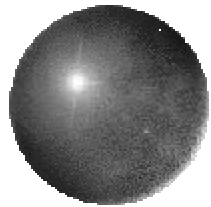




*REPAIR AND*

*MAINTENANCE*



*IMPLEMENTATION:*

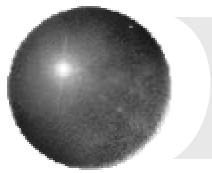
*Airline Experience,*

*Problems, Concerns*

*and Issues*

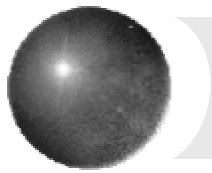
*By Eric Chesmar*

 **UNITED AIRLINES**



# *Airline Experience*

- ⊕ CACRC (Commercial Aircraft Composite Repair Committee)
- ⊕ Airline Maintenance Regulations
- ⊕ Maintenance Process Flow
- ⊕ Repair Process Flow
- ⊕ Training and In-process controls
- ⊕ Airline Maintenance trends

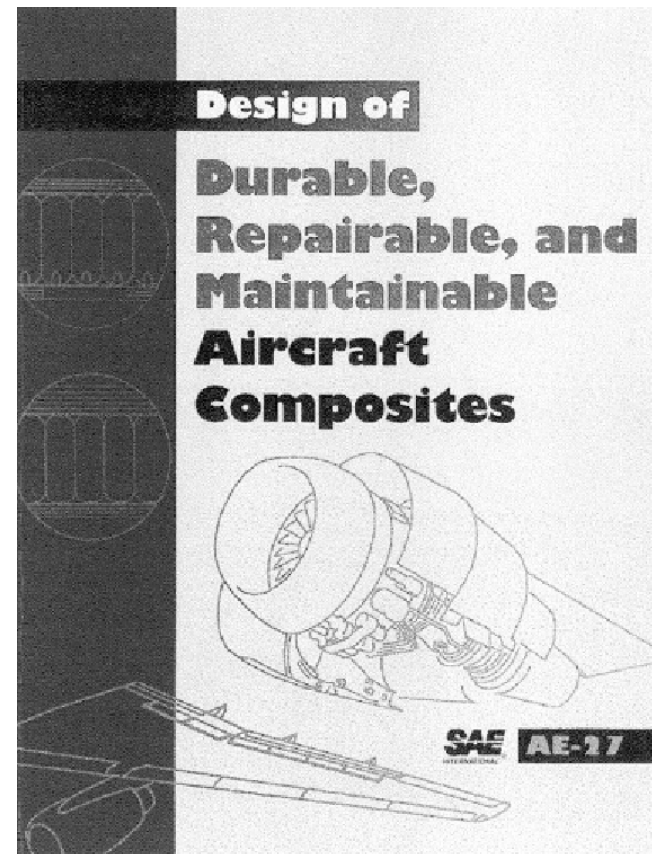


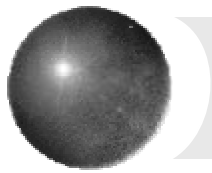
# CACRC

- ❖ Combined in 1991 from ATA, IATA, SAE groups
  - ❑ Consensus on specifications to standardize:
    - Repair Techniques
    - Materials,
    - Airline Conditions (facilities, locations, repair types),
    - Training Curriculums
    - Analytical Techniques
    - Design
  - ❑ Specifications available to purchase from SAE
  - ❑ See website [www.sae.org](http://www.sae.org) to join
  - ❑ Next meeting Oct 18-21, 2004 in Manassas, VA, USA

# *Airline Experience*

- ⊕ Design for Damage and Repair
  - ⊠ In-service, environmental, impact
  - ⊠ Documented in SAE AE-27
  - ⊠ Task group gave 4-hour presentation to several OEMs with lots of pictures
  - ⊠ Available to any OEM who requests it
- ⊕ Revision and additions being considered

