessment Process

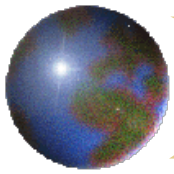
Example:

**Vert. Fin
Front
Spar**

DAMAGE:

“Crack” 0.25
inch with 1
ply delam

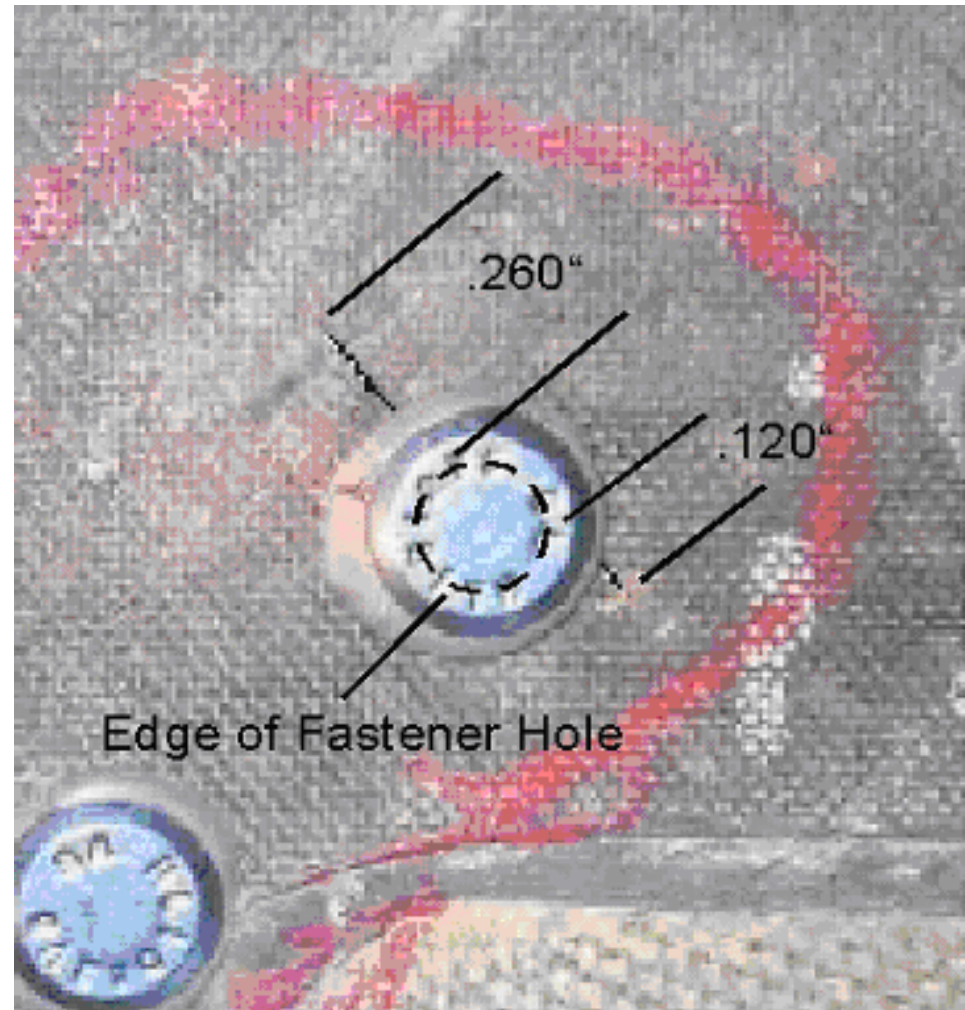


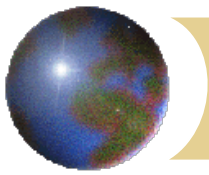


Damage Assessment Process

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”



