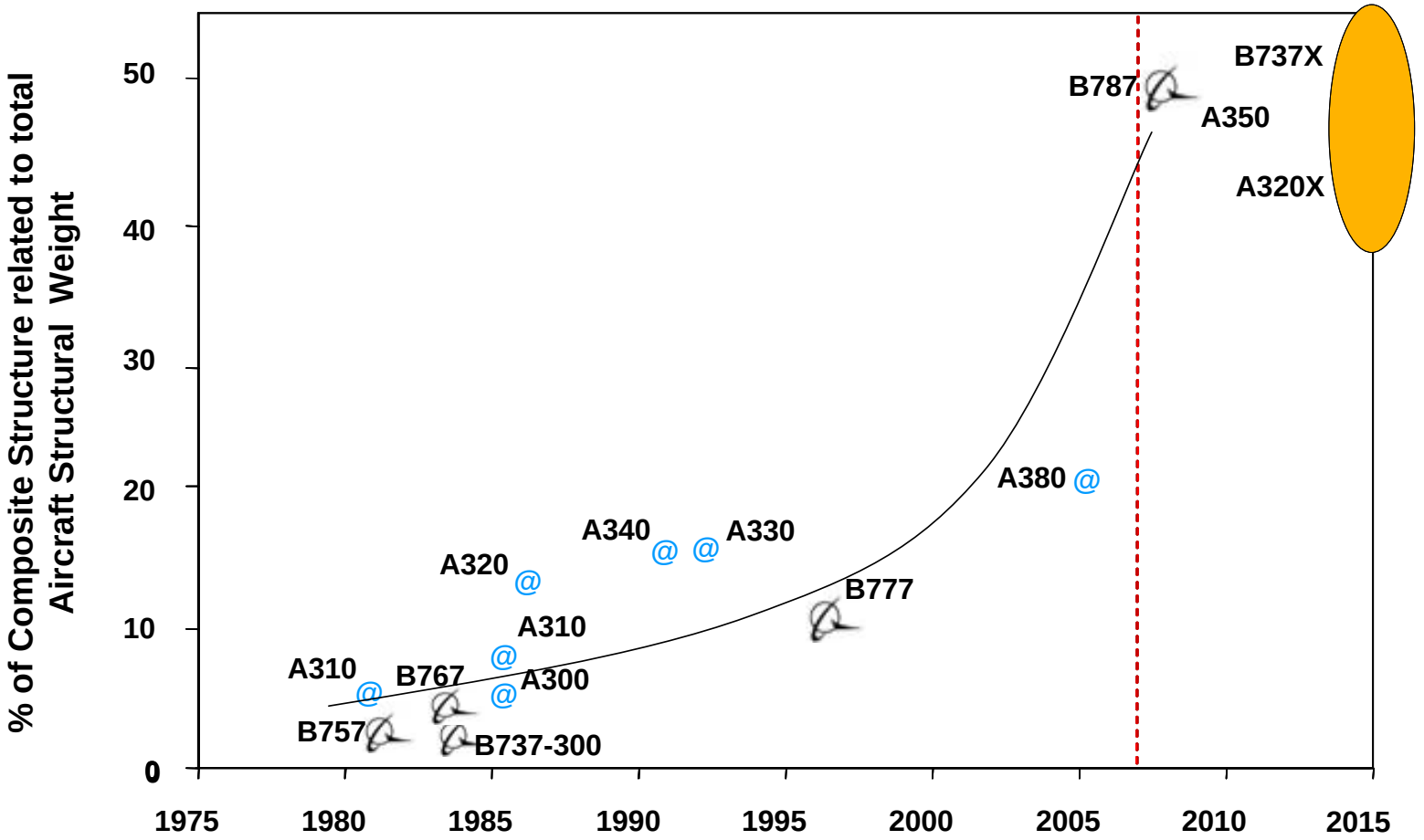
Lufthansa Technik

Lufthansa Perspectives on Safe Composite Maintenance Practices

Lufthansa Perspectives on Safe Composite Maintenance Practices

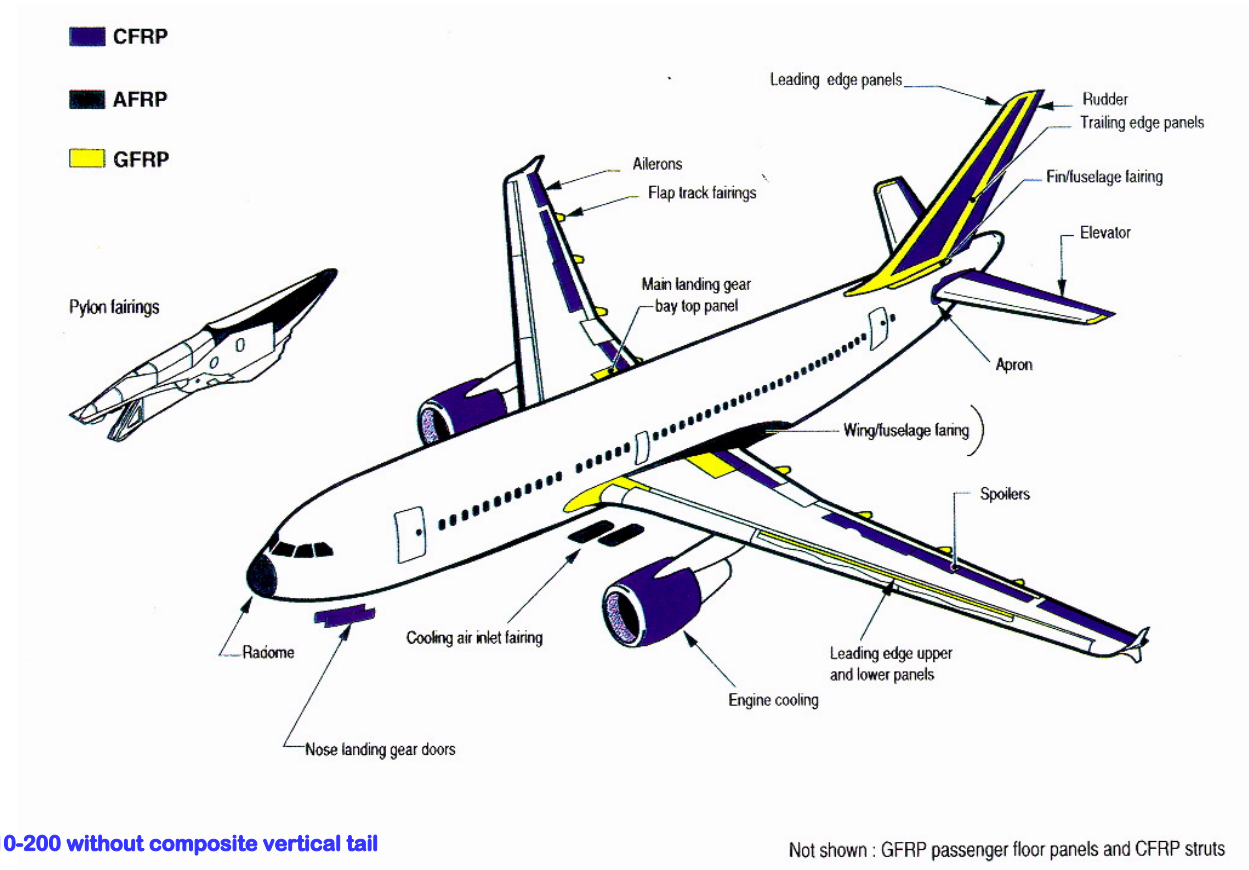
- **Experience with composite components**
- Damages on composite components
- Damage detection
- Repair processes and materials
- Repair quality assurance
- Total maintenance life cycle cost
- Lufthansa perspectives

