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Dynamic Response of Composite Structures Subjected to Blast Loading

2014 Technical Review

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Wichita State University/NIAR

Dynamic Response of Composite Structures Subjected to Blast Loading

- **Motivation and Key Issues**
  - The studies have shown the terrorist attacks against civil transport aircraft is a significant threat, i.e., loss rate of 1 per 10^7 flights worldwide averaged over 30 years. Therefore, the structural improvements augment the added security measures following the Aviation Security Act of 1990 to mitigate the vulnerability of civil aircraft to IED attacks.
- **Objective**
  - Primary goal of this investigation is to assess the vulnerability of modern composite fuselage structures to a damage caused by an internal explosion from an improvised explosive device.
- **Approach**
  - Partnership with FAA and DHS Science and Technology Directorate Organization to leverage unique capabilities (safety and security) of each agency in pursuit of this effort.
  - The applications of composite materials in modern commercial aircraft are evaluated through a literature survey of composite structural details.
  - Composite panels will be fabricated to simulate fuselage details for subsequent blast testing.
    - Initial phase of the research will focus simple (flat, unstiffened) composite panel configurations
    - Subsequent phases will incorporate fabrication and testing of increasingly complex (curved stiffened) composite panel.

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Dynamic Response of Composite Structures Subjected to Blast Loading

- **Principal Investigators & Researchers**
  - John Tomblin, *PhD*, and Waruna Seneviratne, *PhD*
- **FAA Aircraft Structures Division, Technical Monitor**
  - Edward M. Weinstein, *PhD*
  - Lynn Pham
- **Department of Homeland Security, Science & Technology Directorate**
- **Industry Participation**
  - Spirit Aerosystems

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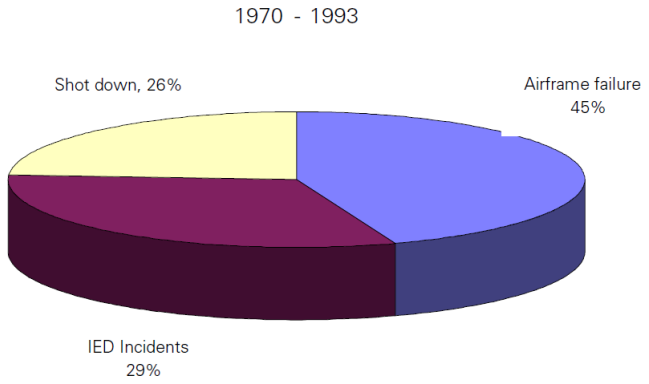
Goals

Primary goal of this investigation is to assess the vulnerability of modern composite fuselage structures to a damage caused by an internal explosion from an improvised explosive device.



Comparison IED incidents between 1970 and 1993 to airframe failures (non-sabotage) and incidents involving aircraft being shot/forced down