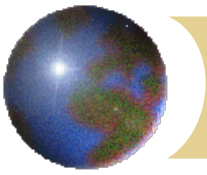


Example: Vert. Fin Lug

- ✦ “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

E. Chesmar, UAL, 20 July 2006

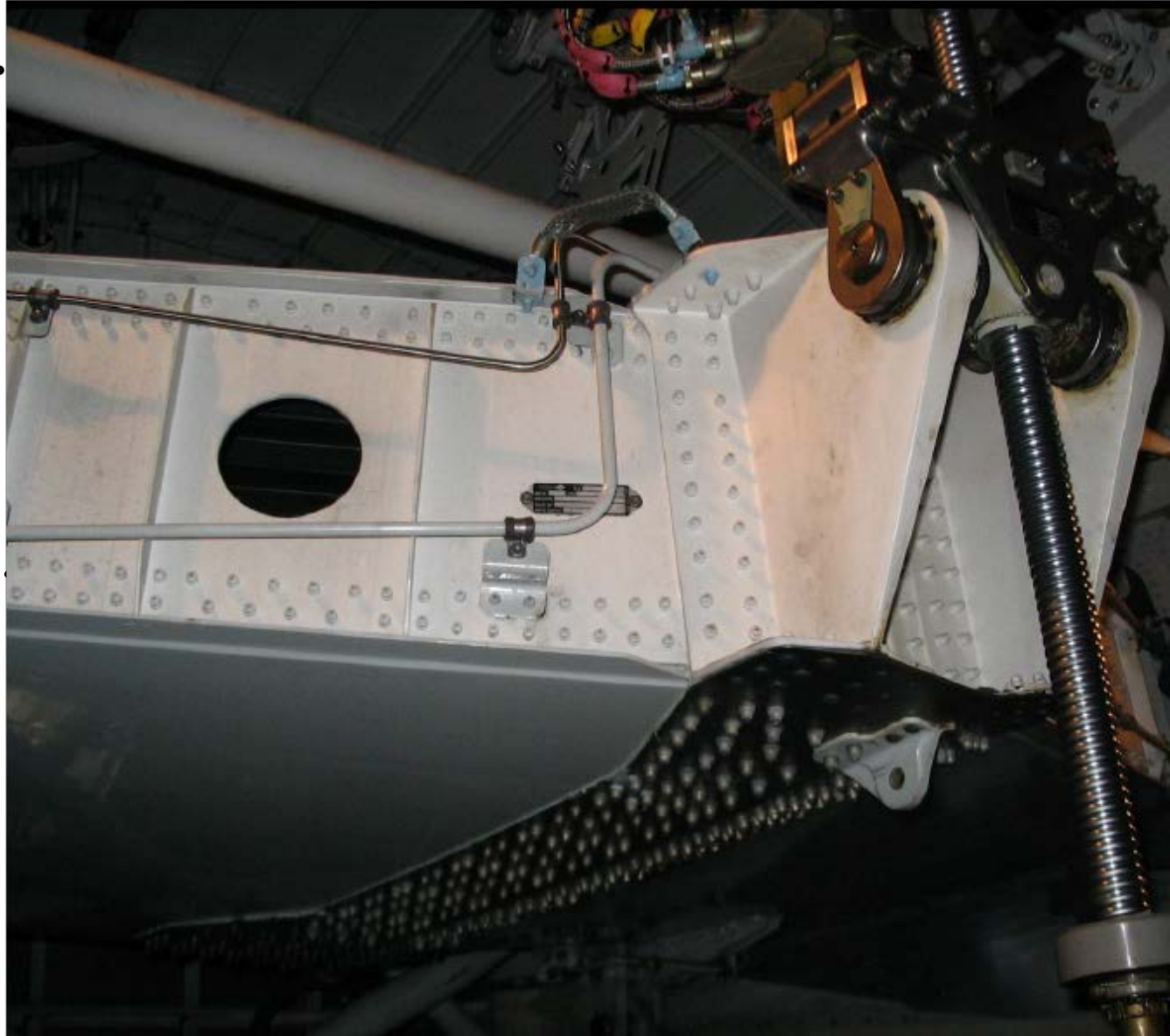


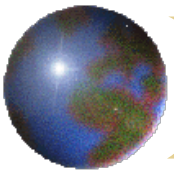


Example:

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.