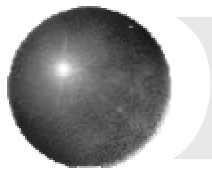




# *Airline Experience*

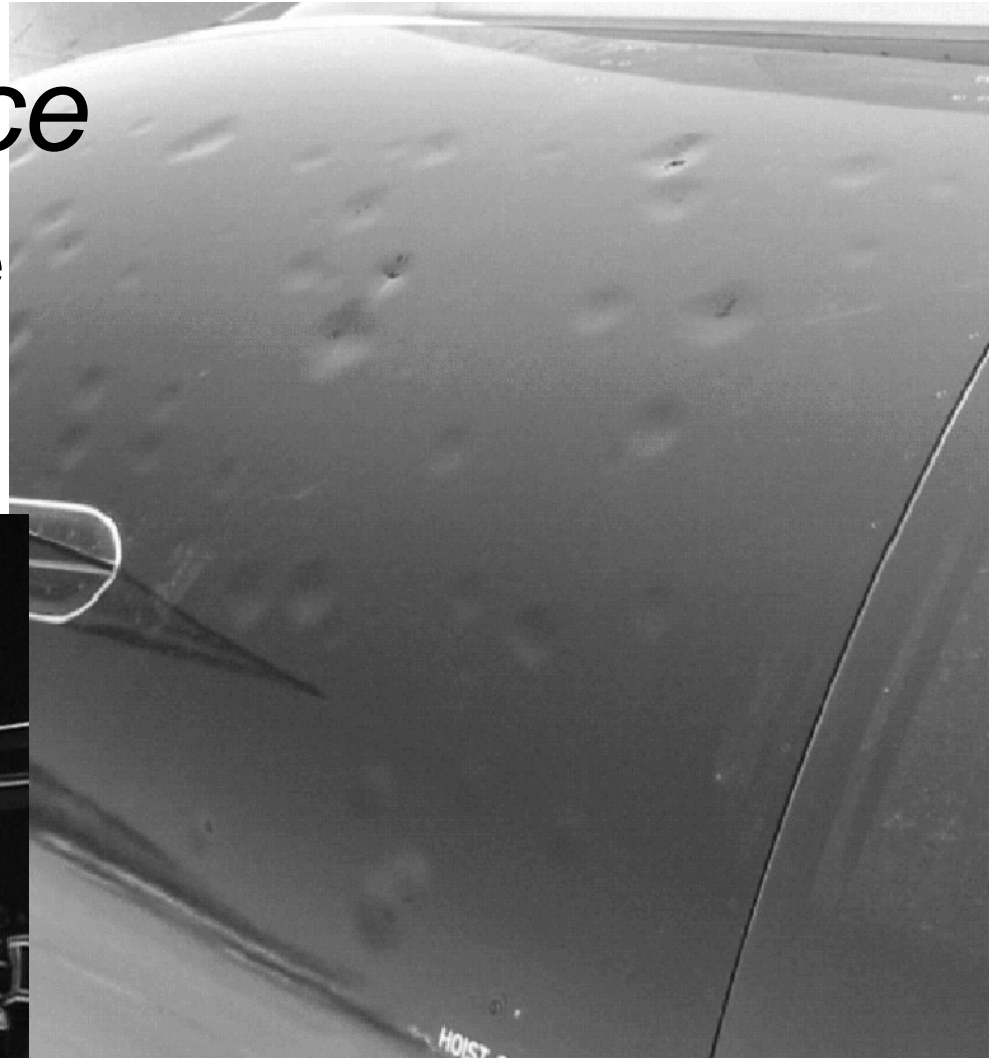
## ✦ AIRLINES DESIGN CONCERNS

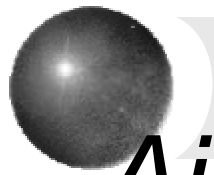
- Based on CACRC surveys in 1995
- ✦ Durability & Impact Resistance
- ✦ Fluid Ingression
- ✦ Erosion
- ✦ Overheating
- ✦ Protective Finish (Paint)
- ✦ Complicated Repairs & Inspection Requirements
  - “Airline maintenance operations live and die by the Structural Repair Manuals”
  - Repair requirements are determined/set upon initial design.



# *Airline Experience*

- ✦ Airlines understand the concept of out-of-service for repair

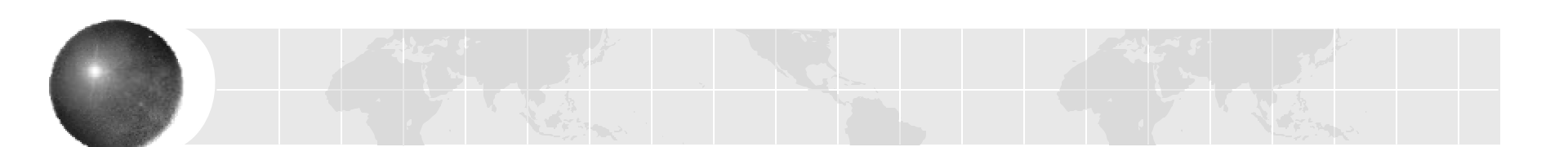




# *Airline Experience*

- ⊕ Airlines understand large damage
- ⊕ These are not safety issues
- ⊕ What about the other end of the spectrum?



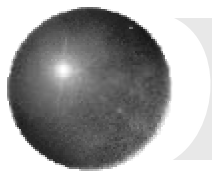


# *Common damage with difficult SRM repair*

- ⊕ Lightning burn at trailing edge
- ⊕ SRM Requires 350F prepreg repair and disassembly
- ⊕ Designed to pass FAR and but AC is grounded due

