Fluid Ingression Damage Mechanism in Composite Sandwich Structures

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July 10, 2007

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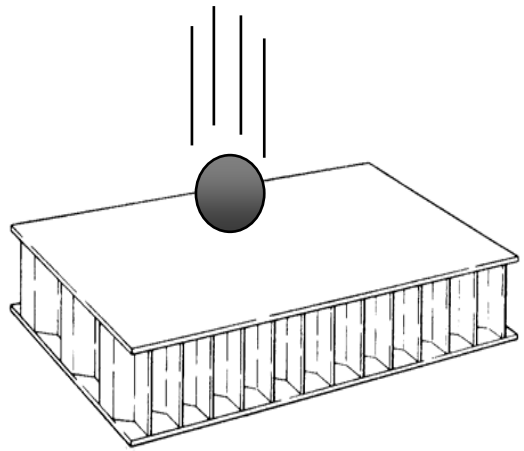
FAA Sponsored Project Information

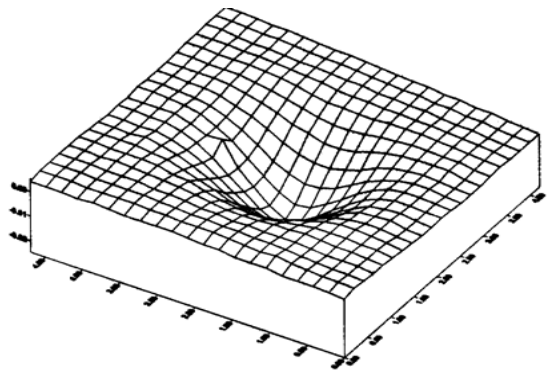
- Principal Investigators & Researchers
  - John Tomblin and Allison Crockett
- FAA Technical Monitor
  - Curt Davies
- Other FAA Personnel Involved
  - Larry Ilcewicz
- Industry Participation
  - Hal Loken, Consultant