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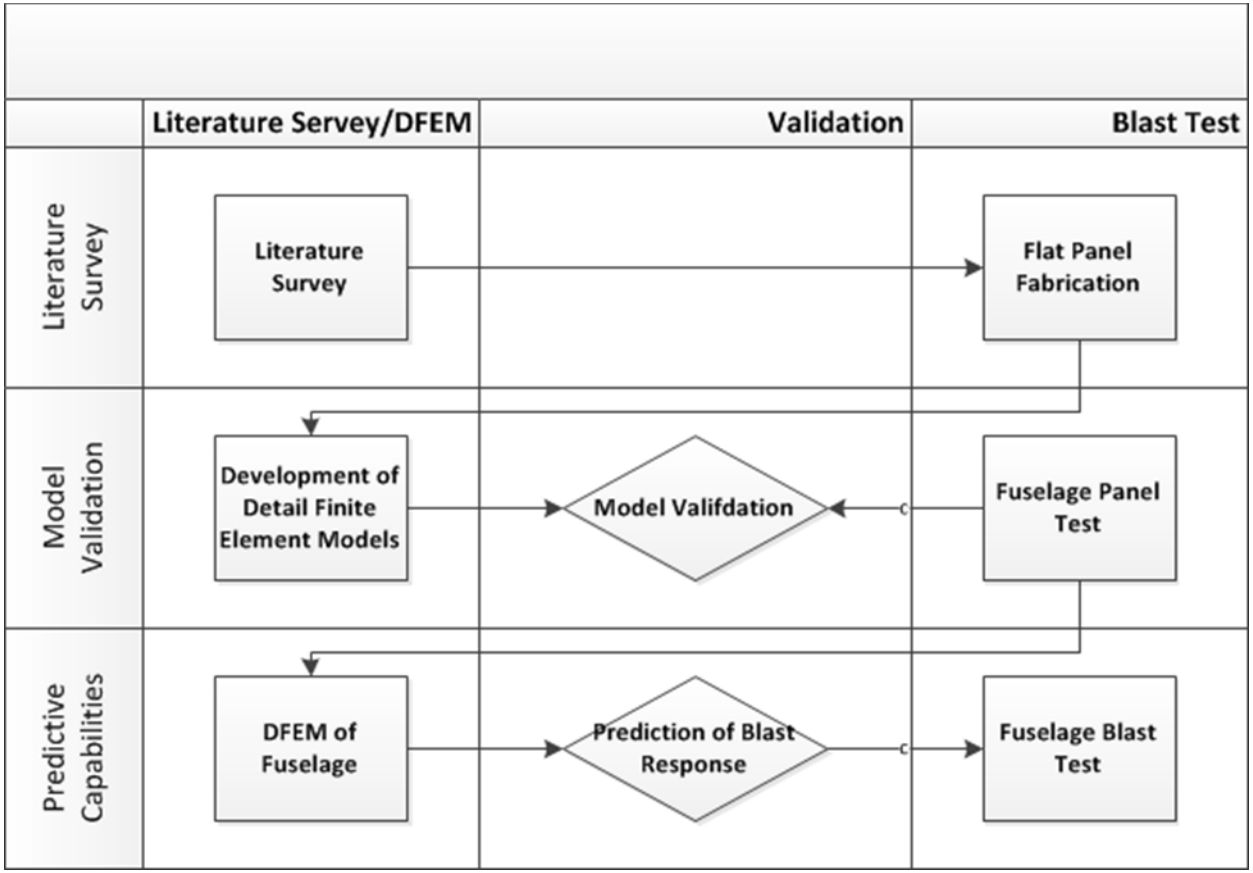
Road Map



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Phase I

- Literature Review [A380/B787/A350]
  - Thickness variations in fuselage
    - Map [min/max]
  - Riveted Joints
  - Cocure/Cobonded Joints
  - Longitudinal Beams
  - Aft Pressure Bulkhead
  - Strain Rate Test Data
- Fabricate Representative Flat Panels
  - 48" x 48"
  - 2 different thickness