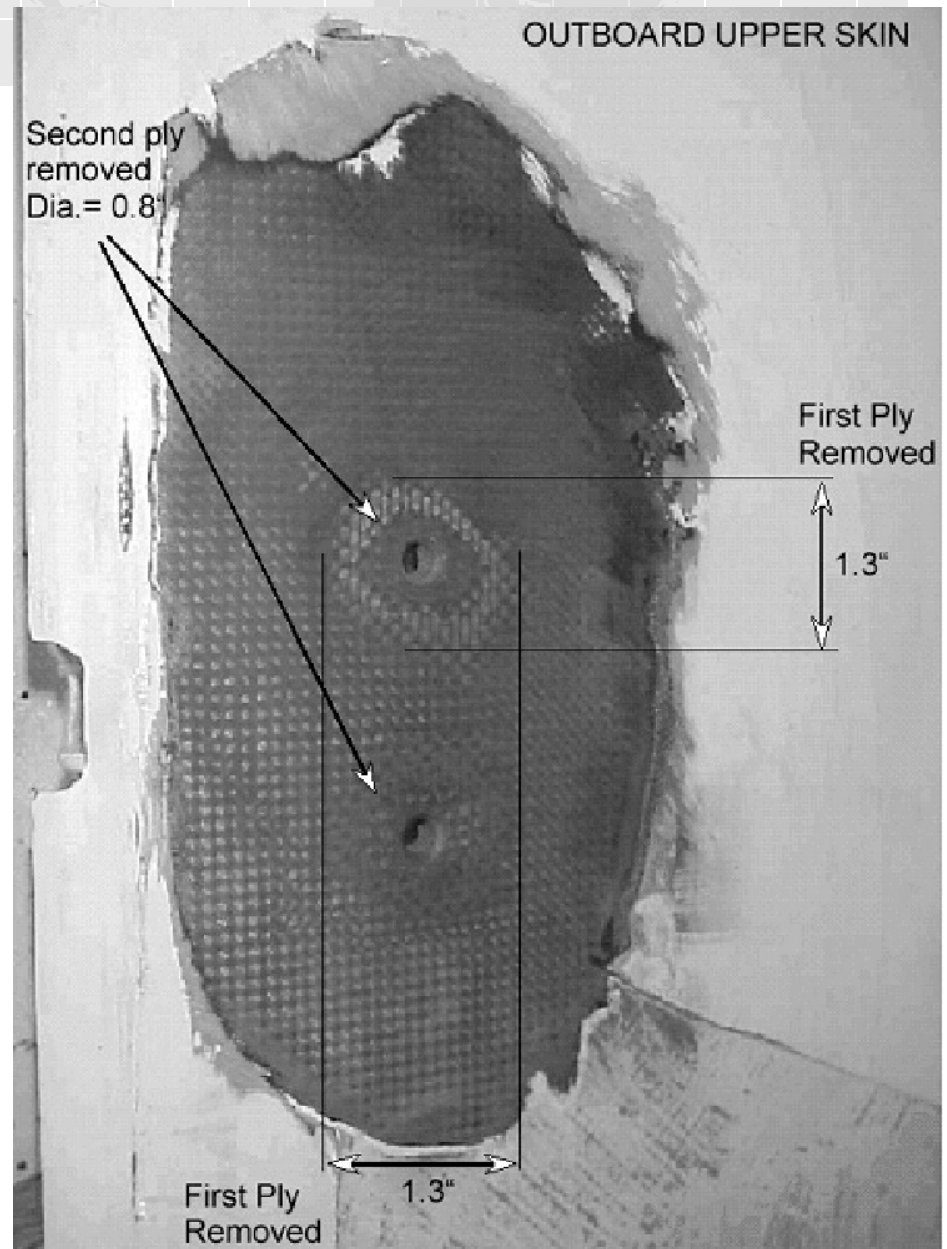


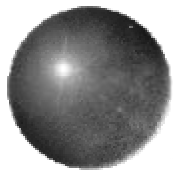




# *Common damage without SRM repair*

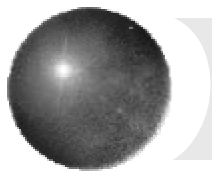
- ⊕ Lightning burn around fasteners which are critical area, therefore “contact OEM”