Experience with composite components



Experience with composite components

A310-200 /-300 composite materials application

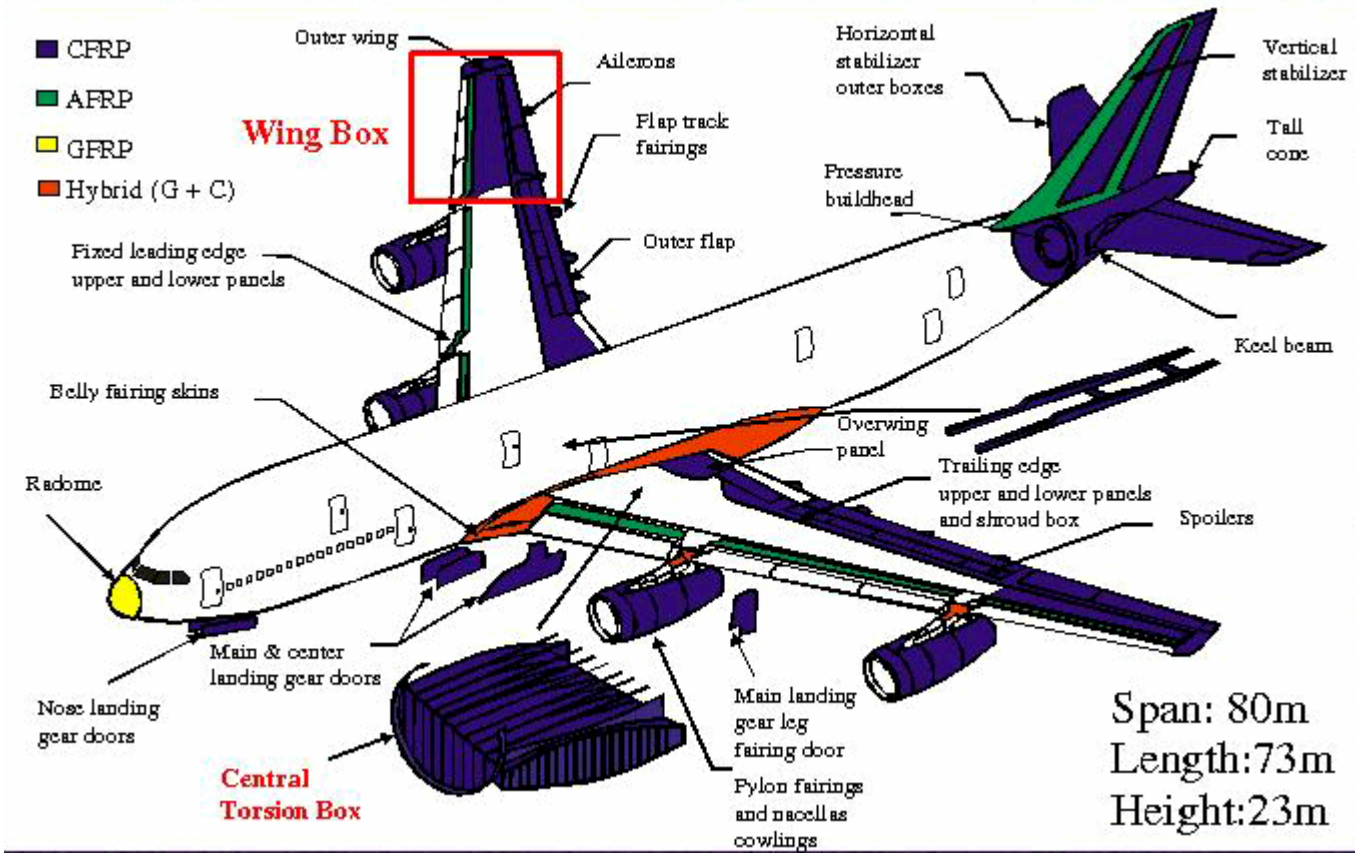


A 310-200 without composite vertical tail

Not shown : GFRP passenger floor panels and CFRP struts

Experience with composite components

A340-500 /-600 composite materials application



Experience with composite components

After 24 years of operational, maintenance and repair experience it can be concluded that:

- **Composite structural components will experience damages.**
- **Damage detection requires specific skills.**
- **Repair processes and materials are not standardized.**
- **Repair quality is material and process dependent.**
- **Difficult to asses quality of repair.**
- **The total maintenance life cycle cost has not always proven to be better than for comparable metallic structures.**

Lufthansa Perspectives on Safe Composite Maintenance Practices

- Experience with composite components
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Damages on composite components

Prevalent damages on composite structural components can result from:

- ground service vehicles
- runway debris, tire separation
- bird strike
- lightning
- hailstorm
- overheat
- erosion
- surface coating removal
- fluid contamination
- design failures
- manufacturing deficiencies
- maintenance errors

Damages on composite components

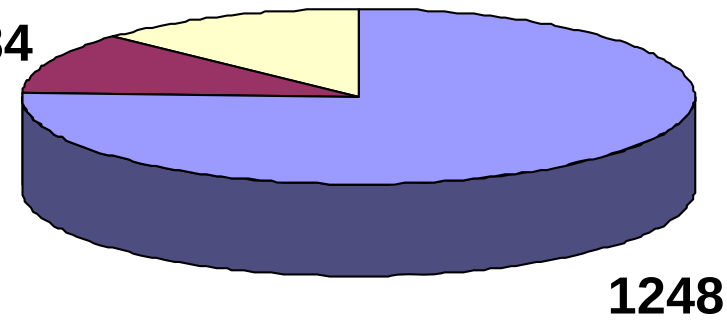
Total damages – Total fleet – Year 2006

Fleet Size: 243 a/c
Total damages: 1647 events
Repair Cost: € 33.200.000

Lightning Strike

216

Bird strike **184**



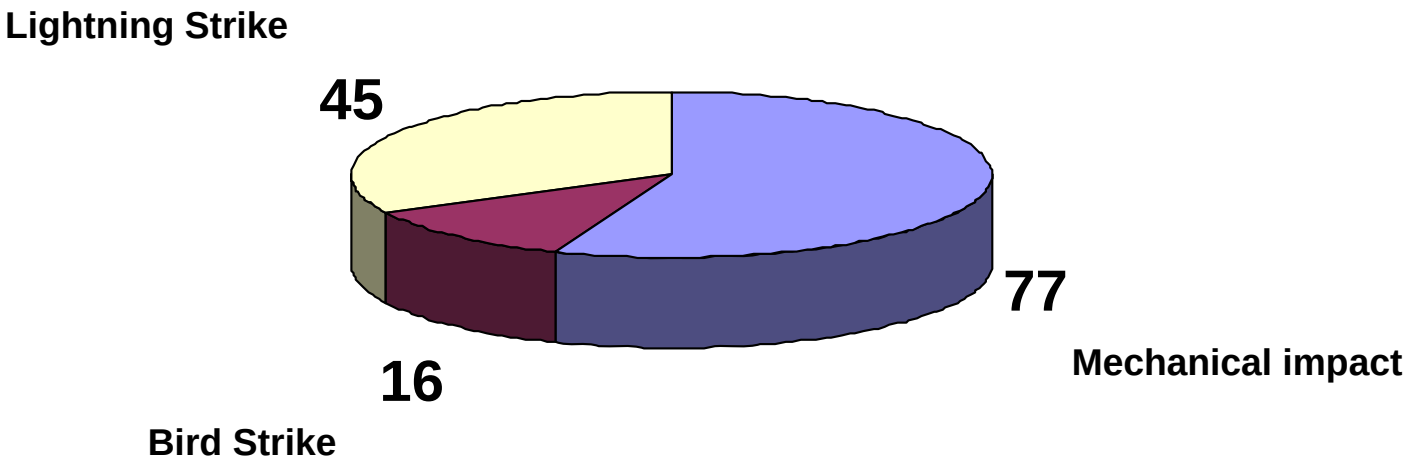
1248

Mechanical impact

Damages on composite components

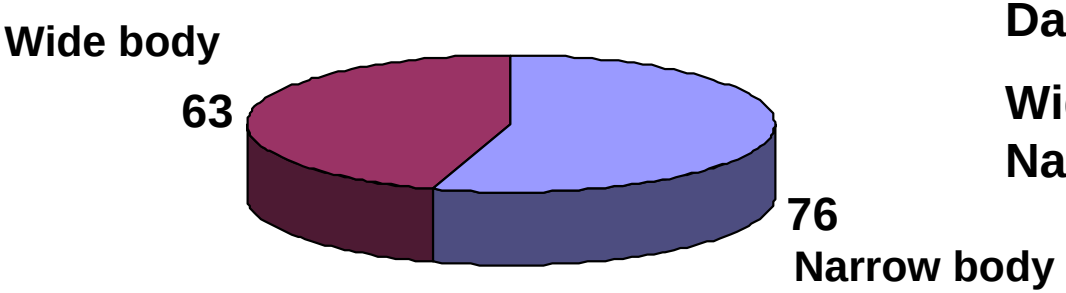
Fuselage structural damages – Total fleet – Year 2006

Fleet Size:	**243 a/c**
Fuselage damages:	**138 events**
Repair Cost:	**€ 3.500.000**



Damages on composite components

Fuselage Structural damages – Total Fleet – Year 2006



Fleet size:

