Full-Scale Carbon Aircraft Fuselage Test Plan (Impact, NDI & SHM)

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Project Goals:

1) Examine the ability of conventional and advanced nondestructive inspection (NDI) techniques to detect impact damage at or below the level of barely visible impact damage (BVID) on a full-scale carbon fuselage section with substructure. Damage levels will span the range of failure threshold energy (FTE) to BVID in order to study critical energy levels.
2) Determine the ability of an embedded, distributed fiber optic sensing system to detect, and locate impact damage on a full-scale carbon fuselage section
3) Determine the ability of a, “retrofit” post bonded distributed fiber optic sensing system to detect and locate impact damage on a full-scale carbon fuselage section
4) Investigate the ability of conventional and advanced NDI techniques to detect substructure damage on full-scale carbon fuselage section subjected to low-velocity, high-mass blunt impacts

Full-Scale Carbon Aircraft Fuselage Panel Test Plan (Impact NDI & SHM)

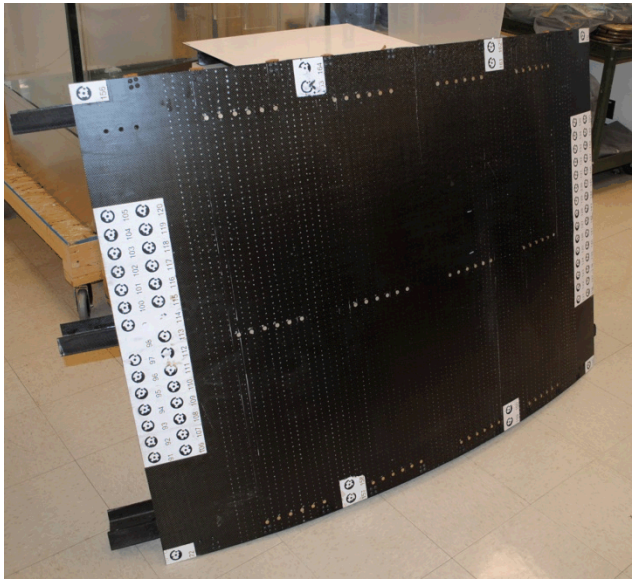


Image: Full-scale carbon fiber aircraft fuselage section with co-cured stringers and attached frames, similar to the ones that are currently being fabricated for impact testing.