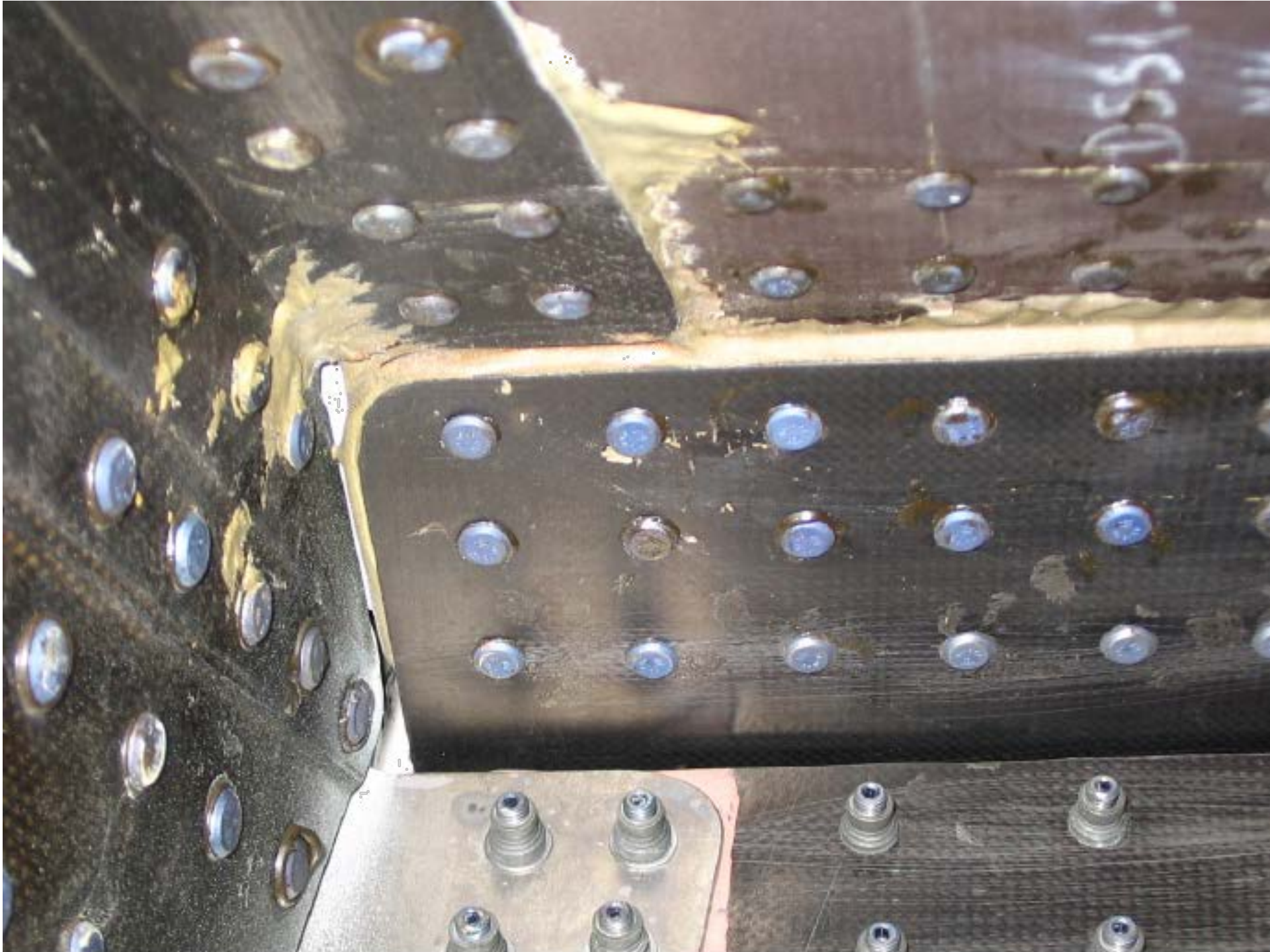
Example: Horiz. Stab.

Tool pad
connection
on fuselage
skin which
cracked
brackets
and pulled
up the skin.