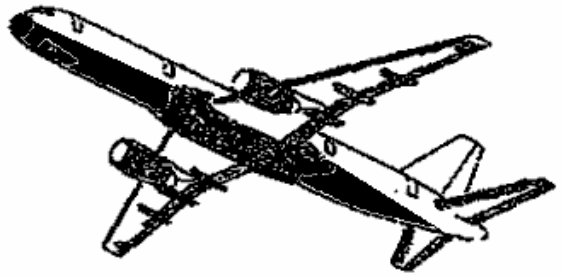
Wide body: 99 a/c
Narrow body: 144 a/c

Damage Frequency:

Wide body: every 1000 flights
Narrow body: every 4600 flights

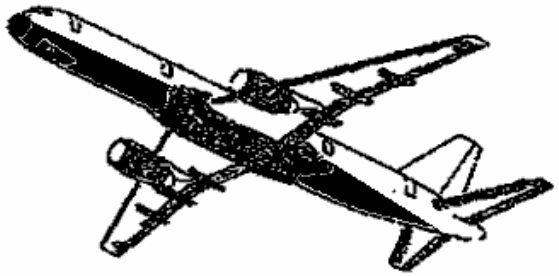
Damages on composite components

Foreign **O**bject **D**amage (FOD) ground service vehicles



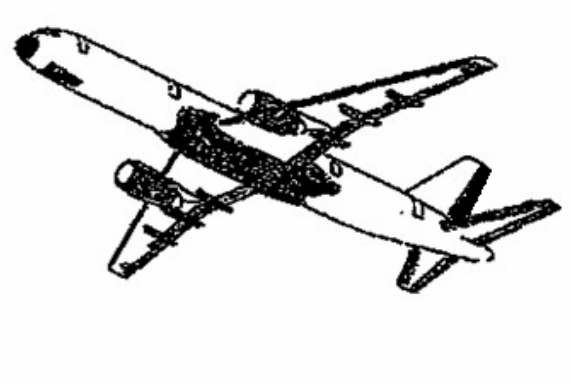
Damages on composite components

Foreign **O**bject **D**amage (FOD) ground service vehicles



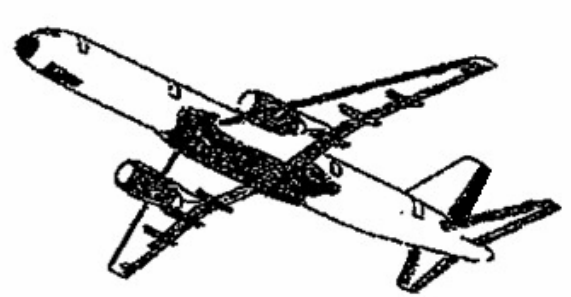
Damages on composite components

Foreign **O**bject **D**amage (FOD) towing damage



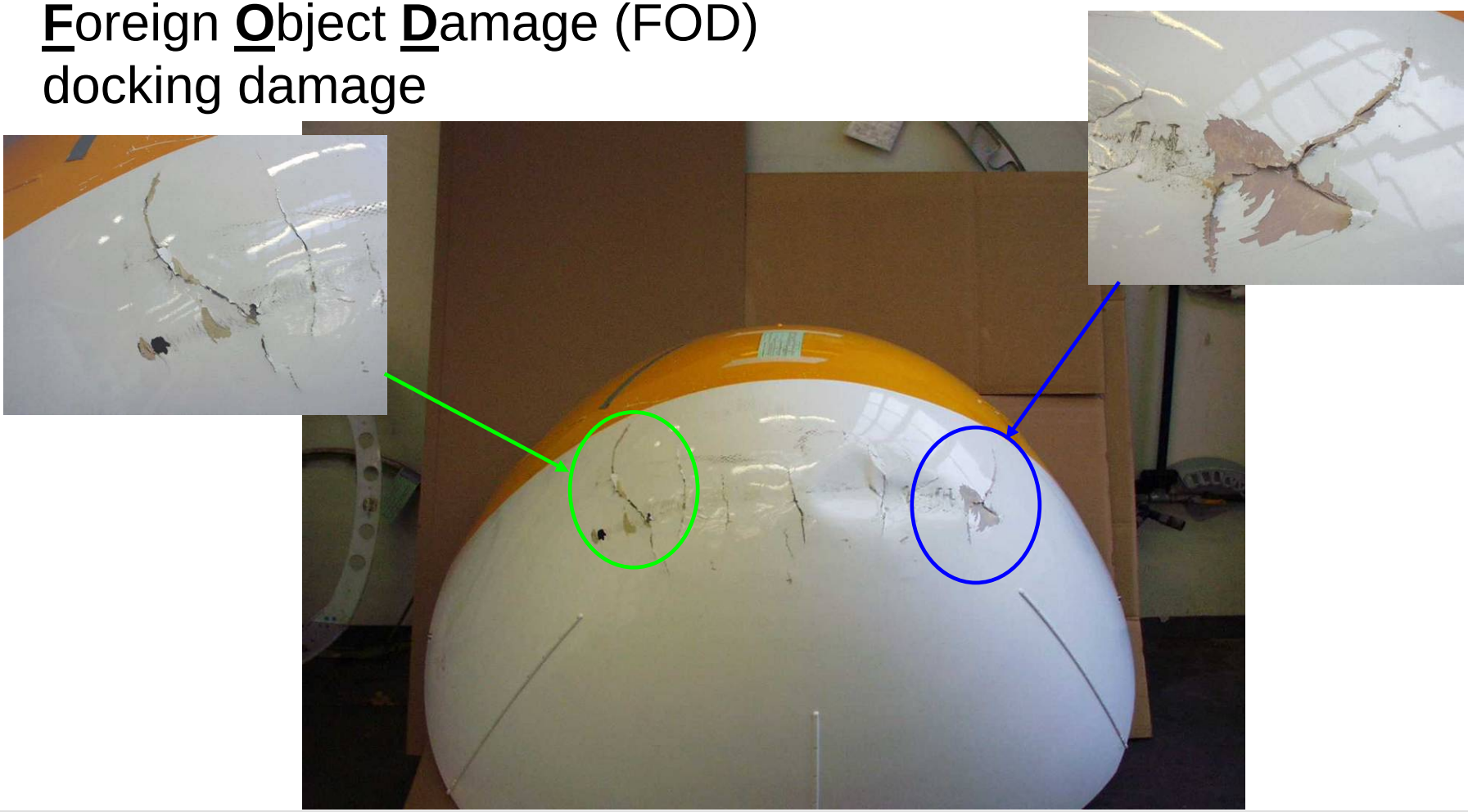
Damages on composite components

Foreign **O**bject **D**amage (FOD) towing damage



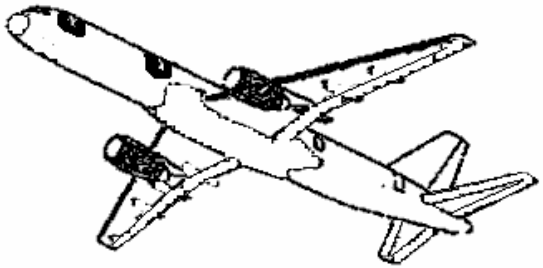
Damages on composite components

Foreign **O**bject **D**amage (FOD) docking damage



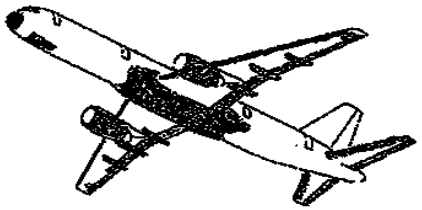
Damages on composite components

Foreign **O**bject **D**amage (FOD)
Passenger fly bridge



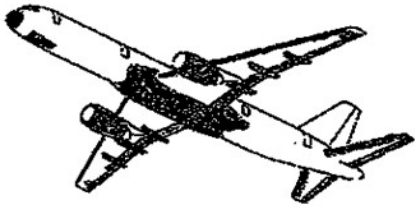
Damages on composite components

Foreign **O**bject **D**amage (FOD) ground service vehicles



Damages on composite components

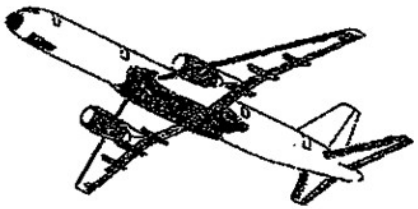
Foreign **O**bject **D**amage (FOD) ground service vehicles



Reverser
translating sleeve

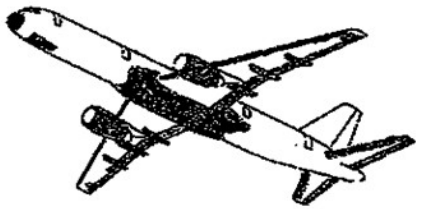
Damages on composite components

Foreign **O**bject **D**amage (FOD) ground service vehicles



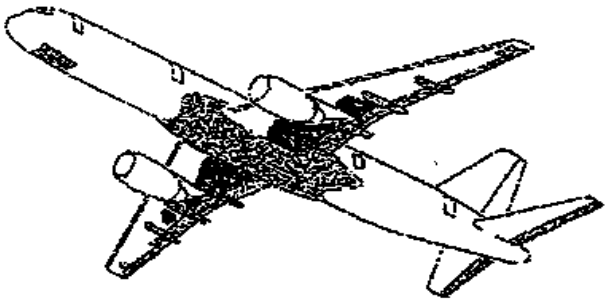
Damages on composite components

Foreign **O**bject **D**amage (FOD)
runway debris - damage on horizontal stabilizer



Damages on composite components

Foreign **O**bject **D**amage (FOD) tire separation



Parts of a tire or debris on the runway may damage composite structures heavily.