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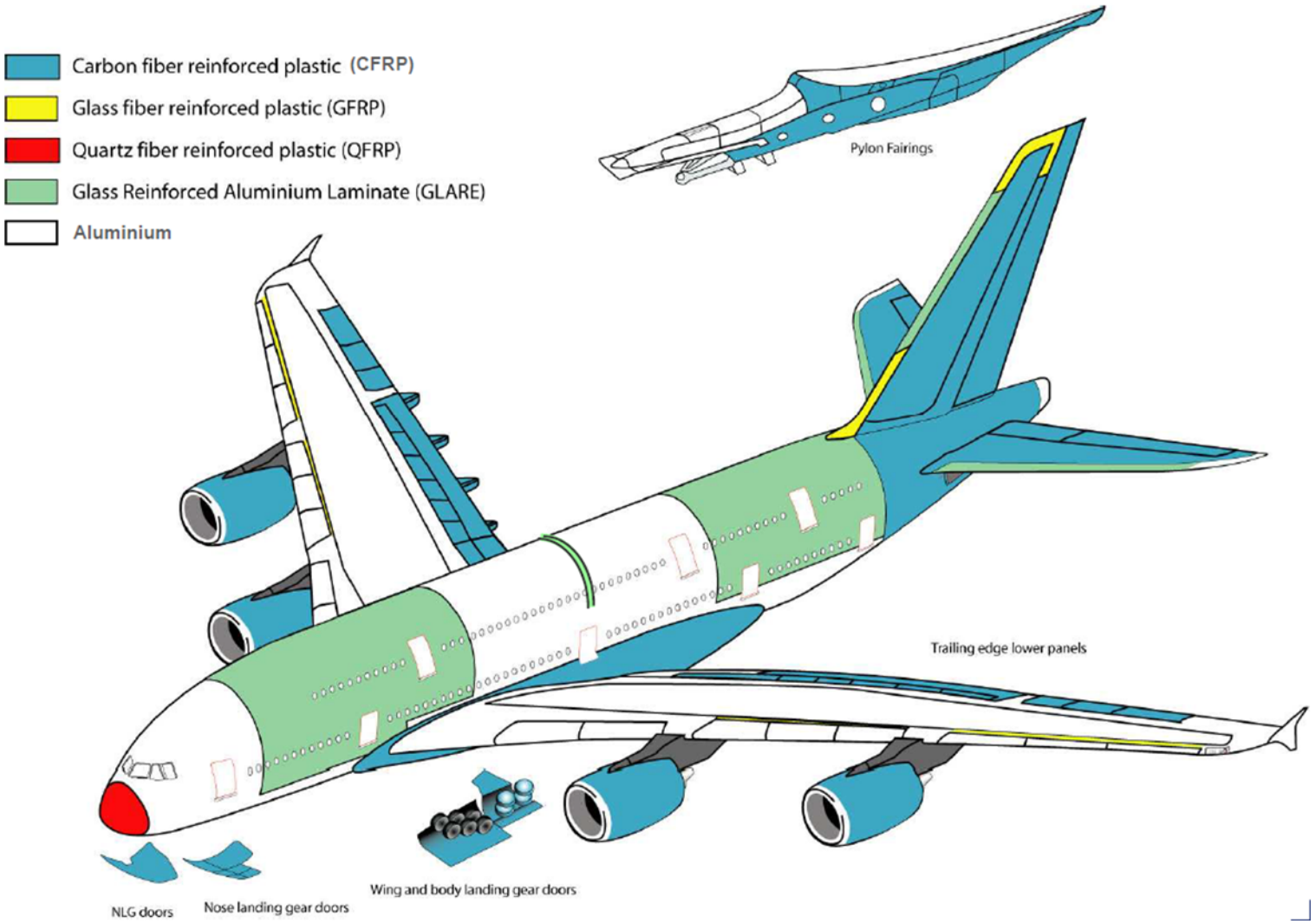
Airbus A380