15

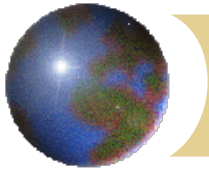




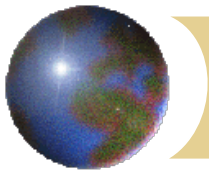
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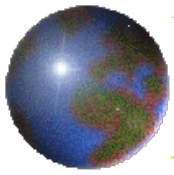
Repairability



Airline Experience

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

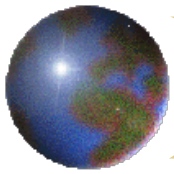




Airline Experience

- ✚ Obvious damages are not safety issues but repair and economic issues



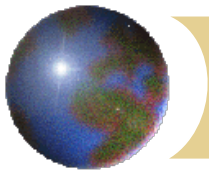


Common damage with difficult SRM repair

Rudder

- ⊕ Lightning burn at trailing edge
- ⊕ SRM Requires 350F prepreg repair and disassembly
- ⊕ Days out of service

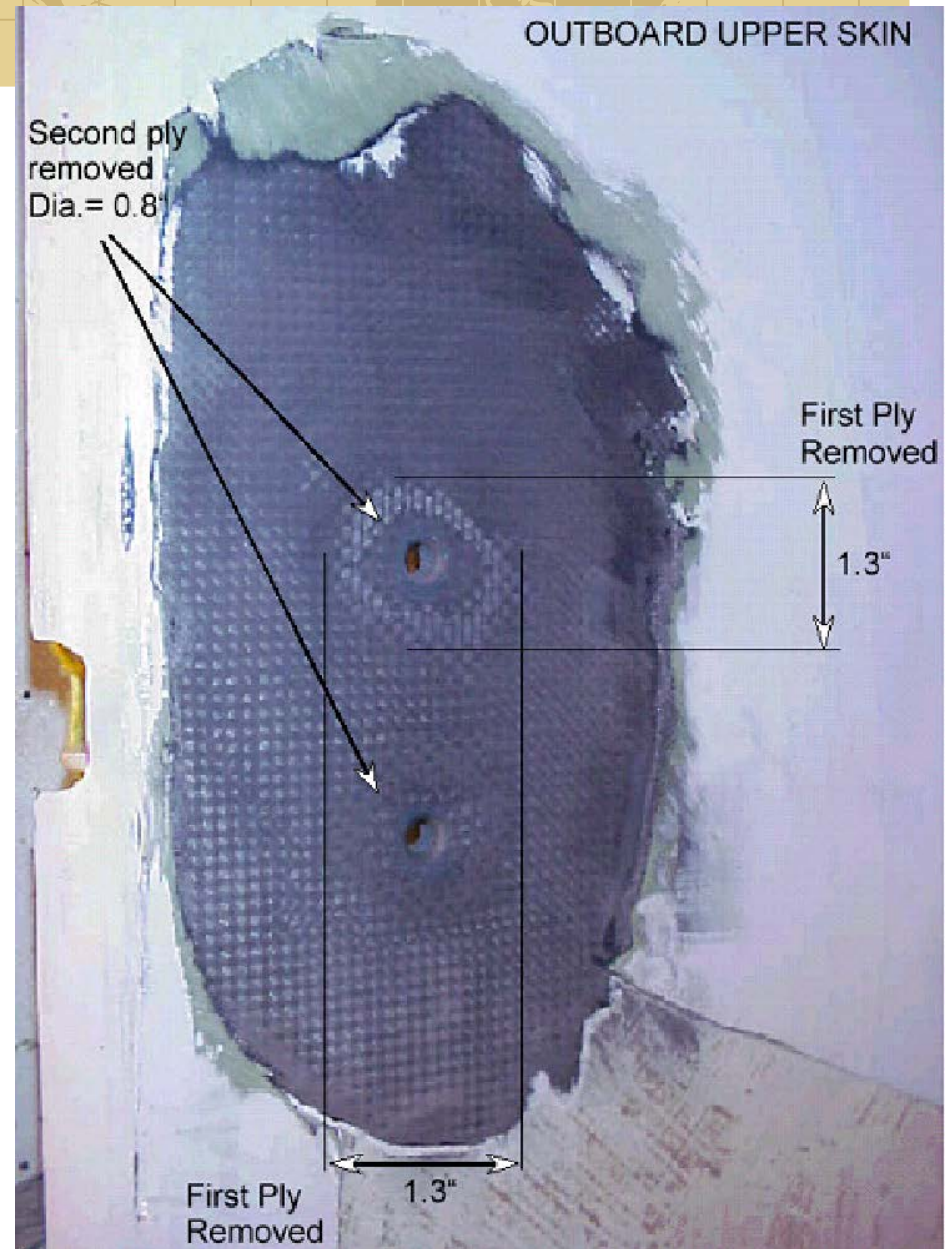


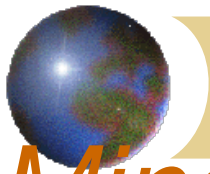


Common damage with no SRM repair

Aileron

- ✚ Lightning burn around fasteners which are in a critical area
- ✚ No SRM repair - “Contact OEM”