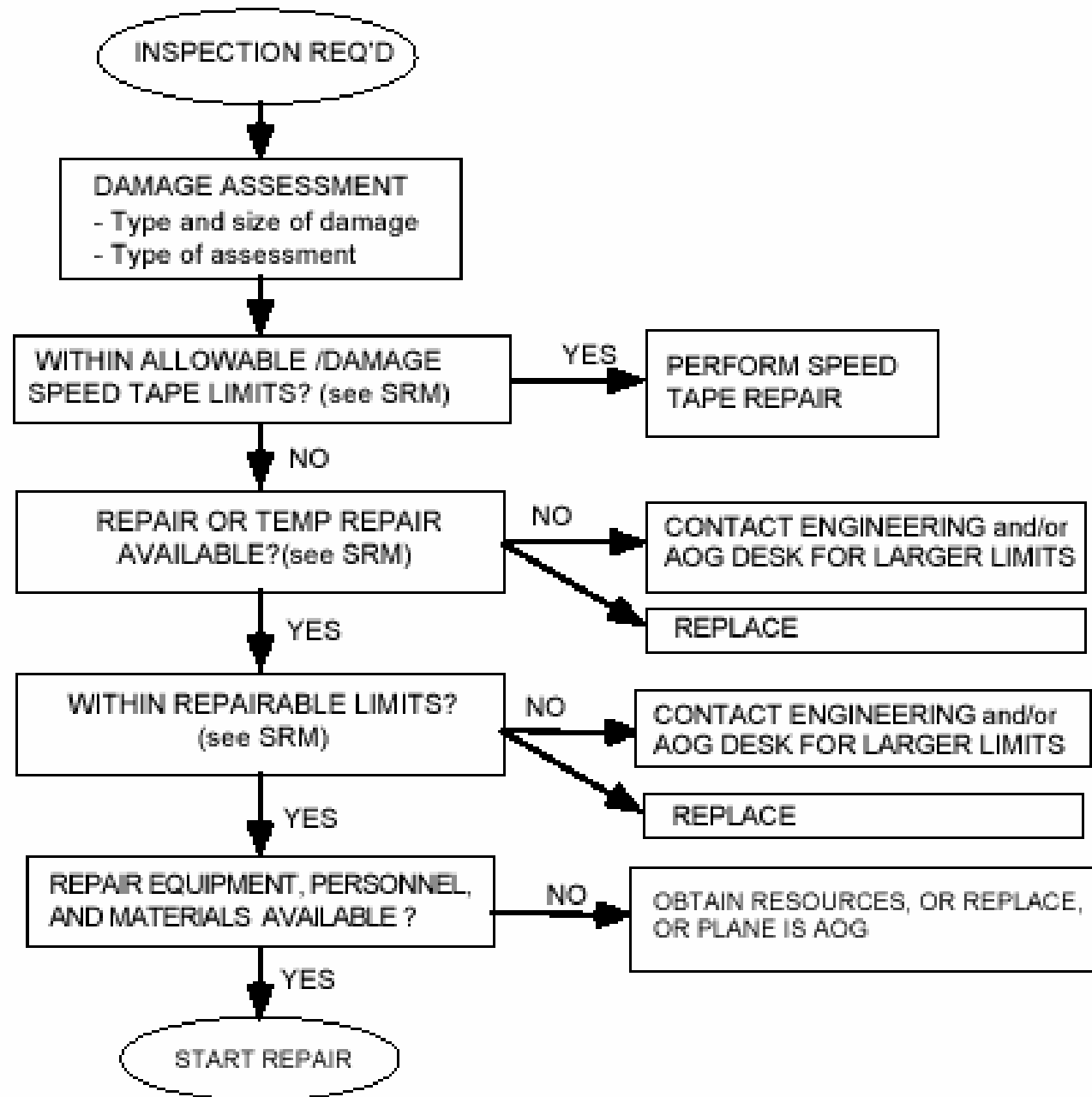


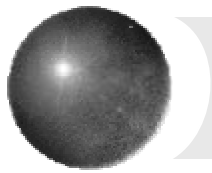
# *Airline Maintenance Regulations*

- ❖ Instructions for Continued Airworthiness
  - ❖ Structural Repair Manual - not all parts covered
  - ❖ Aircraft Maint Manual., Component Maint. Manual, NDT Manual
  - ❖ Configuration Dispatch List, Minimum Equipment List
- ❖ Maintenance Program
  - ❖ On-condition visual inspection at A-Check (monthly), B-check (6month), C-check (1-year), C-check (5-year)
  - ❖ Very few composite parts with routine NDT
    - For example: 757 and 767 Rudder/Elevator critical areas
- ❖ Reliability Program - monitor/reporting of removals
- ❖ Service Difficulty Reports: flight interruptions, major repairs, etc.
- ❖ Engineering Request and Alert System
- ❖ FAA oversight
- ❖ 1-800 number for whistle-blowers