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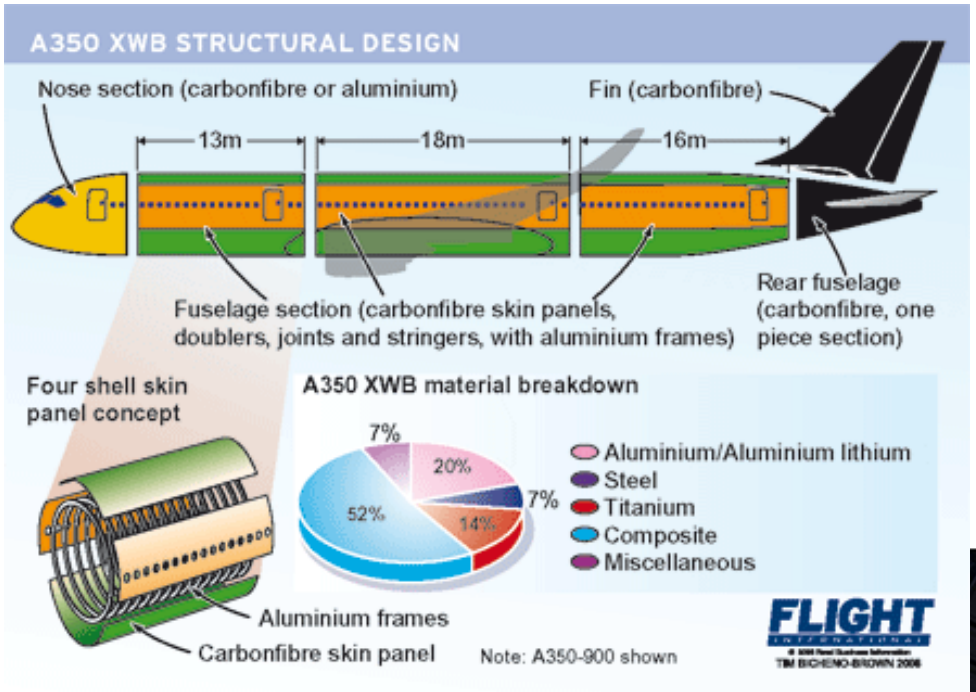
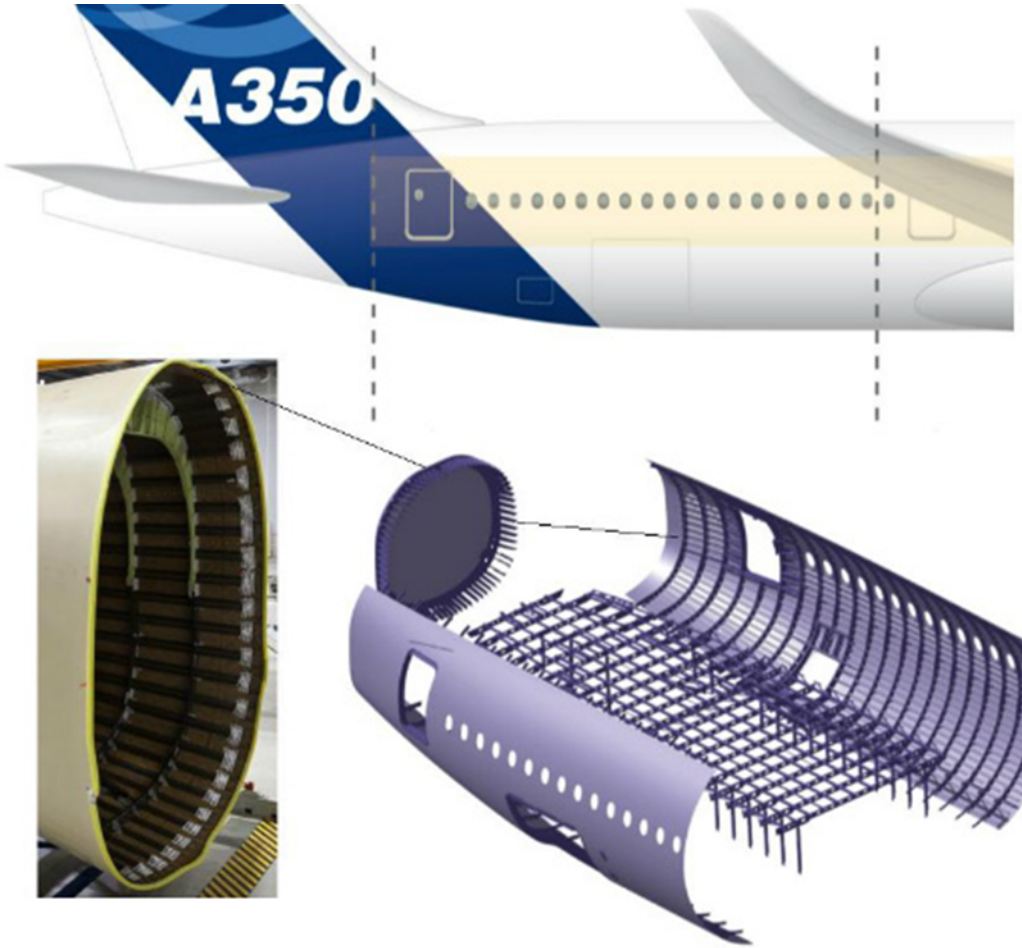
Airbus A350