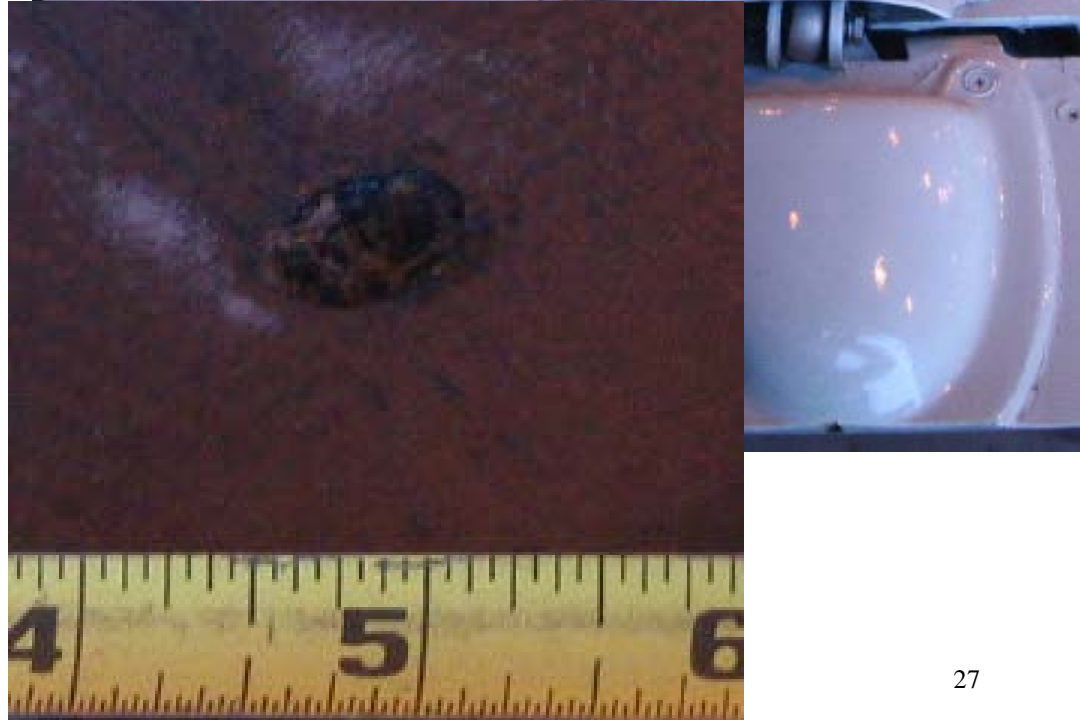


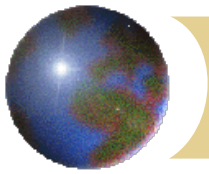


Minor damage with SRM difficult repair

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



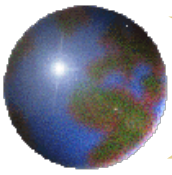


Minor damage with no SRM repair

737 Rudder Spar

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