FAA Research Investigations

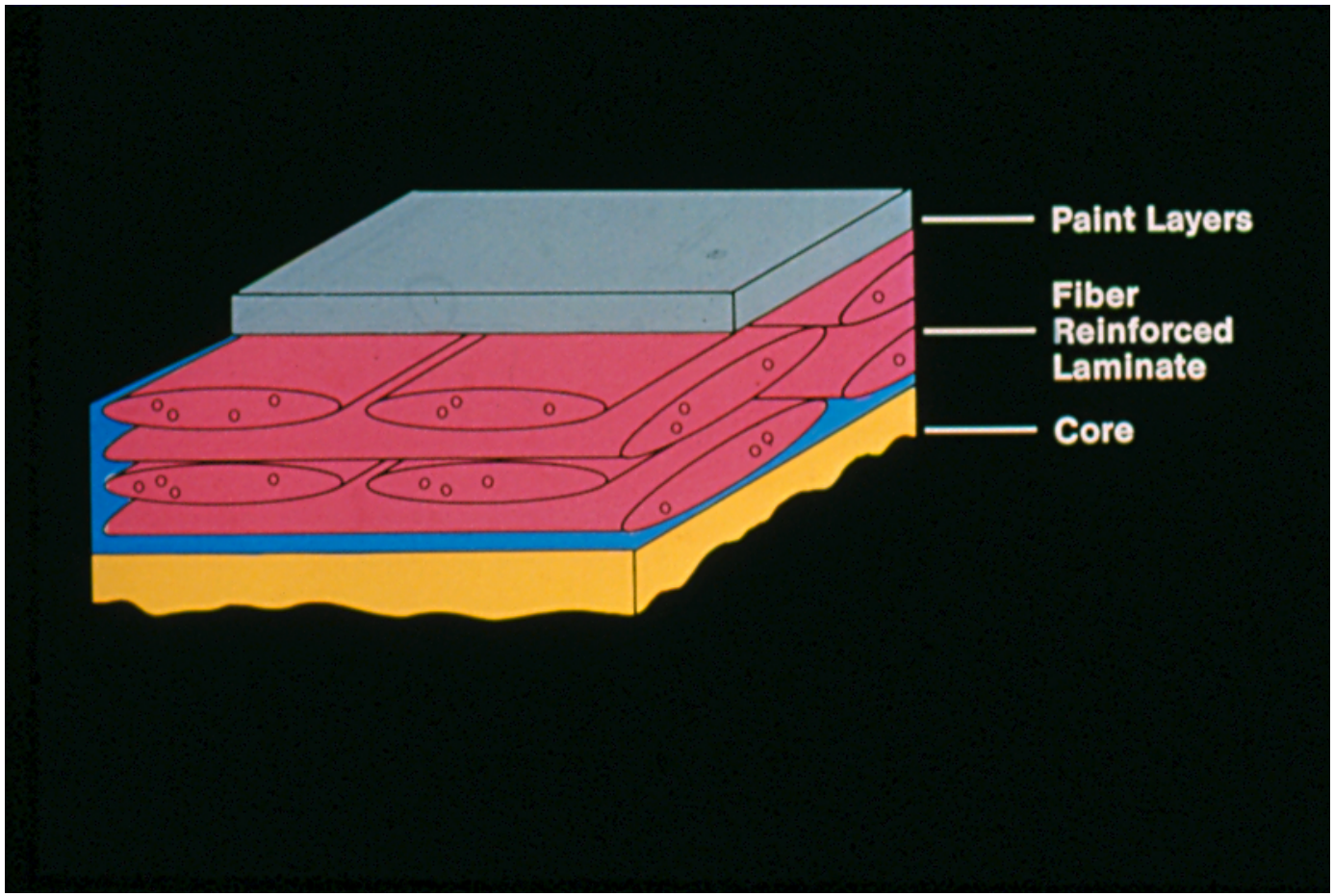
Research Objective

Characterize the fluid ingression phenomenon in composite sandwich structures as well as to document the damage mechanisms which allow the fluid ingression to propagate and potentially degrade the structural performance