Damages on composite components

Foreign **O**bject **D**amage (FOD) bird strike

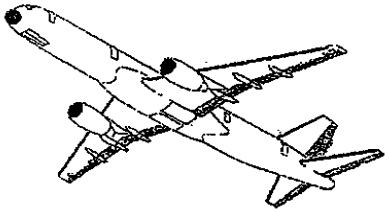
Bird strike results in heavy structural damages. Affected areas are radomes, engines and leading edges.

Damages on composite components

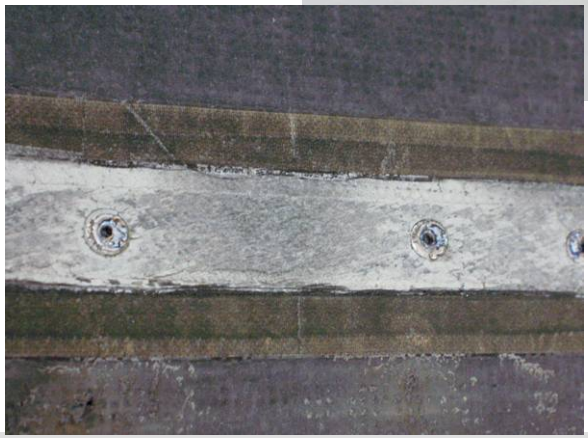
Foreign **O**bject **D**amage (FOD)
bird strike

Damages on composite components

Lightning



Lightning strike on
a CF6-80 translating
cowling

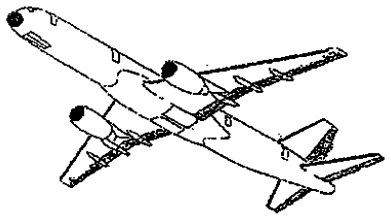


Composite materials are electric conductors.

Because of thermal overload and/or sparking, adjacent fasteners have to be changed after lightning damage.

Damages on composite components

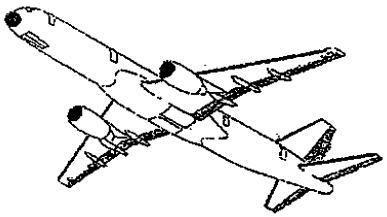
Lightning



Lightning strike on CFM56-5A
Fan Reverser

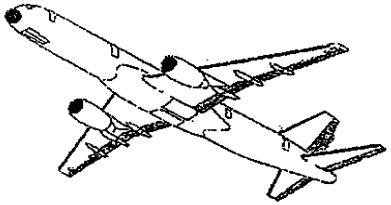
Damages on composite components

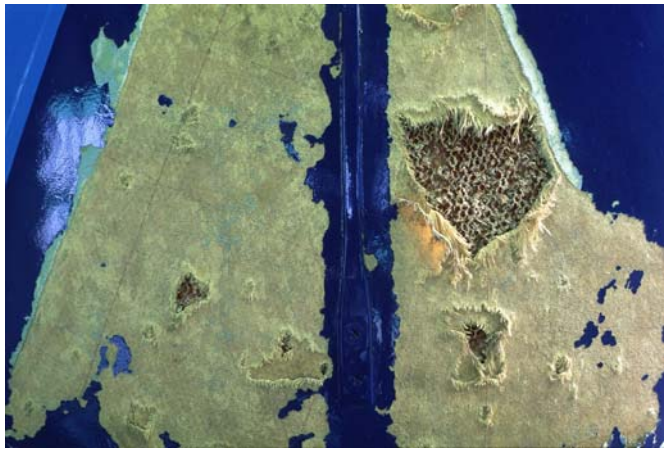
Lightning



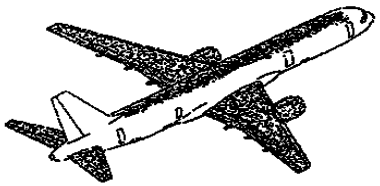
Damages on composite components

Foreign **O**bject **D**amage (FOD) hailstorm





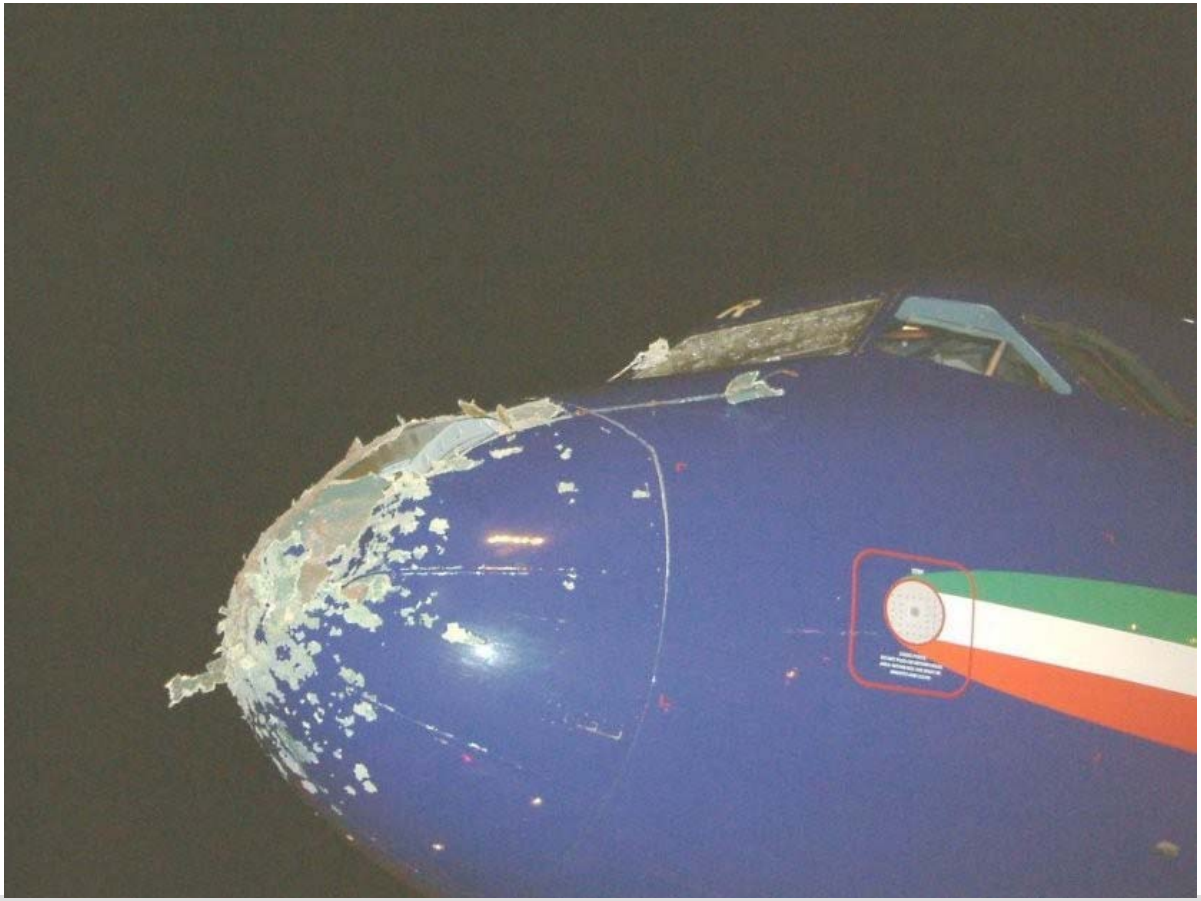
Hailstorm damage often occurs on leading edges, engine nose cowl and radome areas.