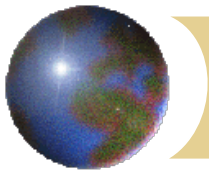




737 Rudder Spar - Close Up View

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

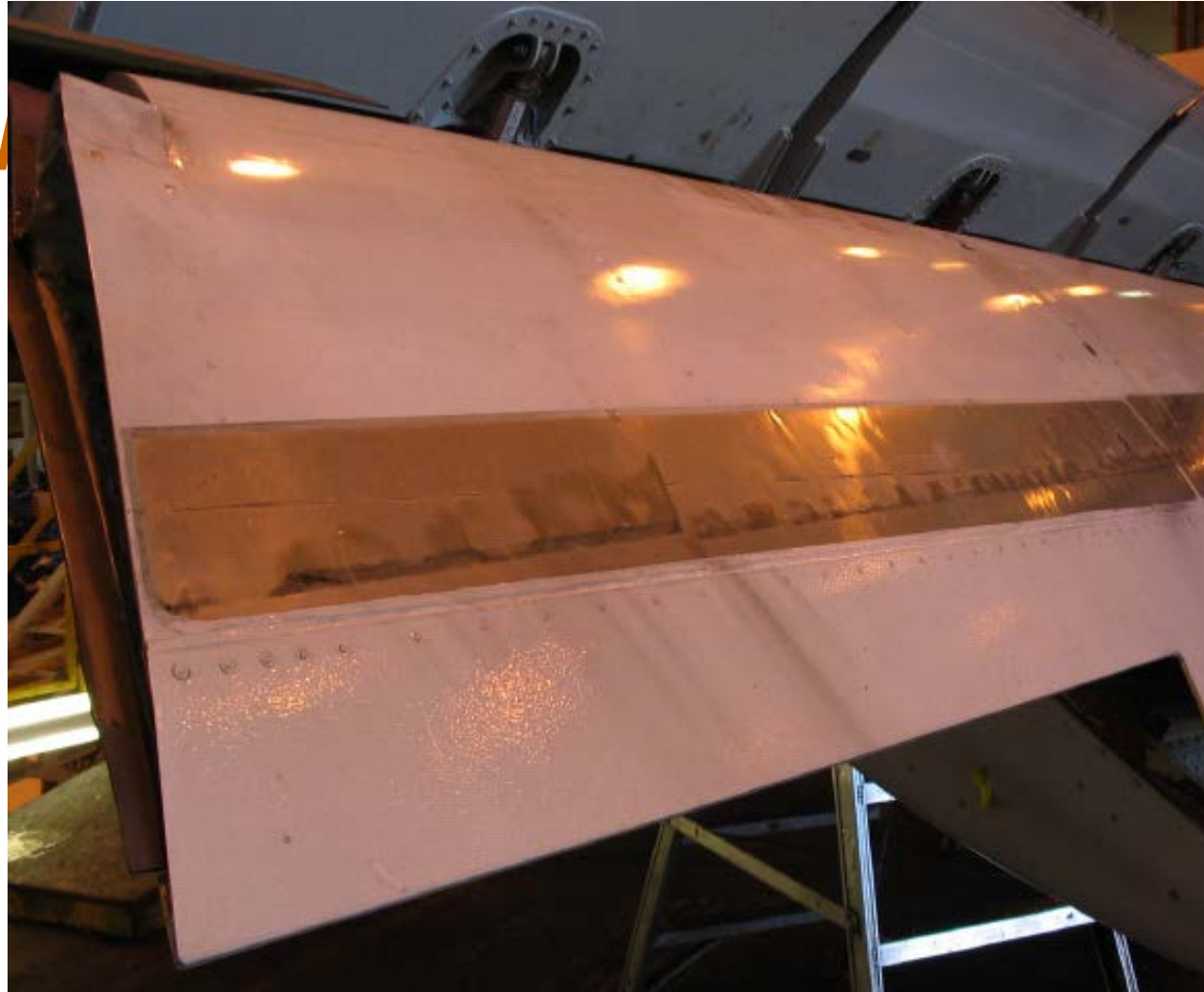


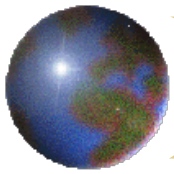


Common damage with difficult SRM repair

PROBLEM: Flap
CRES Rubstrip
delaminates.