A350 XWB STRUCTURAL DESIGN
Nose section (carbonfibre or aluminium)
Fin (carbonfibre)
13m
18m
16m
Fuselage section (carbonfibre skin panels, doublers, joints and stringers, with aluminium frames)
Rear fuselage (carbonfibre, one piece section)
Four shell skin panel concept
A350 XWB material breakdown
7%
20%
7%
52%
14%
Aluminium/Aluminium lithium
Steel
Titanium
Composite
Miscellaneous
Aluminium frames
Carbonfibre skin panel
Note: A350-900 shown
FLIGHT

Airbus A350



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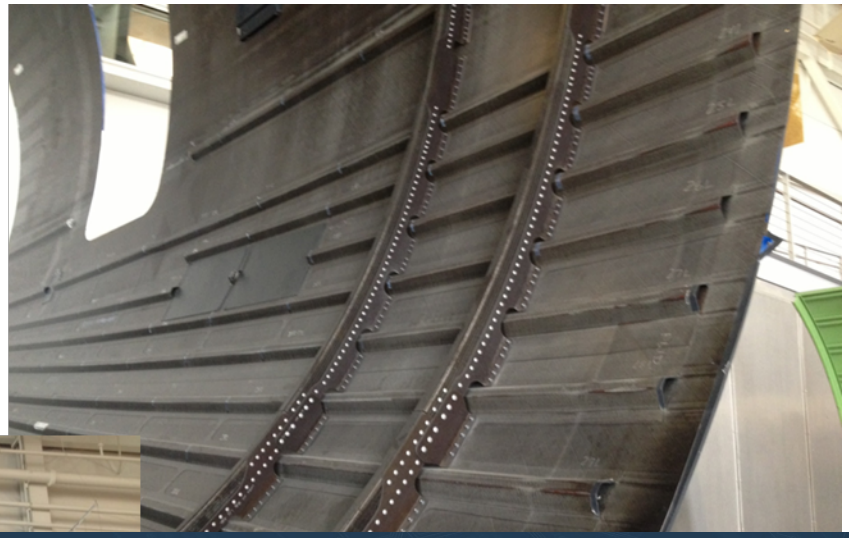
Boeing 787



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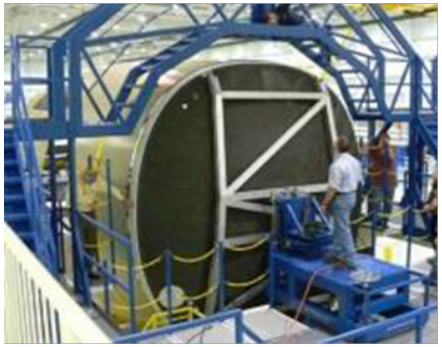
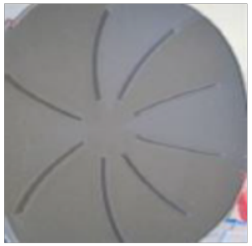
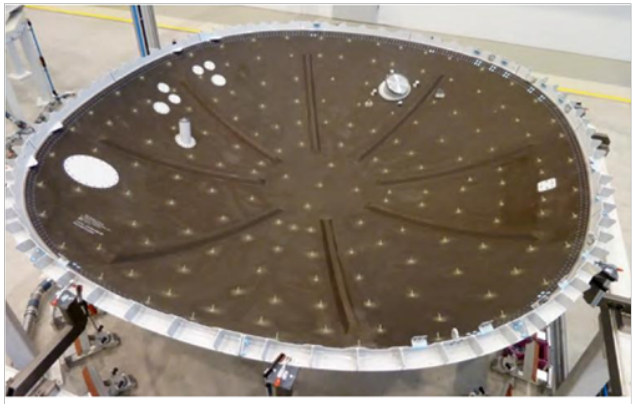
Resin Infusion