**Two full-scale panels are being fabricated*

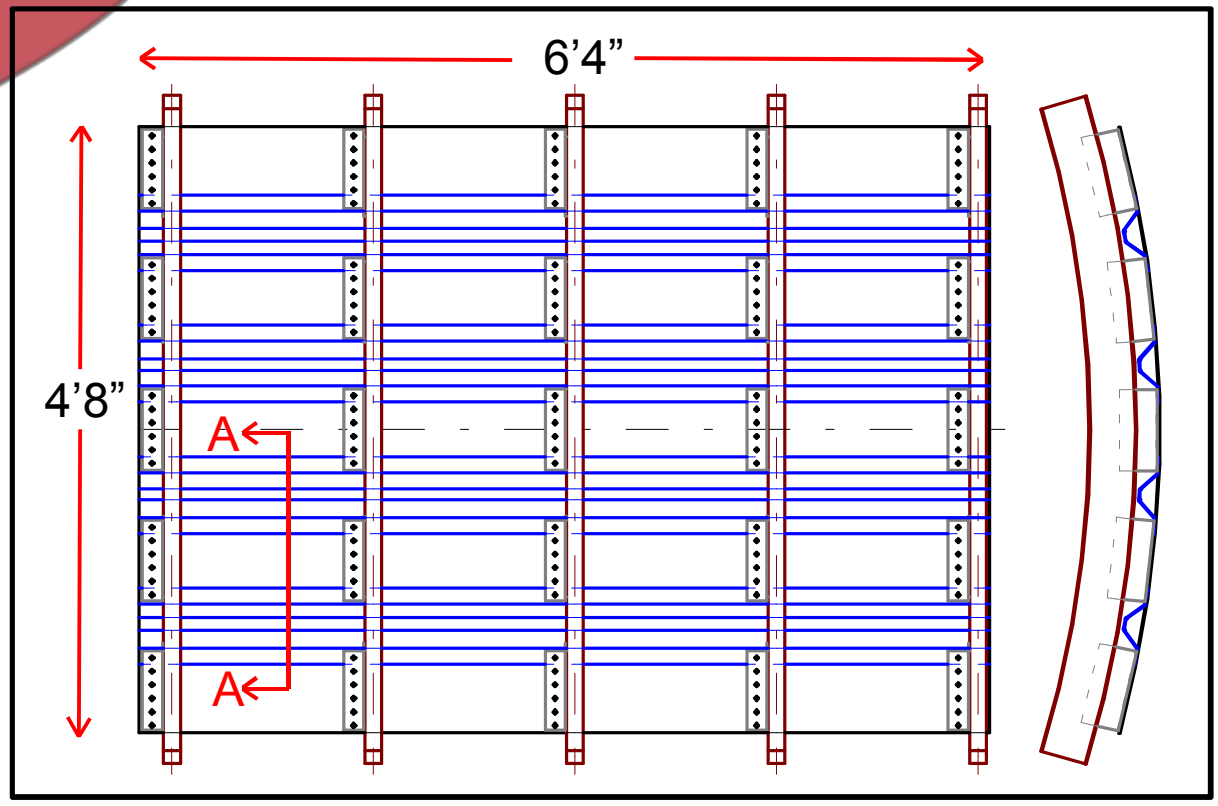
Full-Scale Panel Test Plan

1) Impacts
- Hail
- Dropped Tools
- Blunt-Ended, Low Velocity, Quasi-Static

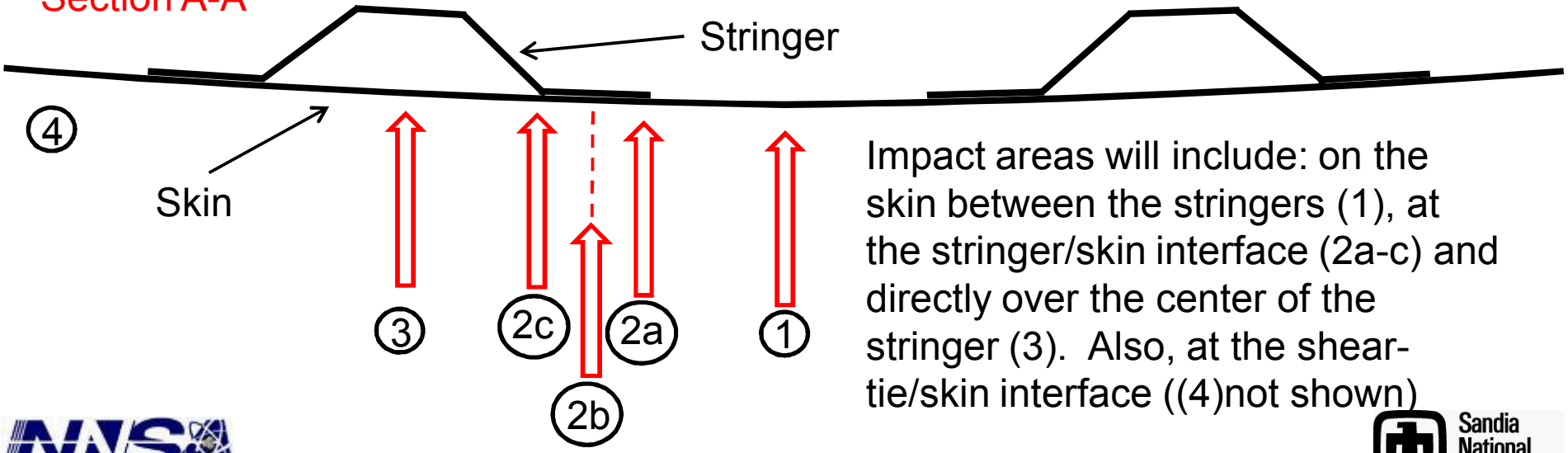
2) SHM
- Fiber optic installed during fabrication (embedded)
- Fiber optic retrofit (bonded to the back)
- Installation
- Calibration and Characterization

3) Real Time Monitoring
- SHM
- NDI
- Baseline
- After each impact
- After all impacts completed

4) Post Impact NDI Characterization



Section A-A



Impact areas will include: on the skin between the stringers (1), at the stringer/skin interface (2a-c) and directly over the center of the stringer (3). Also, at the shear-tie/skin interface ((4)not shown)