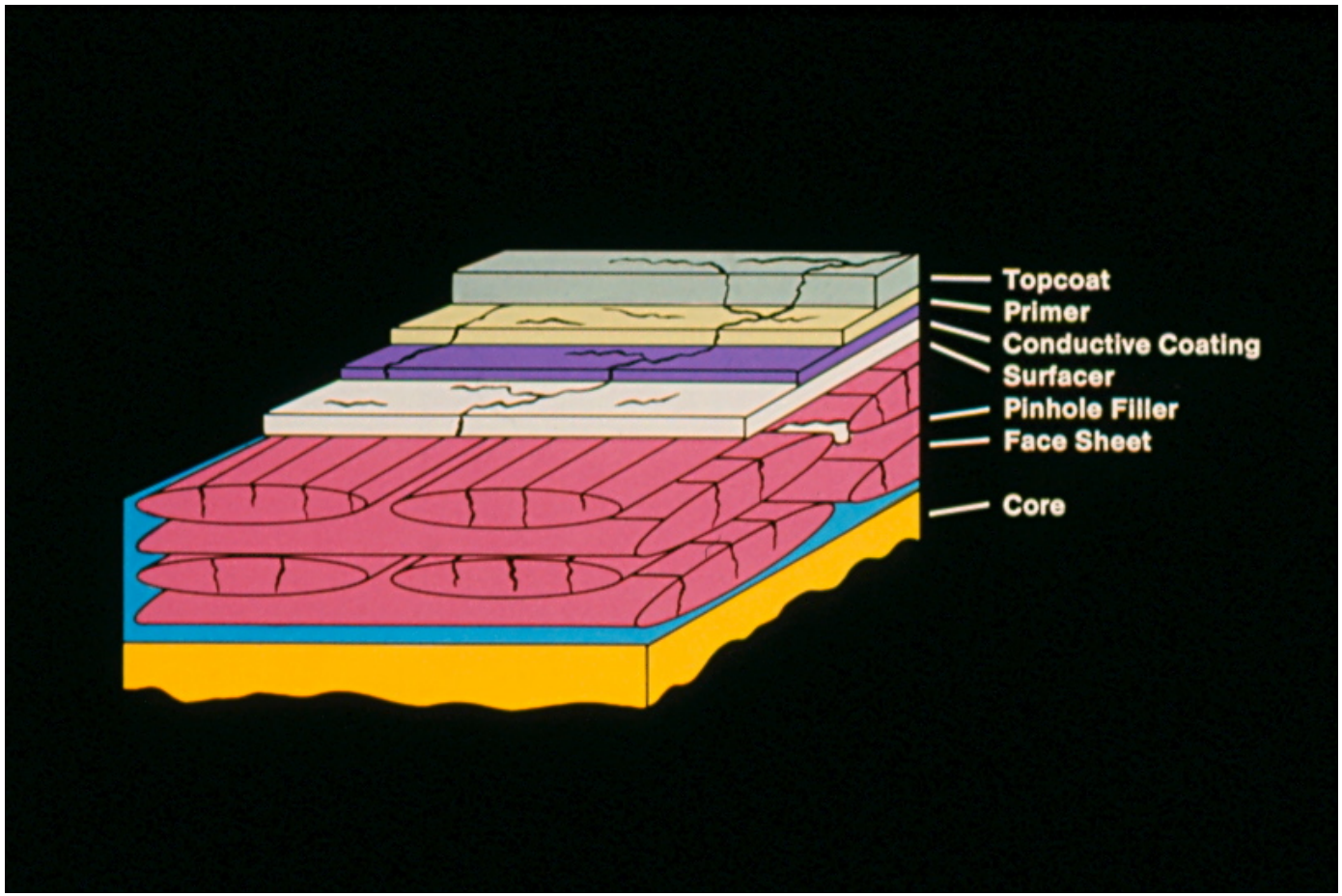




Perfect Composite Sandwich Structure



Problematic Composite Sandwich Structure



Lessons Learned in 1980's

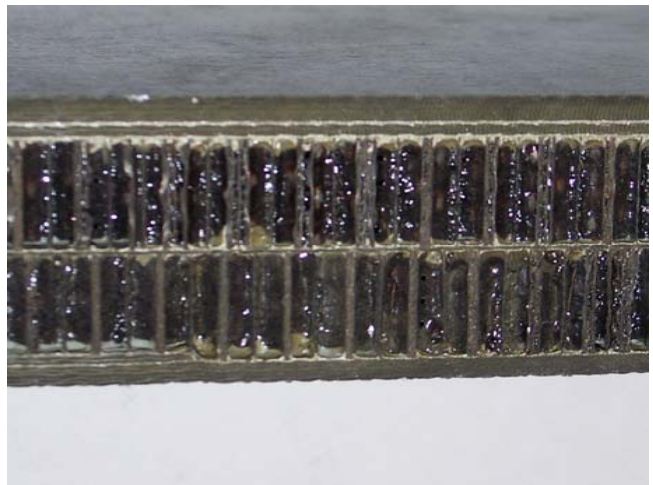
- The trailing edge wedge on a 1970's wide-body transport aircraft was constructed of the following:
  - Woven fabric composite facesheets, solid laminate spar/attachment and aramid honeycomb core.
- The prepreg resin level had been minimized to reduce weight and the facesheet laminate had channels that directed water and Skydrol into the honeycomb core at the ply drop-offs.
- An increase in prepreg resin content solved this problem.
- As new materials and methods come into use, we must research application limits and define good practices.

Lessons Learned in 1980's

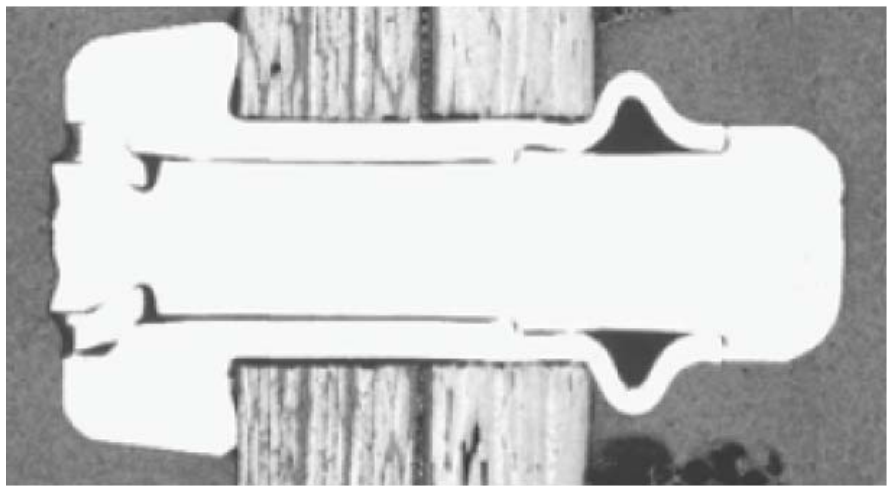
- One of the biggest problems for an airline operator is when large hailstones strike at a major airport.
- Composite sandwich fixed trailing edge panels are typically damaged by the hailstones
- If not sealed or repaired, these panels will later develop water ingression into the honeycomb core at the spot where each large hailstone struck.
- Research will establish a cost effective standard for hailstone resistance.

More Recent Lessons Learned

- This septum design allows fluid to migrate easily between the two cores and one ply of fabric.



- From the rudder series with the Z-Profile design a fluid path is created with the blind rivet used.