Hailstorm damage is frequently more difficult to detect on composite structures.

Damages on composite components

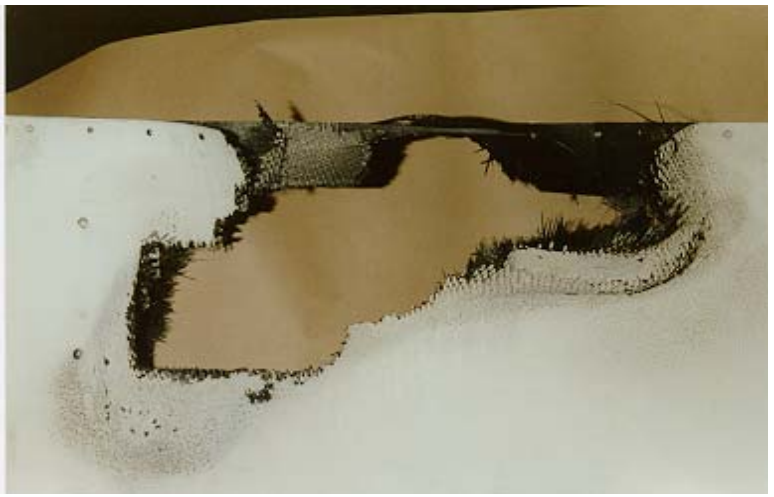
Foreign **O**bject **D**amage (FOD)
hailstorm

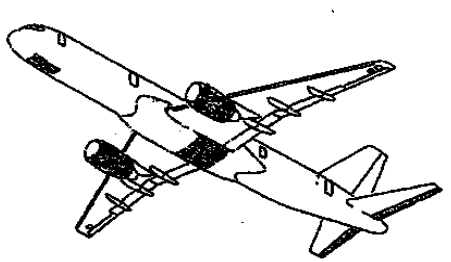


Damages on composite components

Overheat

Fan cowl overheat damage resulted from failed anti-ice duct clamp



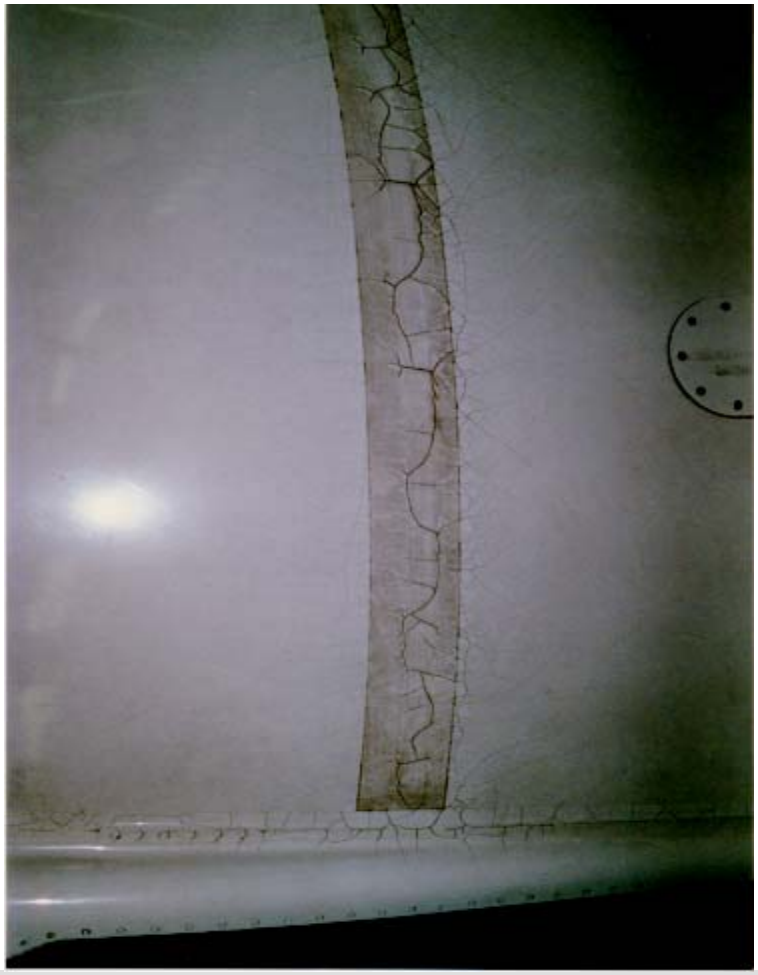


Damages on composite components

Surface protection

Cracks in the surface protection coat suggest structural damages which could result in a premature removal of the component.

Source of the cracks is not yet completely identified, but can be related to the excessive filler thickness or to a change in the paint flexibility by a chemical interaction with the composite resin hardener.



Damages on composite components

Surface protection

Damages on composite components

Fluid contamination

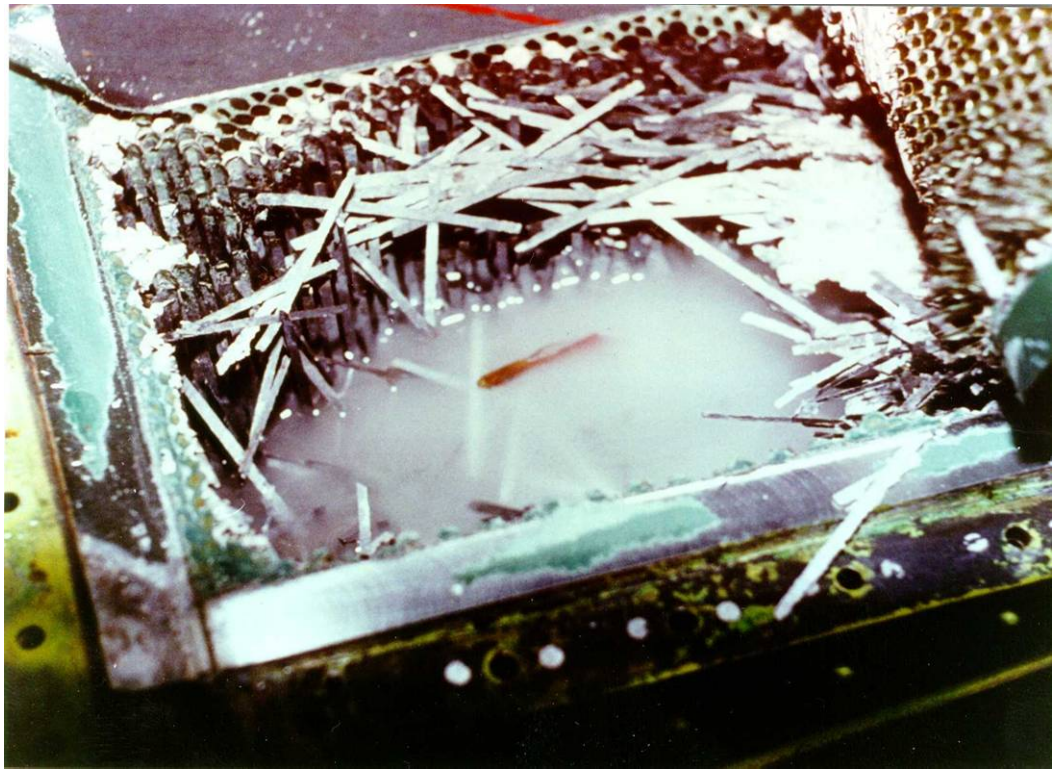
water in an elevator

Water enters the elevator honeycomb core through fastener holes due to component „breathing“.

Repairs are difficult and time consuming.