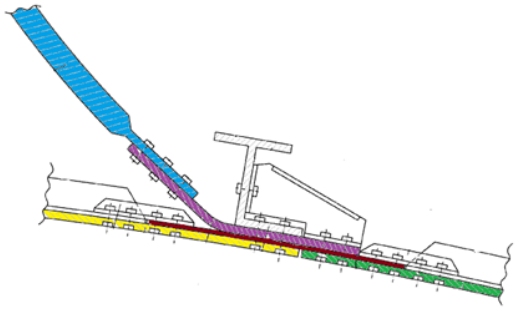


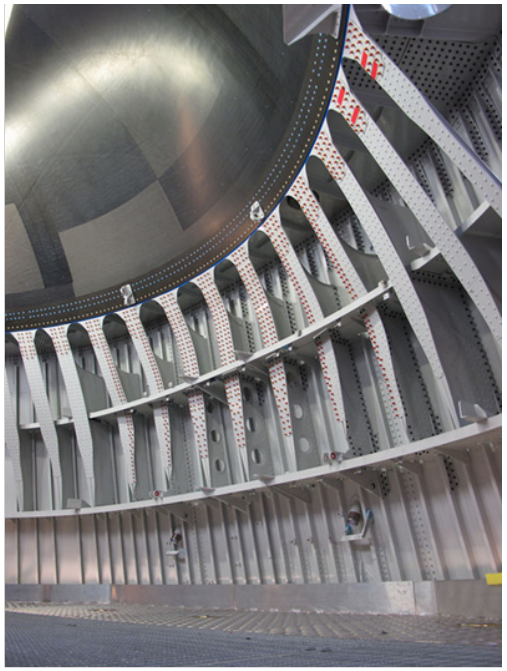
B787 Aft Pr. Bulkhead





A350 Aft Pr. Bulkhead





A380 Aft Pr. Bulkhead

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Panel Fabrication

- 12" x 12" panels for equipment calibration
  - T650/5320 Unidirectional tape
  - Layup: [45/0/-45/45/90/-45]s
  - Multiple flat panels tested
- 48" x 48" panels for Phase 1 blast testing
  - Two thicknesses:

Panel Category	Stacking Sequence	Number of [0°/45°/-45°/90°] Plies	Number of Plies
t1	$[-45/0/45/\overline{90}]_s$	[2/2/2/1]	7
t2	$[45/0_2/(-45/45)_2/90/-45]_{2s}$	[8/12/12/4]	36

  - Material: T800/3900-2 unidirectional tape
  - Unsiffened
  - Multiple thin and thick flat panels tested

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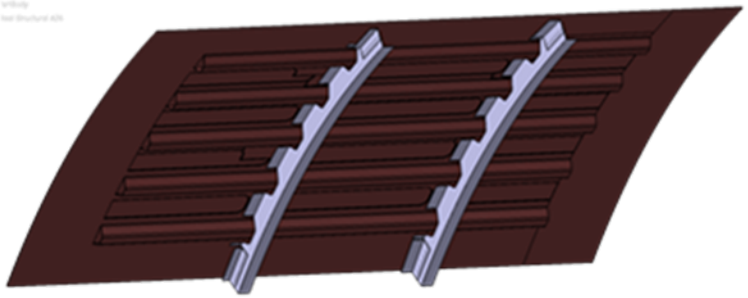
Summary

- Survey of commercial composite aircraft materials and structures properties and configurations.
- High speed imaging and digital image correlation data acquisition system evaluation for flat composite panel explosive testing is completed.
- Explosive tests (series I) of 48" x 48" unstiffened flat composite panels have been completed.
- Future flat composite panel tests are scheduled for the month May 2014.
- Phase II
  - Generic and representative curved stiffened composite panel design
  - Material selection



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Looking Forward

- **Benefit to Aviation**
  - Assessment of the vulnerability of modern composite fuselage structures to a damage caused by an internal explosion from an improvised explosive device.
  - Increased understanding and insight on strain rate dependent composite material properties and composite aircraft structures failure modes subjected to high rate dynamic loading and potential benefits to the design and safety of commercial composite aircraft.
  - Assessment of modern composite fuselage structures to a damage caused by an internal explosion from an improvised explosive device
- **Future needs**
  - Information related to fabrication of representative fuselage panels

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End of Presentation.

Thank you.

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