AIRBUS OVERVIEW

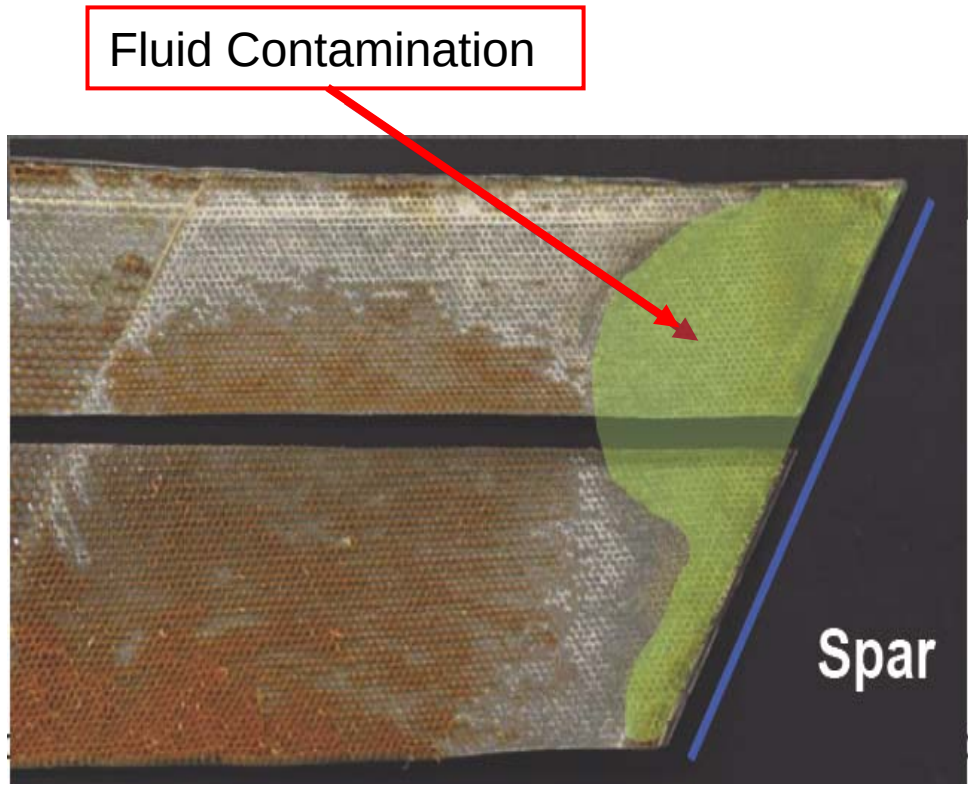
- A320 Elevators
  - Affected Areas: Trailing edge inserts, bonding straps, panel surface.
- A300/A310 Rudders
  - Disbonds between skin and honeycomb cores
  - Water and Skydrol contamination
  - Incorrect repairs, not bonded correctly and excessive paint build-up
- Water ingress leads to
  - Deterioration on the honeycomb/skin bonding line
  - Delamination
  - Weight Increase

AIRBUS Needs……

- Need to improve the inspection program and the associated NDT technique to cover invisible damages.
- This lower rib was removed for maintenance when this damage was discovered.

AIRBUS Needs……

- Upon removing the inner skin for maintenance the fluid damage was revealed.
- After some investigation the fluid was identified as Hydraulic fluid.



Terminology-Current Research

Fluid Ingression Damage Tolerance

Resistance to the propagation of damage due to fluid ingression and degradation of structural performance

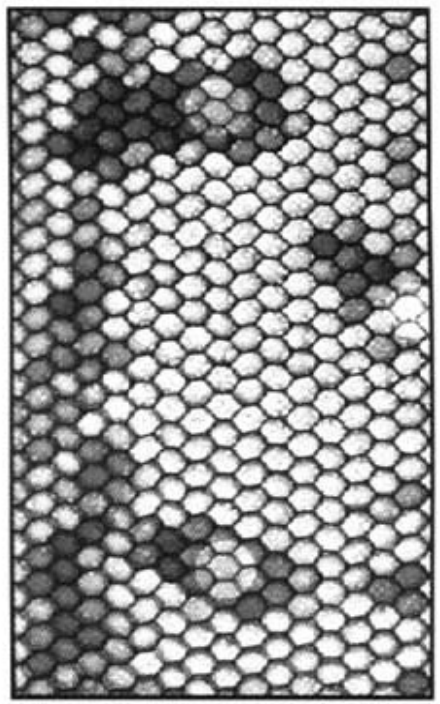
Fluid Ingression Damage Resistance

Material performance, design details and maintenance practices which resist fluid ingression into the core