# Airline Damage Assess- ment Process Flow





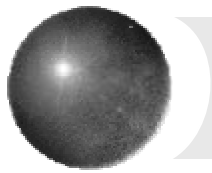
# *Damage Assessment Process*

## ⊕ Type of Assessment

- ⊞ Visual Inspection method is primary
- ⊞ Human factors – eyesight standards,
  - Should definition of BVID be standardized?
- ⊞ NDI methods - usually used to prove no defects

## ⊕ Defects types

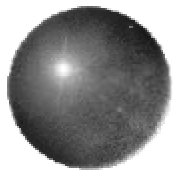
- ⊞ Defect definition not well documented
- ⊞ Defect types not complete
  - Burns in fiber, fiber breakout at drilled hole, etc,
- ⊞ Depth as well as area should be covered in SRM
- ⊞ Manufacturing flaws not included
  - wrinkles, surfacer, injection, etc.
  - One-time concessions or MRB action not in Rework Log



# *Damage Assessment Process*

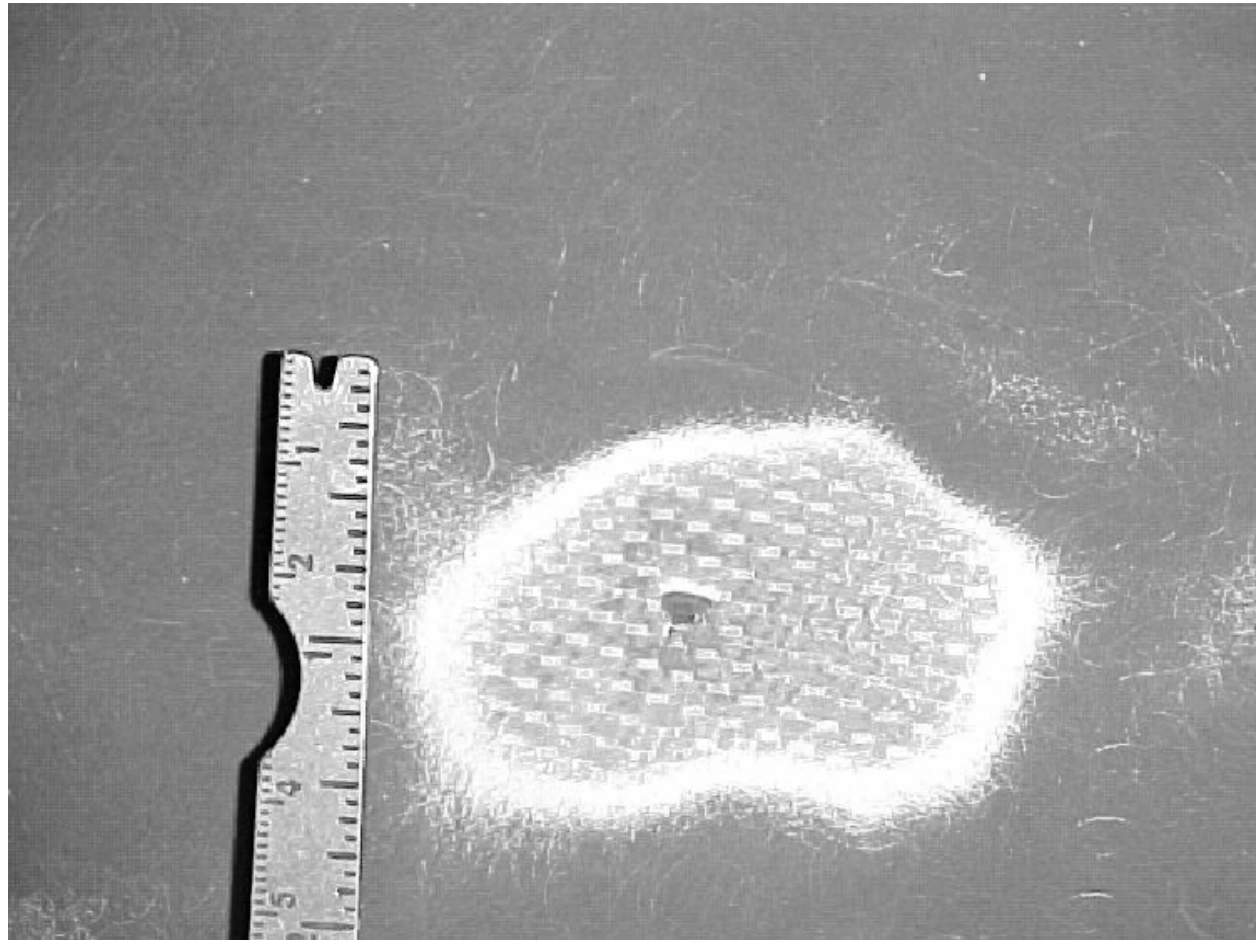
## ⊕ REPAIR EQUIPMENT, PERSONNEL, AND MATERIALS AVAILABLE?