Damages on composite components

Fluid contamination

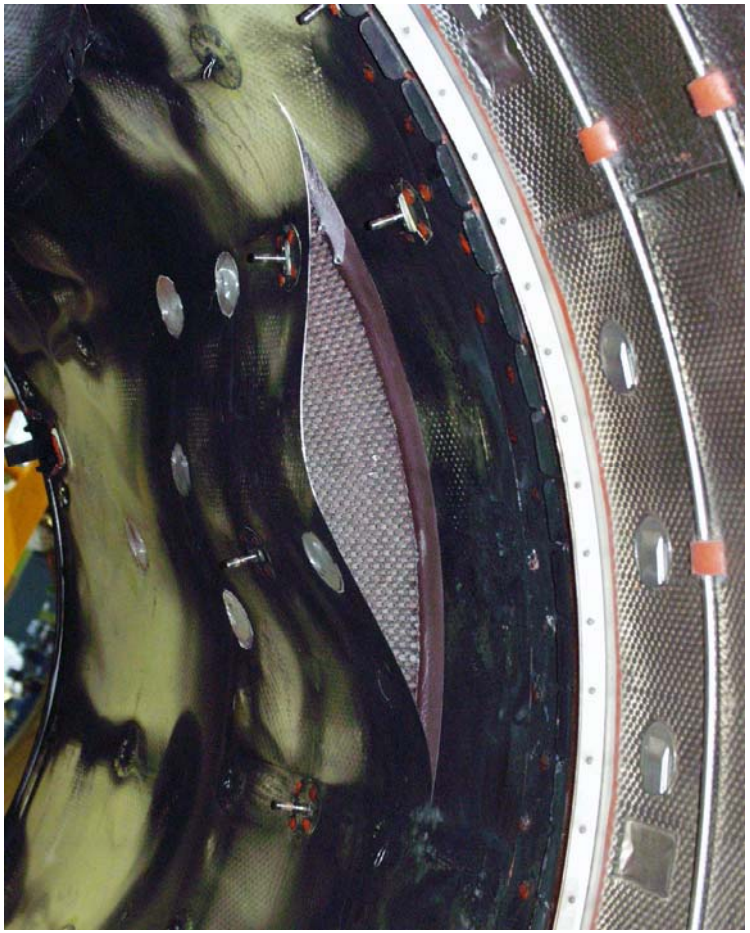


Fish is still swimming !

General problem on many honeycomb sandwich components

Damages on composite components

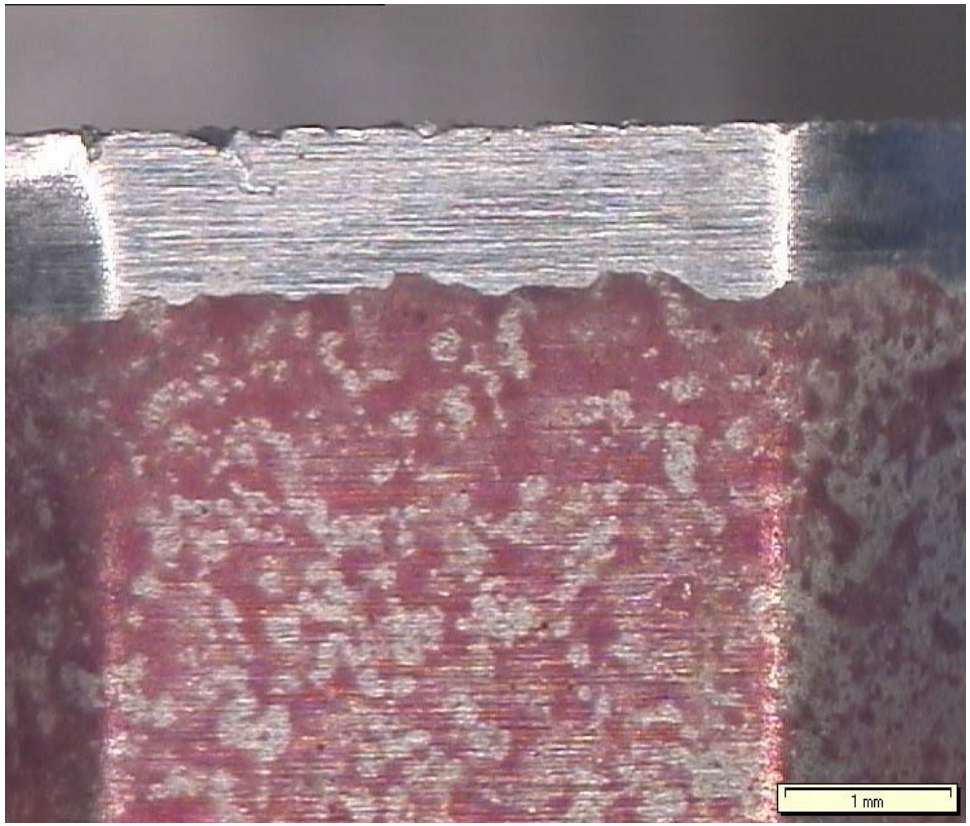
Manufacturing deficiencies

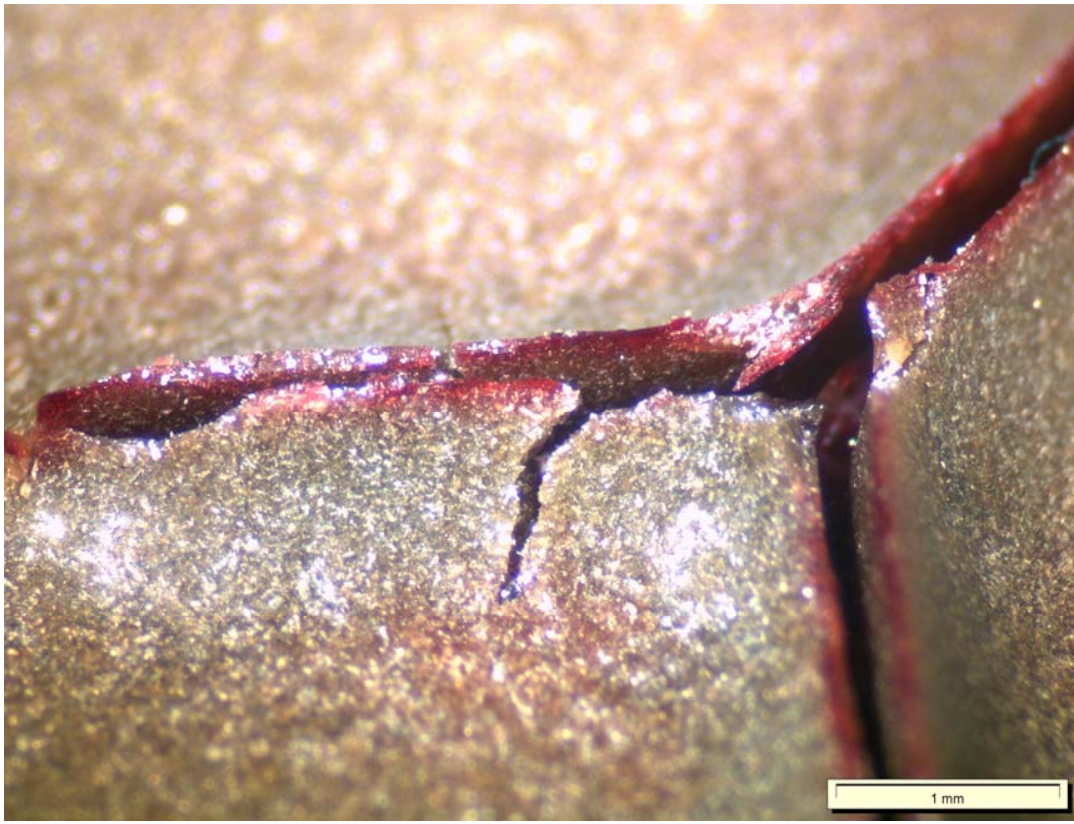


Surface treatment on honeycomb foil leads to poor bonding properties

Damages on composite components

Manufacturing deficiencies





Surface treatment on honeycomb foil leads to poor bonding properties

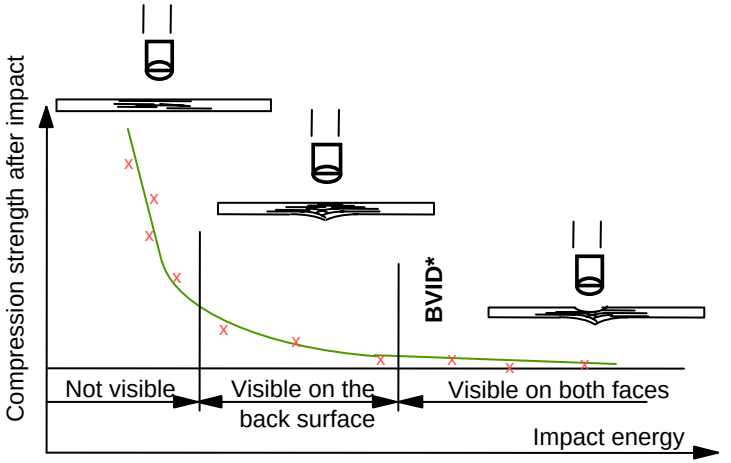
Lufthansa Perspectives on Safe Composite Maintenance Practices

- Experience with composite components
- Damages on composite components
- **Damage detection**
- Repair processes and materials
- Repair quality assurance
- Total maintenance life cycle cost
- Lufthansa perspectives

Damage detection

Many damages on composite structures are difficult to detect visually and / or require special trained technicians and special equipment to be detected.