Flap skin gouged
during rubstrip
trimming





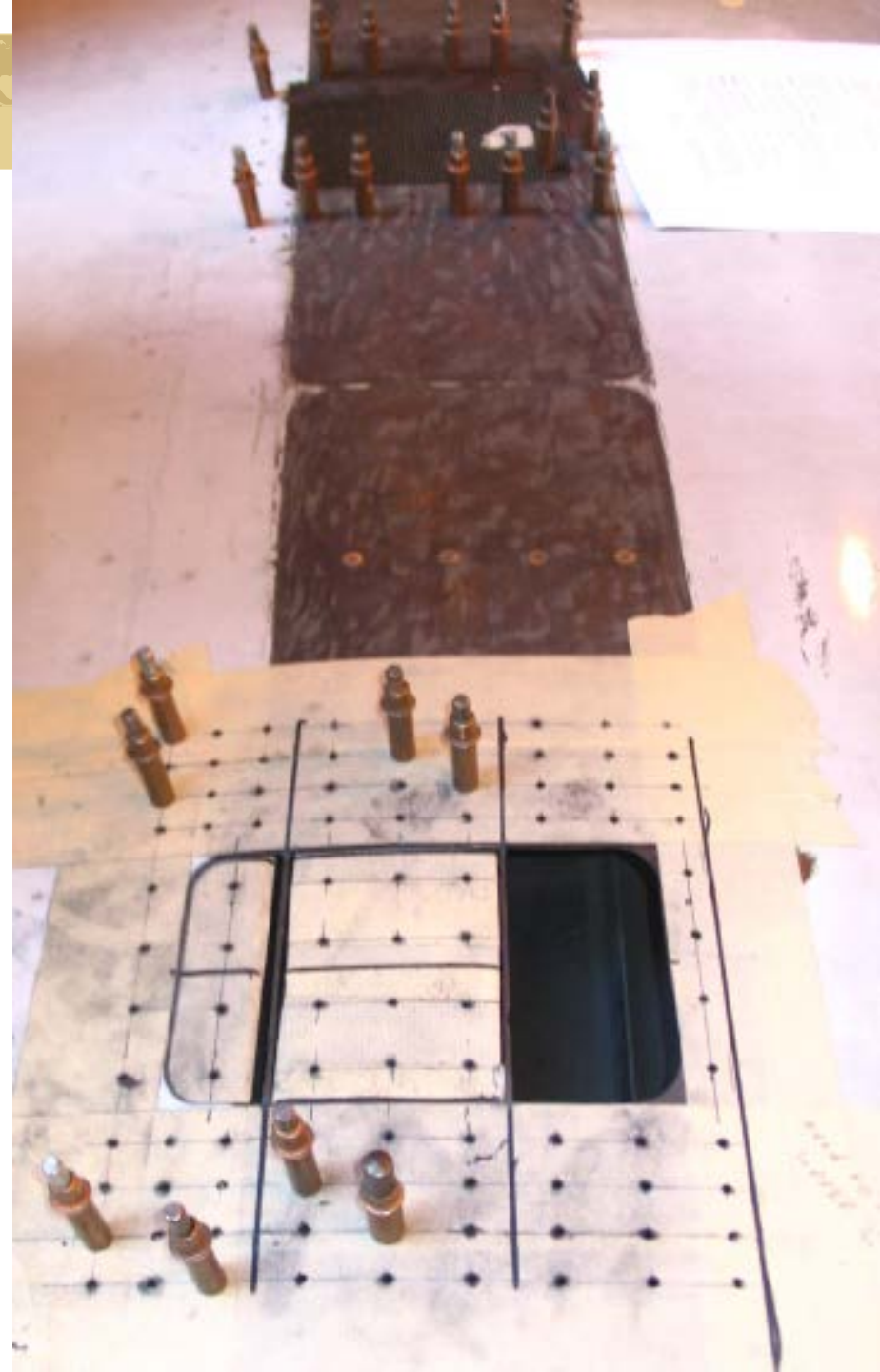
SRM Repair

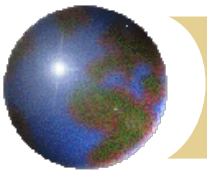
DAMAGE: Gouges .005 to .050" deep, 6" long (70% of skin thickness)

SRM REPAIR: No bonded repair - bolted only

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

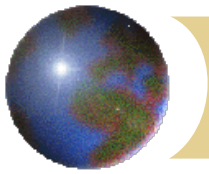
RESULT: 8 Days out of service





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

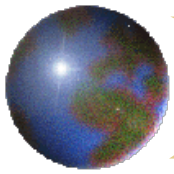
✚ Airline maintenance:

- 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?

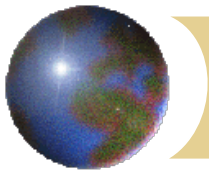
✚ For the airlines that are out-sourcing, OSVs are also handling the shop work to support checks, and the engineering

✚ 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 Curriculumms
 - 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