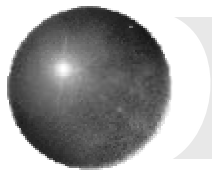
- ⊕ Materials: still an issue until standard materials implemented by OEMs. Wet layup resin approved. Prepreg not on the horizon. HazMat shipping on airline not allowed (such as dry ice). Equivalency or cross-labeling not widely accepted.
- ⊕ Equipment: hotbonders usually available but constrained by NDT equipment reference standards when required.
- ⊕ Personnel: easy to train but difficult to keep proficient. AOG teams a good solution.
- ⊕ Typical permanent SRM repair takes 2 days – 1 for logistics.



# *Damage Assessment Process*

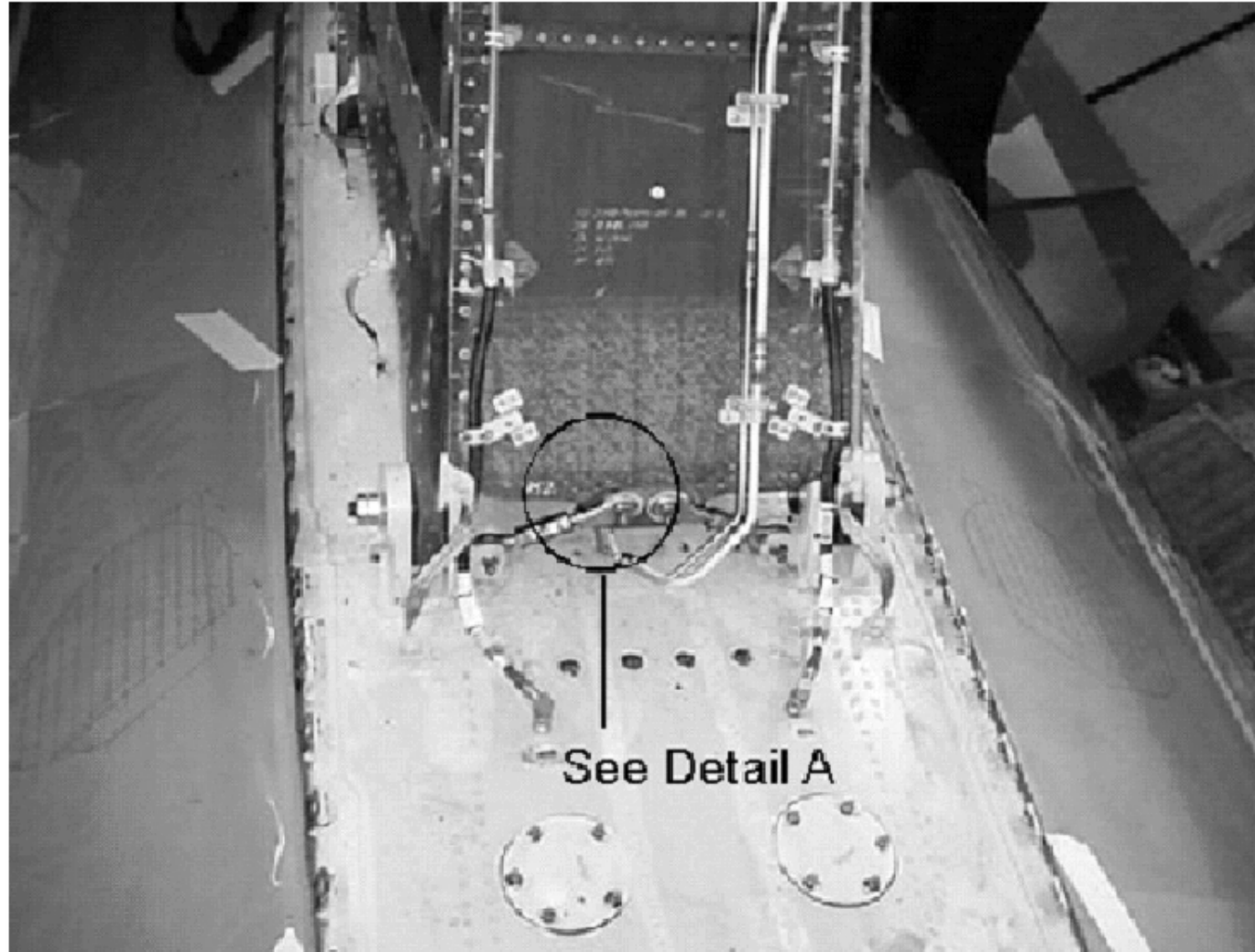
- ⊕ Factory Flaw Found during AC repaint at OSV
  - ⊕ SRM Requires wet layup repair