- Fluid ingress on honeycomb sandwich components.
- Overheat on structures covered with heat insulation blankets.
- Lightning damage secondary effects.
- Barely visible impact damages (BVID).



* BVID = Barely Visible Impact Damage

Damage detection

Visible damage on outside surface

Total damage on inner side of structure

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- **Repair processes and materials**
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Repair processes and materials

The repair of damages experienced in daily aircraft operation is hindered by following peculiarities on the repair process and repair material area:

- Process
  - Standard repairs have only been developed for minor , “cosmetic” type damages.
  - Lack of design information (material, lay up sequence, …) to assist in new repair development.
  - Missing of an agreed upon minimal substantiation criteria acceptable to the authorities.
  - Repair substantiation often requires full scale test articles.
  - Repair quality very much process dependent.
  - Special dedicated training required for maintenance and shop composite repair personnel.

Repair processes and materials

- Material
  - Lack of material standardization, there is no worldwide official identification system establishing the equivalence between two or several materials.
  - Perishable material with limited storage life.
  - Availability in small quantities very difficult and often with long lead times.
  - Material for older products often not in production any more.
  - Incoming material quality assurance inspection requires extensive equipment and special skills.

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Repair quality assurance

The peculiarity of all bonded composite repairs is that the quality strength wise of the of the bonded joint and the laminate build up can not be measured without destroying the part. There is an equivalency to the welding process and a similar industry standard as established since many years for the welder qualification and process control should be implemented for bonded and composite repairs, i.e.:

- Dedicated training and qualification, including recurrent training to maintain the skills.
- Periodic showing of compliance with the acquired skills.
- Process control coupon destructive testing.
- Material control coupon destructive testing.

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- **Total maintenance life cycle cost**
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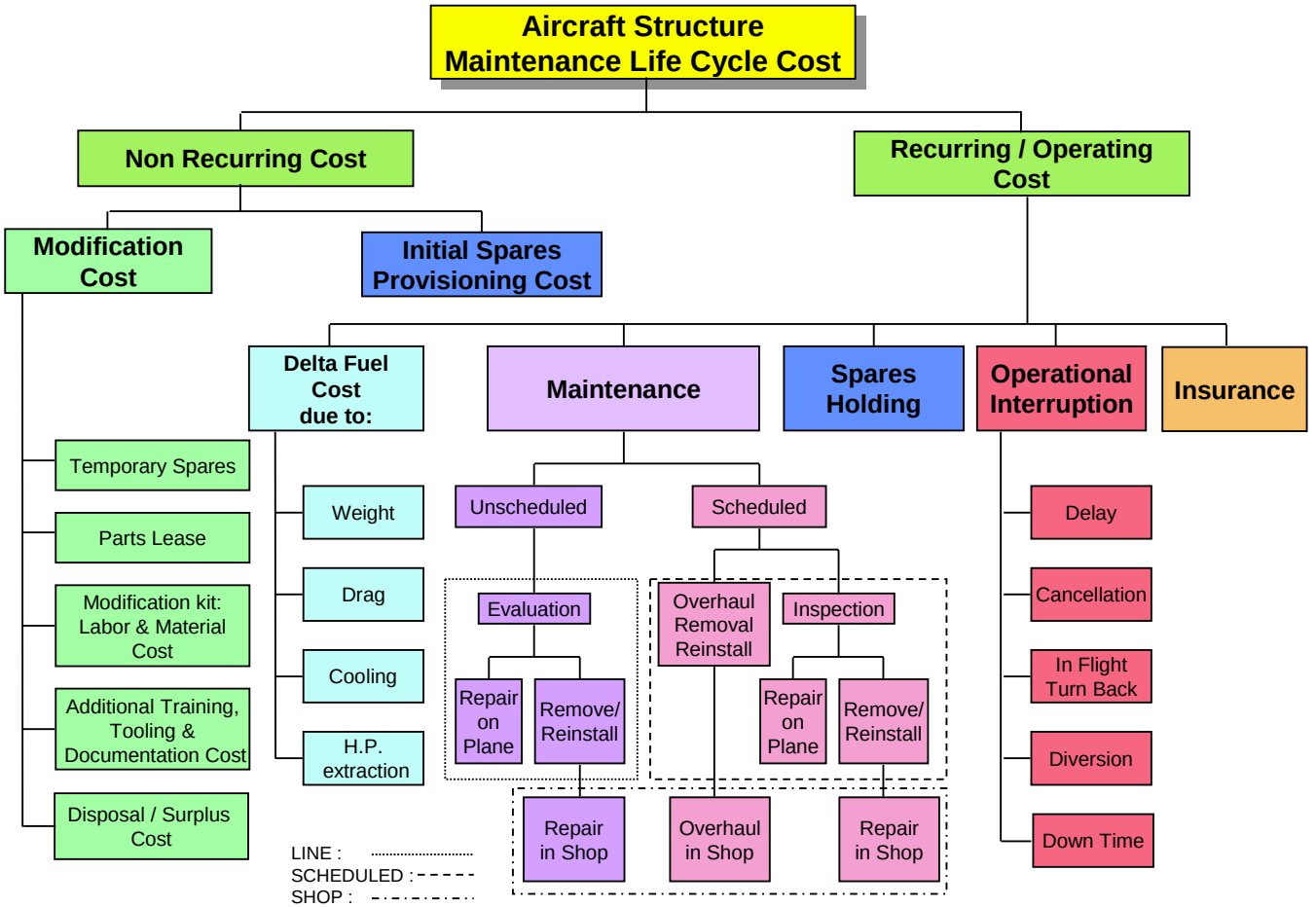
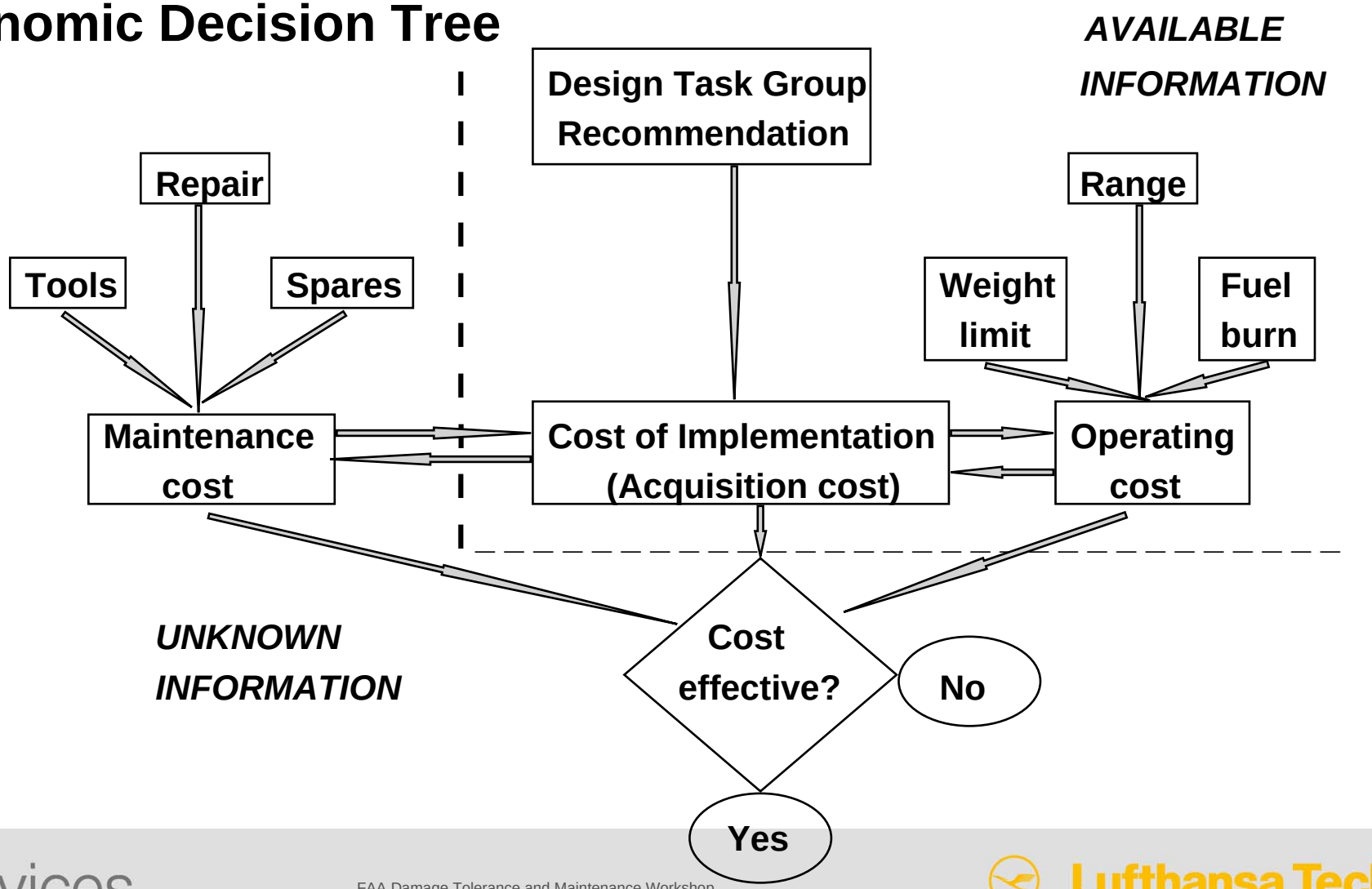
Total maintenance life cycle cost