Proposed research program will focus on

Fluid Ingression Damage Tolerance

Proposed Program Outline



BASIC ASSUMPTIONS

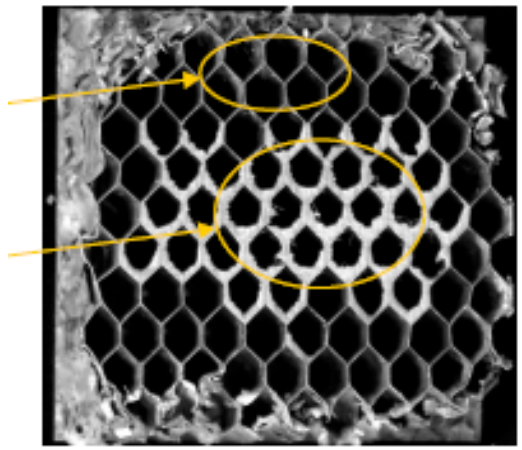
- Fluid ingression path is established
  and
- Ingression **HAS** occurred

GOAL

Characterize the fluid ingression growth mechanisms and rates due to hygrothermal exposure based upon a number of variables

Laboratory Panels

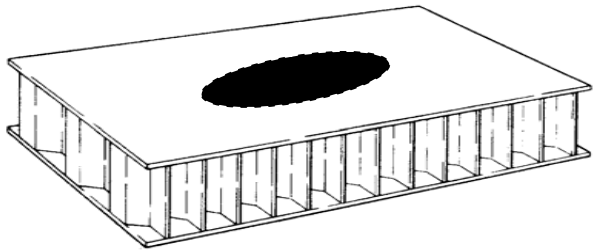
- Proposed Experimental Laboratory Variables
  - Different Core Types
    - Aluminum, m-aramid, p-aramid, and glass.
  - Different Core Densities
  - Different Fluid Types
    - Water, Skydrol, Hydraulic

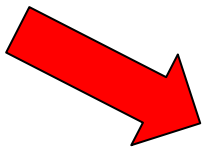


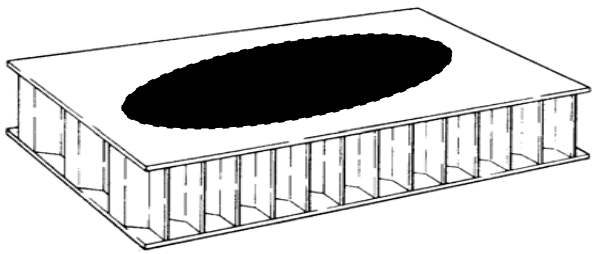
Existing Fleet & Recently Retired

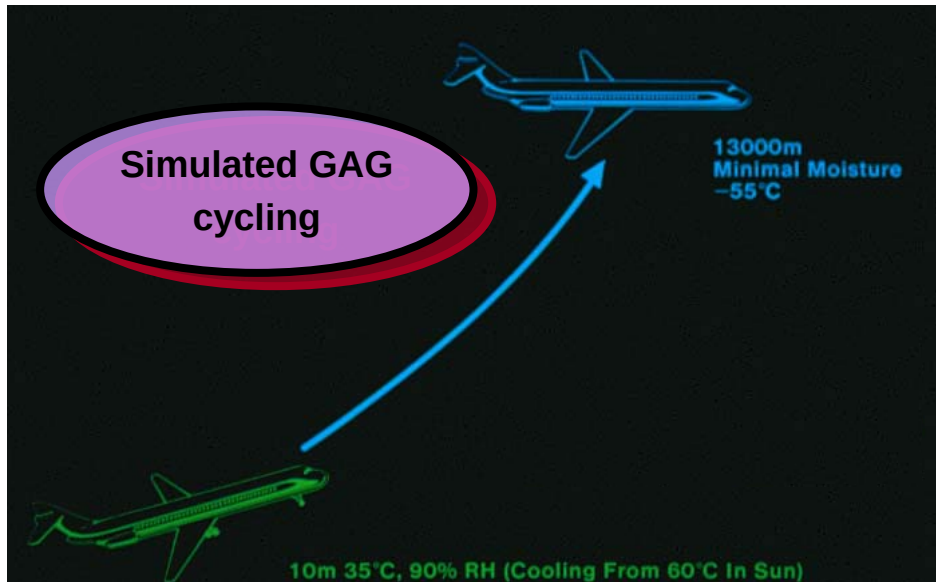
Characterize existing structural parts and configurations (with potential aging effects)