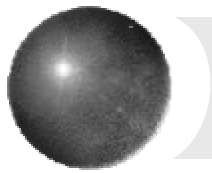




# *Damage Assessment Process*

- Example:  
Vert. Fin,  
front spar,  
at lower  
attach lug  
(VIEW 1)

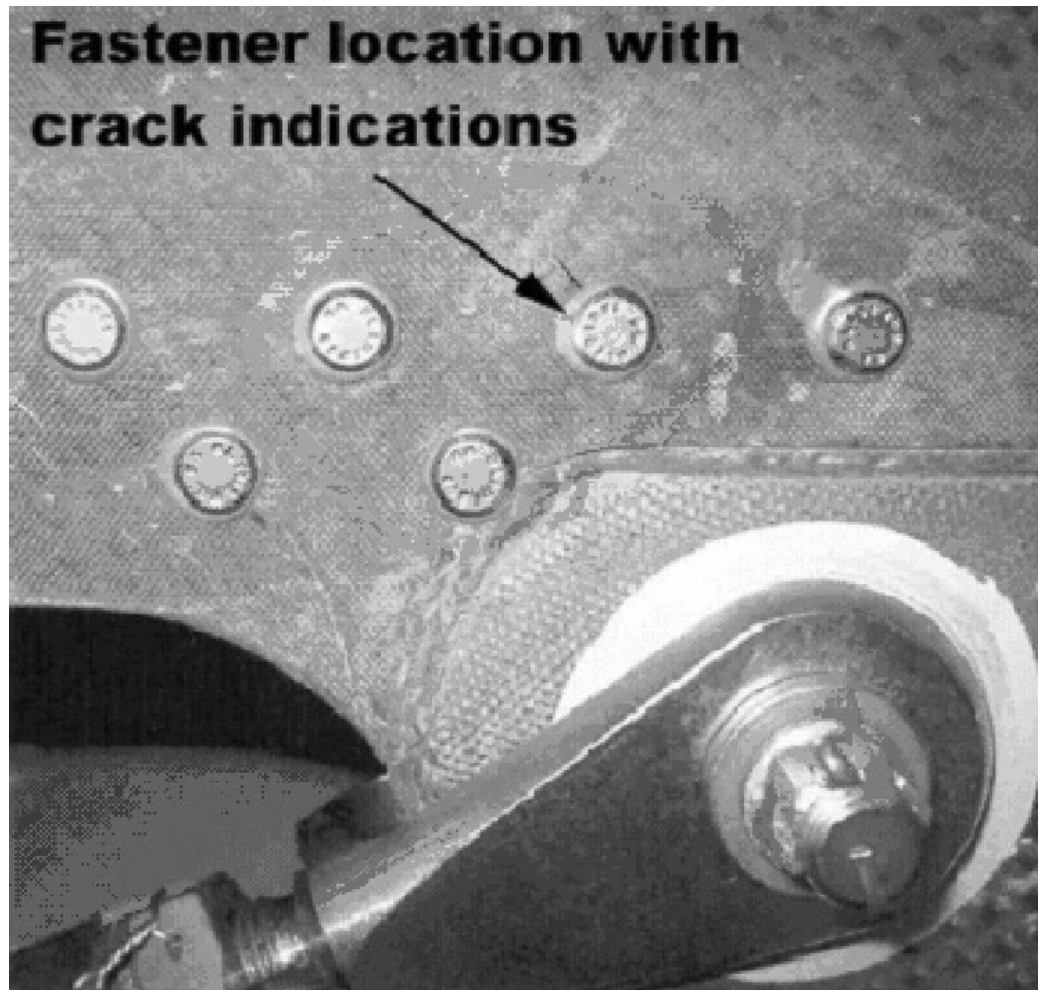




# *Damage Assessment Process*

✦ Example:  
Vert. Fin,  
front spar

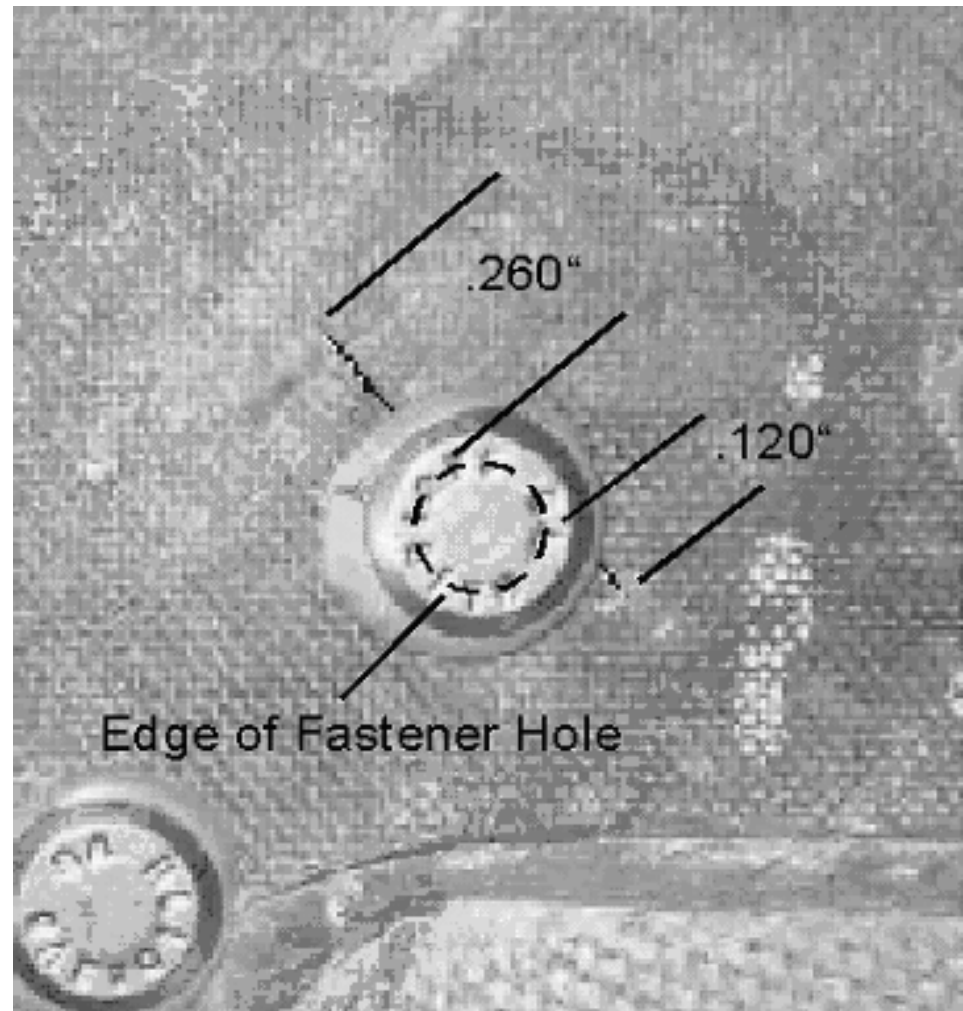
(VIEW 2)





# Damage Assessment Process

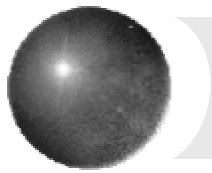
- ⊕ **Example: Vert. Fin, front spar close-up**
  - ⊕ “crack” enhanced for this picture
  - ⊕ To find allowable damage limits takes 15 pages, jumps to 5 SRM chapters
  - ⊕ Resolved after 4 telexes, 3 days, removal of fastener and NDT, and “repair”