Total maintenance life cycle cost

Economic Decision Tree



Lufthansa Perspectives on Safe Composite Maintenance Practices

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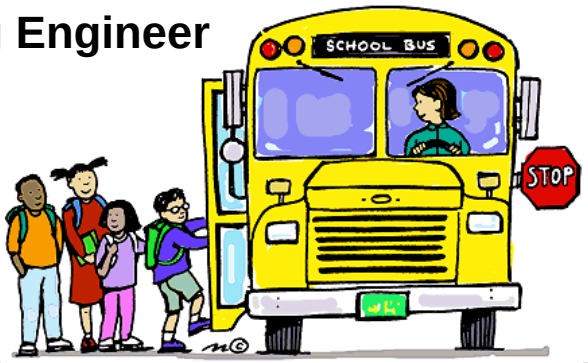
Damage prevention activities

- **Campaign with mayor hubs, Frankfurt and Munich for awareness and damage reduction.**
- **Flyer and Poster distribution.**
- **Awareness sessions to highlight a/c docking, towing and loading procedures.**
- **Information visits of airport personnel at repair stations.**
- **Main message: “it is better to pay attention!”**

Lufthansa perspectives
Training

Dedicated training for composite maintenance, repair and engineering personnel.

- **Training courses for technicians, engineers and inspectors developed at Lufthansa Technical Training using as guideline:**
  - **CACRC training curricula (AIR 4938A, AIR 5278, AIR 5279)**
  - **FAA / AMTAS / Edwards C.C. Teaching Points (AIR 5719)**
- **Additional engineering attendance at:**
  - **Alteon Composite Repair course for engineers.**
  - **Abaris Composite Repair course for engineers.**
  - **Fraunhofer Institute / IFAM European Bonding Engineer course.**



Lufthansa perspectives
Quality assurance

Elaborated Quality Assurance concept to control process and material quality (using AC145.6 as reference)**.**

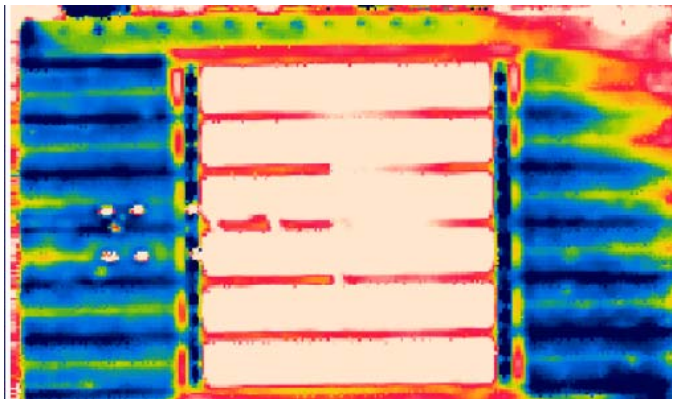
- **Process control:**
  - **Traveler coupon implementation for each process step.**
  - **Write-ups for temperature, pressure, vacuum parameters on each repair step.**
- **Material:**
  - **Purchase from approved sources only.**
  - **Conformity certificate inspection.**
  - **Incoming material test to confirm certificate data.**
  - **Controlled and monitored storage.**
  - **Traveler coupon implementation for each material used in the repair.**

Elaborated Quality Assurance concept to control process and material quality. (cont.)

- **NDI**
  - **Cooperation with Industry and Research Institutes to develop a new NDI method to assess the bond-strength in the joint of composite structures.**
  - **Investigation to implement existing NDI methods (shearography, lockin thermography, ultrasonic excited lockin thermography etc.) in routine maintenance for large area inspections.**

shearography

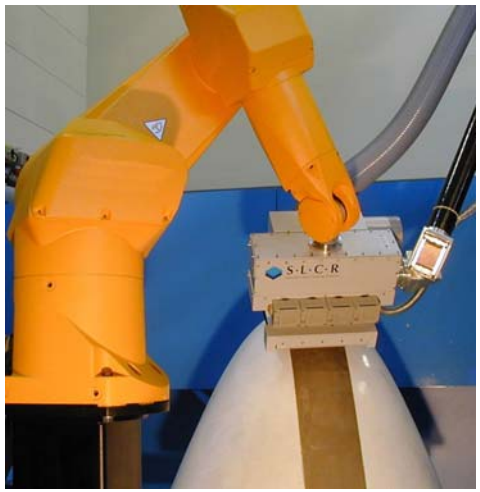
lockin thermography



Lufthansa perspectives
Process and Facility Equipment

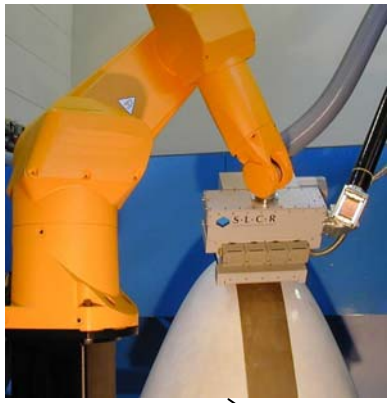
New Processes and Facility Equipment will be considered / introduced for future repair capability

- **Process**
  - **Cooperation with Industry and Research Institutes to develop a surface preparation method providing more reliable adhesion properties on bonded repairs on composite structures.**
  - **Follow up on Selective Laser Coating Removal process.**
- **Facility Equipment**
  - **Larger autoclave.**
  - **Laser coating removal equipment.**



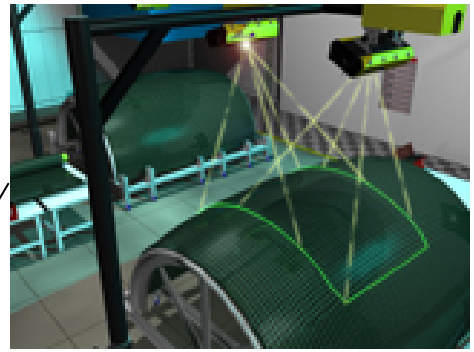
Lufthansa perspectives
New tools needed to optimize repair process for composites

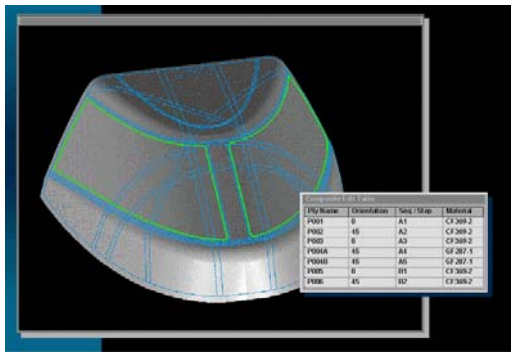
Laser paint removal



Automatic cutting of repair plies

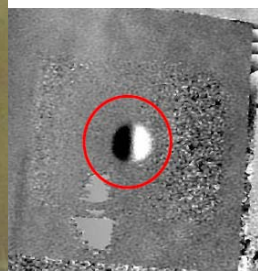
Laser projection of repair plies on damaged part





Composite repair design
(Special CAD modules)

Integrated composite repair design & implementation



ND Quality control
Shearography or Holography

Conclusion

Summary:

- Composite parts demonstrate significant benefits and are established in commercial aircraft structures.
- All composite parts will get damaged.
- Durability, repairability and maintainability issues must be addressed in the design phase and repairs for frequent damages must be available at EIS.
- Introduction of new a/c models with high percentage of composite primary structure will require mayor efforts at airline and MRO personnel training.
- The composite industry has matured but is still young.

Questions ?

Thank you for your attention.

Lufthansa Technik