Proposed Program Highlights





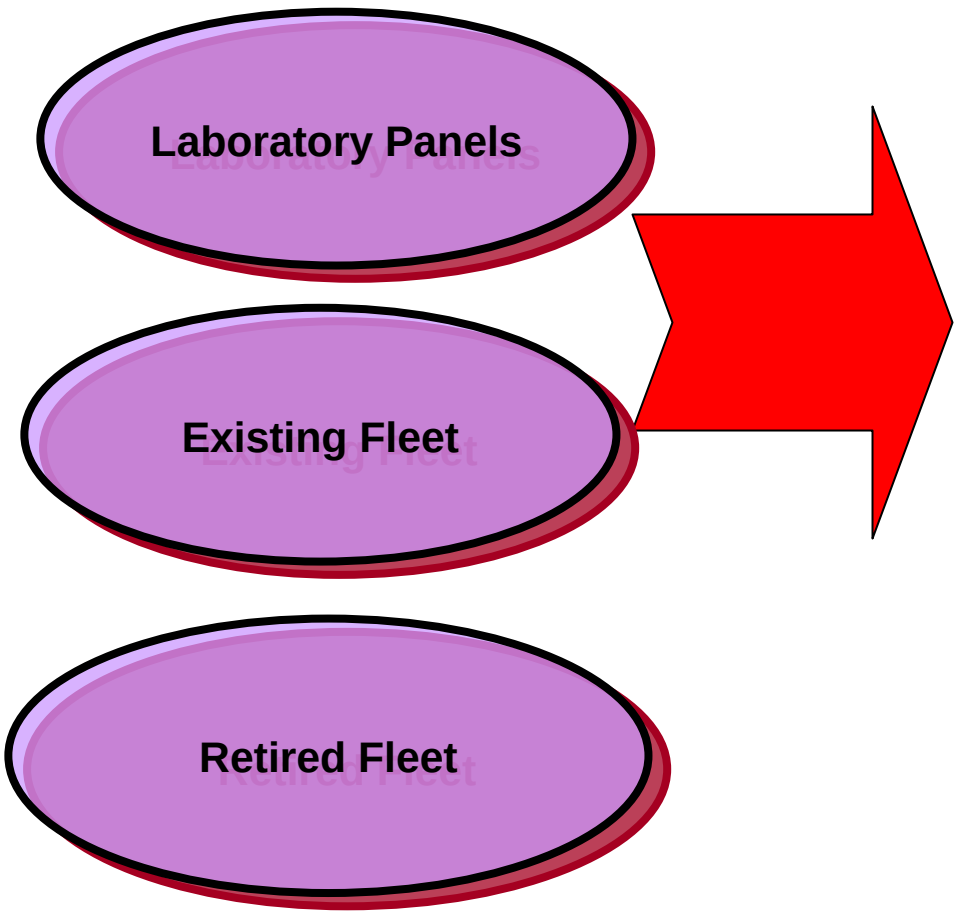




What Industry Wants

- In May 2007, Fluid Ingression was highlighted at the Damage Tolerance Workshop in Amsterdam.
- As a result Industry wants to know some details about Fluid Ingression before other details.
- From our breakout session to following outcomes where determined to be the most important.

Desired Outcomes



- Intercellular diffusion (good cell wall)
- Permeable cell wall
- Permeability as a function of age/load sensitivity
- Filleting quality
- Poorly machined honeycomb (poor bond)
- Freeze/thaw
- Porous or discontinuous adhesive (adhesive type/process)

Follow on Questions

- How resistant is core?
- Is fluid ingression noticeable without impact?
- Should there be a process control for core?
- Can foams be added to the test matrix?

Current Industry Contributors

- As a result of Amsterdam the following people will contribute parts from the flying fleet:
  - AIRBUS Anna Rodriguez Bellido of Airbus Spain: 320 Elevators
  - Boeing – fixed trailing edge panels on upper surface of Early 747 wings
  - David Mills ICES Corporation – variety of parts with core and fluid ingression

A Look Forward

- Benefit to Aviation
  - *Characterize the damage mechanisms which allow the fluid ingression to propagate and potentially degrade the structural performance*
  - *Identify potential areas which should be monitored during routine aircraft service*
  - *Provide awareness of the fluid ingression phenomenon as related to continued airworthiness*
- Future needs
  - *Provide guidance materials for design and maintenance of composite sandwich structures*