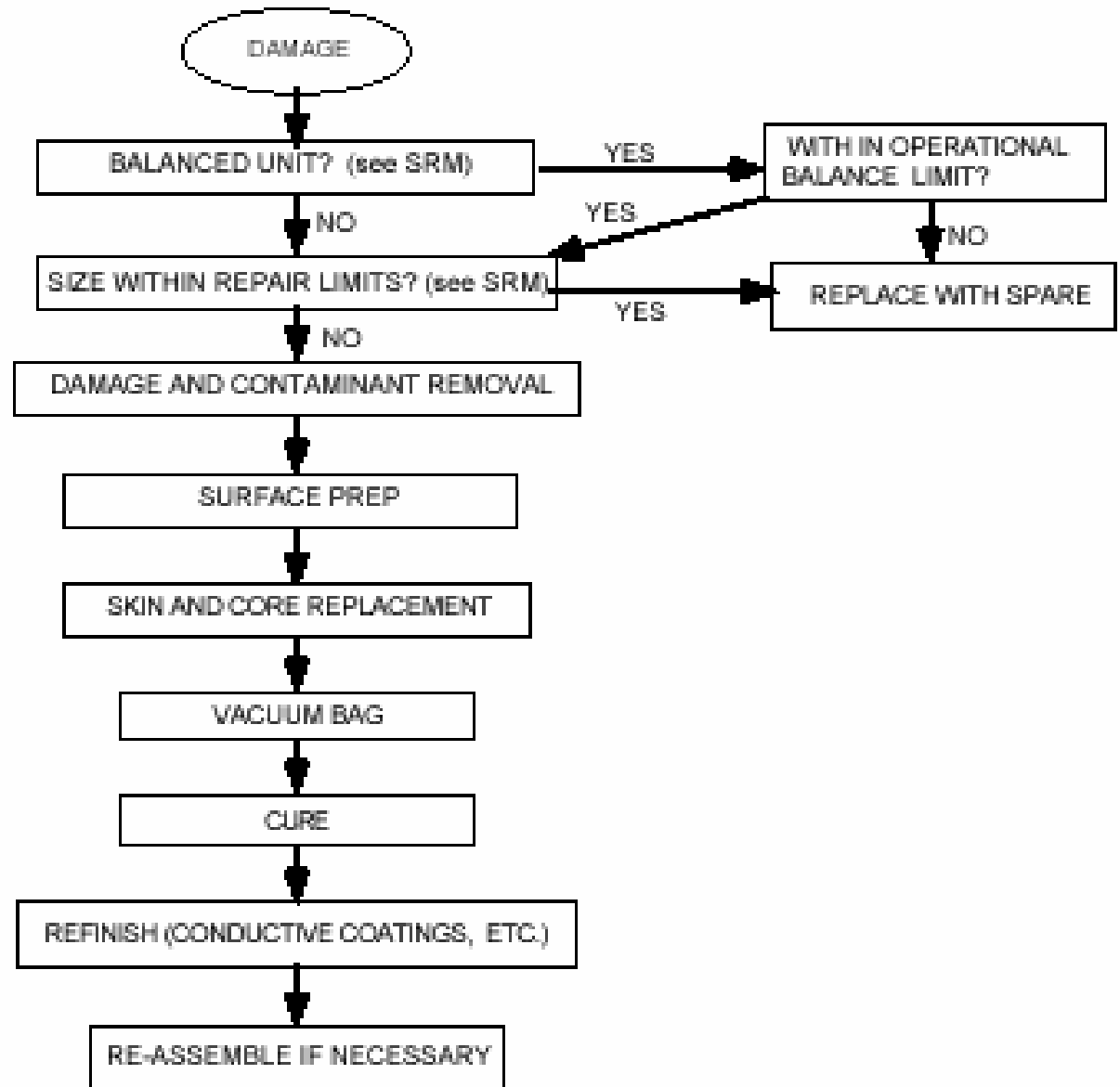
# Damage

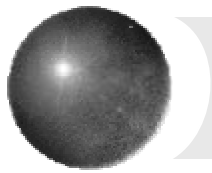
- ❖ Mfg flaws not documented in Rework Log
  - ❑ Resolved after 8 telexes, 10 days, and NDT
  - ❑ 30 hours engineering time
  - ❑ “OK as is”





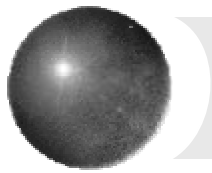
# *Airline Repair Process Flow*





# *Airline Repair Process*

- ⊕ **Balanced units –**
  - ⊕ Tags not found, repairs not documented
  - ⊕ Uncertainty forces part removed for shop static balancing
- ⊕ **Damage and contaminant removal**
  - ⊕ Water ingress always a concern, including for solid laminates when curing at 350F.
  - ⊕ Oil and hydraulic fluid very stubborn to remove.
  - ⊕ Corrosion of aluminum core is difficult to assess.



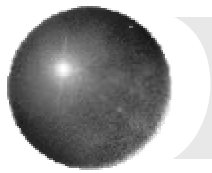
# *Airline Repair Process*

## ⊕ Vacuum Bagging

- ⊕ Leaks through honeycomb into bondline or composite skin. Solution is to close-out core before skin repair.
- ⊕ On-wing vacuum bags can be very difficult. Leak test is essential.

## ⊕ Heat Application

- ⊕ Hotbonding has wide range of heat-up rates due to heat sinks, different cross-sections, etc.
- ⊕ Heat blankets have large difference in quality- temp range, durability



# *Airline Repair Process*

## ⊕ Post-Repair evaluation

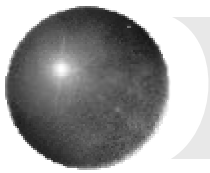
### ⊕ Visual checks of repair

- Bondline - Flow, no gaps, porosity
- Cure - hardness for under cure, color for over-cure
- Tap test for thin skins for
- Contour - bumps, waviness, depressions
- Composite - porosity (using color, dry fibers, bridging of vacuum bag),

## ⊕ Re-assembly

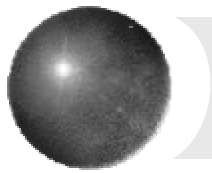
- Single-source fasteners or unique OEM part numbers often pacing item

## ⊕ In-process checks and sign-offs



# *Training*

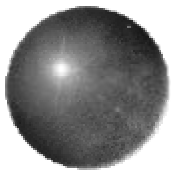
- ❖ Levels of training corresponds to repair readiness planned for:
  - ❖ 1st level: Room temp wet layup. Capability at many line maintenance stations. Included in most A&P training.
    - 67% of Line repairs are room temperature wet layup
  - ❖ 2nd level = 200F wet layup. Hotbonders at large stations (9 for UAL, 4 with hangers). No prepreg or metalbond. 3 day training.
    - 11% of Line repairs are 200F cure wet layup
  - ❖ 3rd level = Repair station. Prepreg and hotbond. Autoclave, PAA line, mechanical and chemical testing capability, engineering support for repairs and process specs. 250 and 350 cures. NDT common and routine (ultrasound, X-ray, thermography). Shop technicians support hanger and line operations. 2 week training plus OJT and probation period.



# *Industry trends*

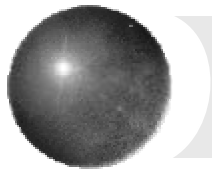
- ⊕ More out-sourcing
  - ⊞ Airline maintenance: Line, Base, and Component. Fewer stations with Maintenance Technicians
  - ⊞ OEM subcontracting of engineering, design, fabrication. Are Lessons Learned lost?
- ⊕ Less Airline engineering
- ⊕ Reduction and sharing of spares inventory
- ⊕ Shorter turn-times at gates





# Conclusions

- ⊗ Safety Issues
  - ⊗ Live by the letter of the Manual
  - ⊗ If not covered by the manual, then must be conservative
    - Uncertainty equals NO GO and grounded aircraft
    - Fear of Safety Risk results in economic cost
- ⊗ Lack of Confidence
  - ⊗ Widespread among non-specialists
  - ⊗ What they do hear
- ⊗ Mixed messages?
  - ⊗ Need different messages for different audiences
  - ⊗ Past infractions and fines not proportional to airworthiness impact
- ⊗ Worrying about the wrong things and missing the right things?



# *The End*

⊕ Questions?