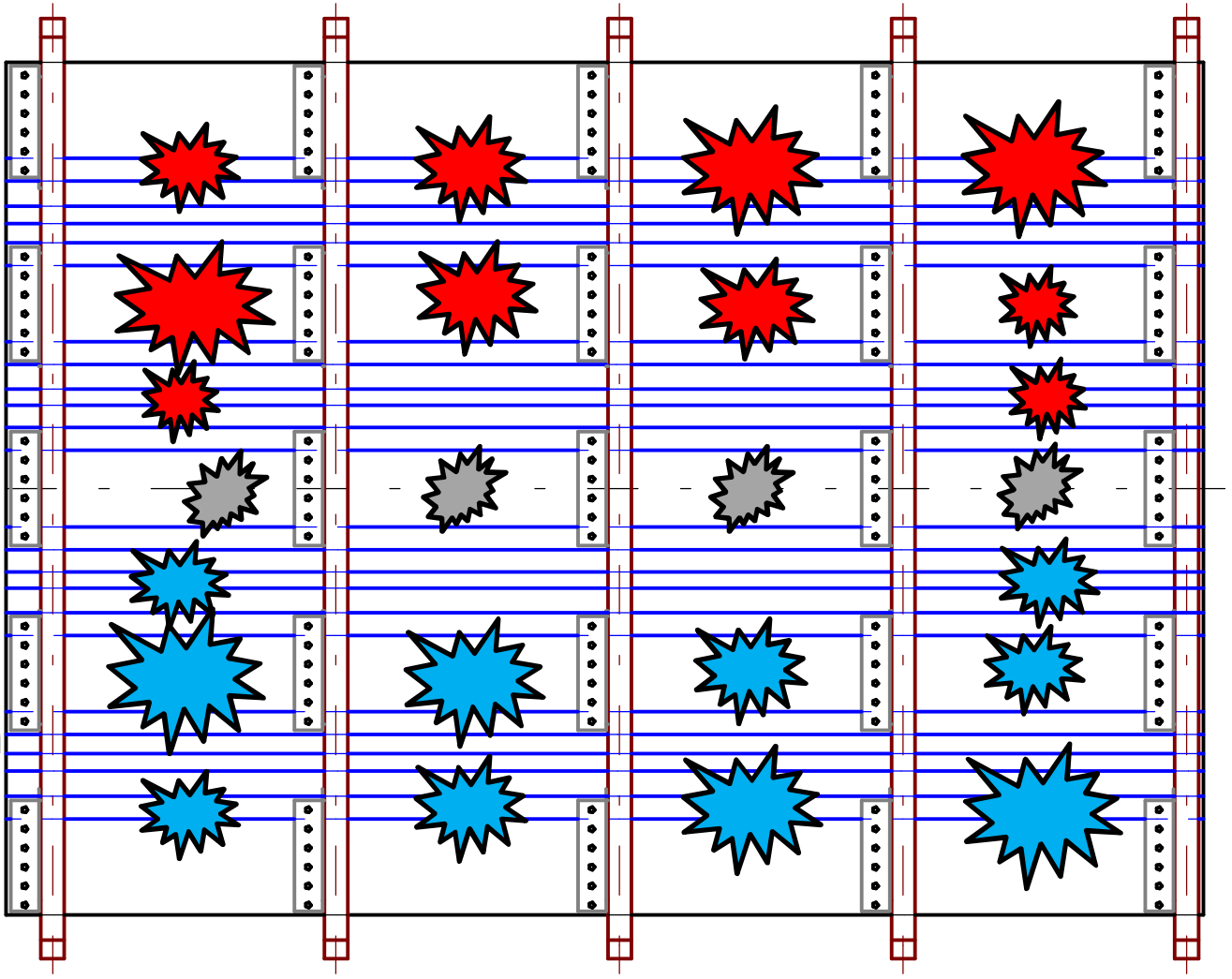
Rough Impact Schematic

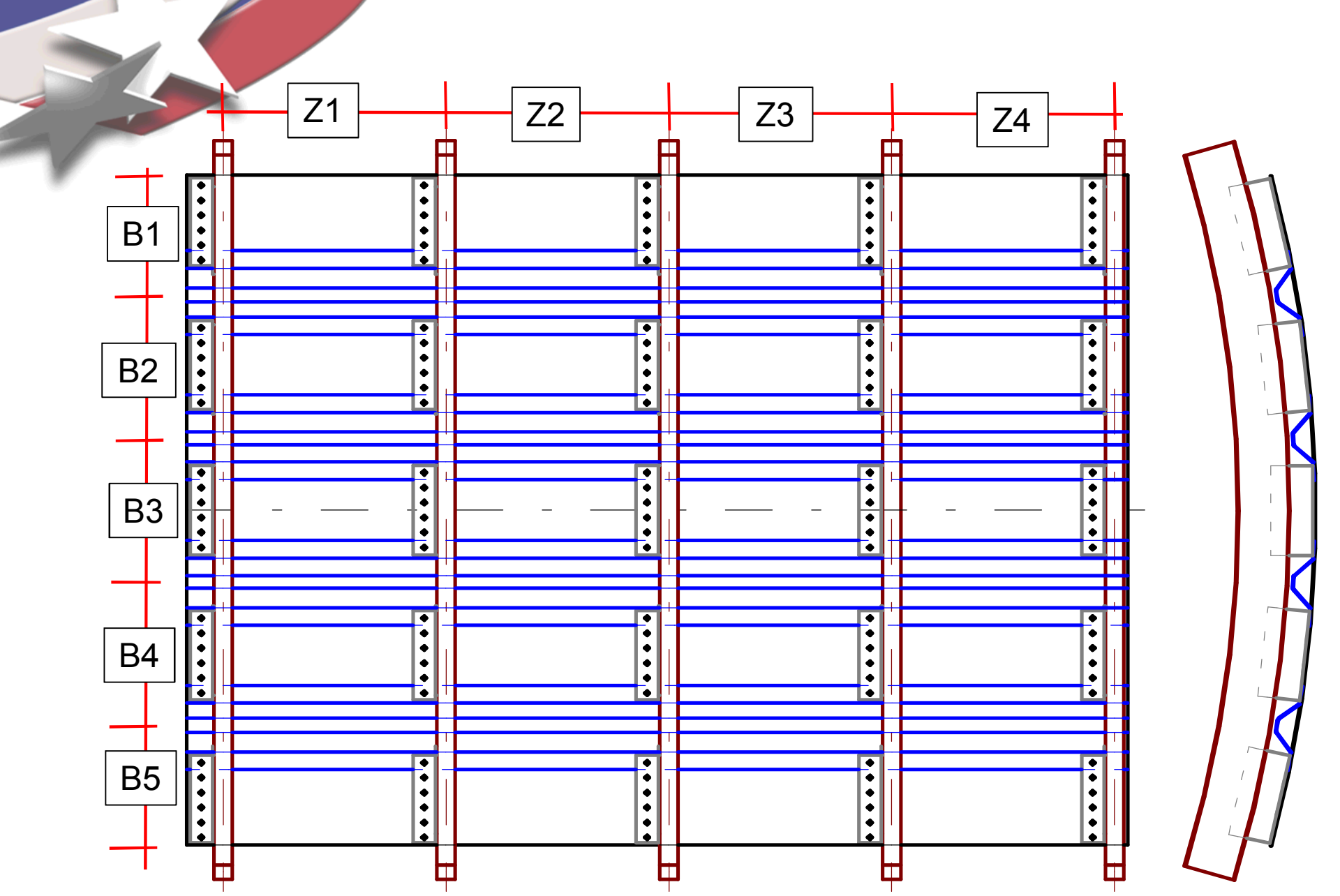
Drop Weight or Swing Arm Impact

Quasi-Static Impact

Ice Impact

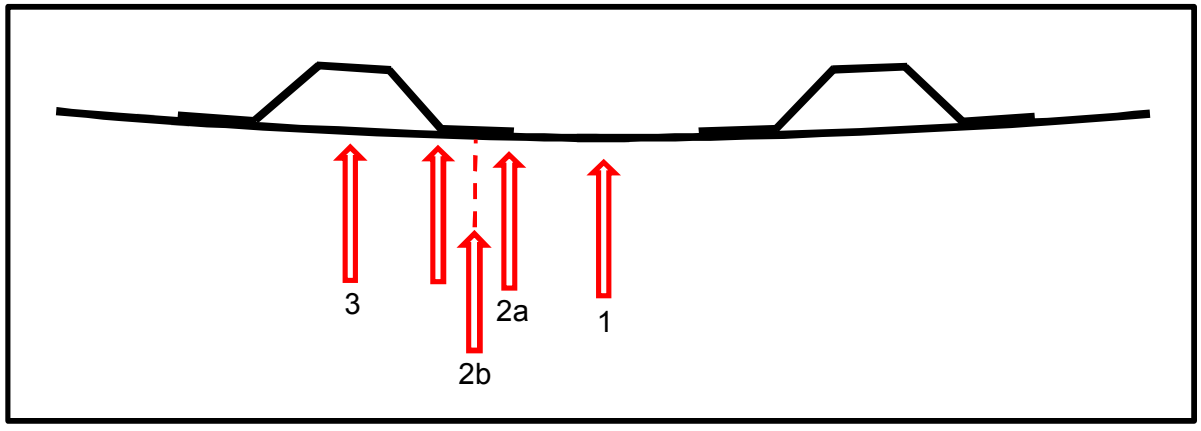
Impacts will not be intended to cause severe damage. Damage location is divided into "bays" separated by stringers and shear-ties in order to not effect neighboring impacts.



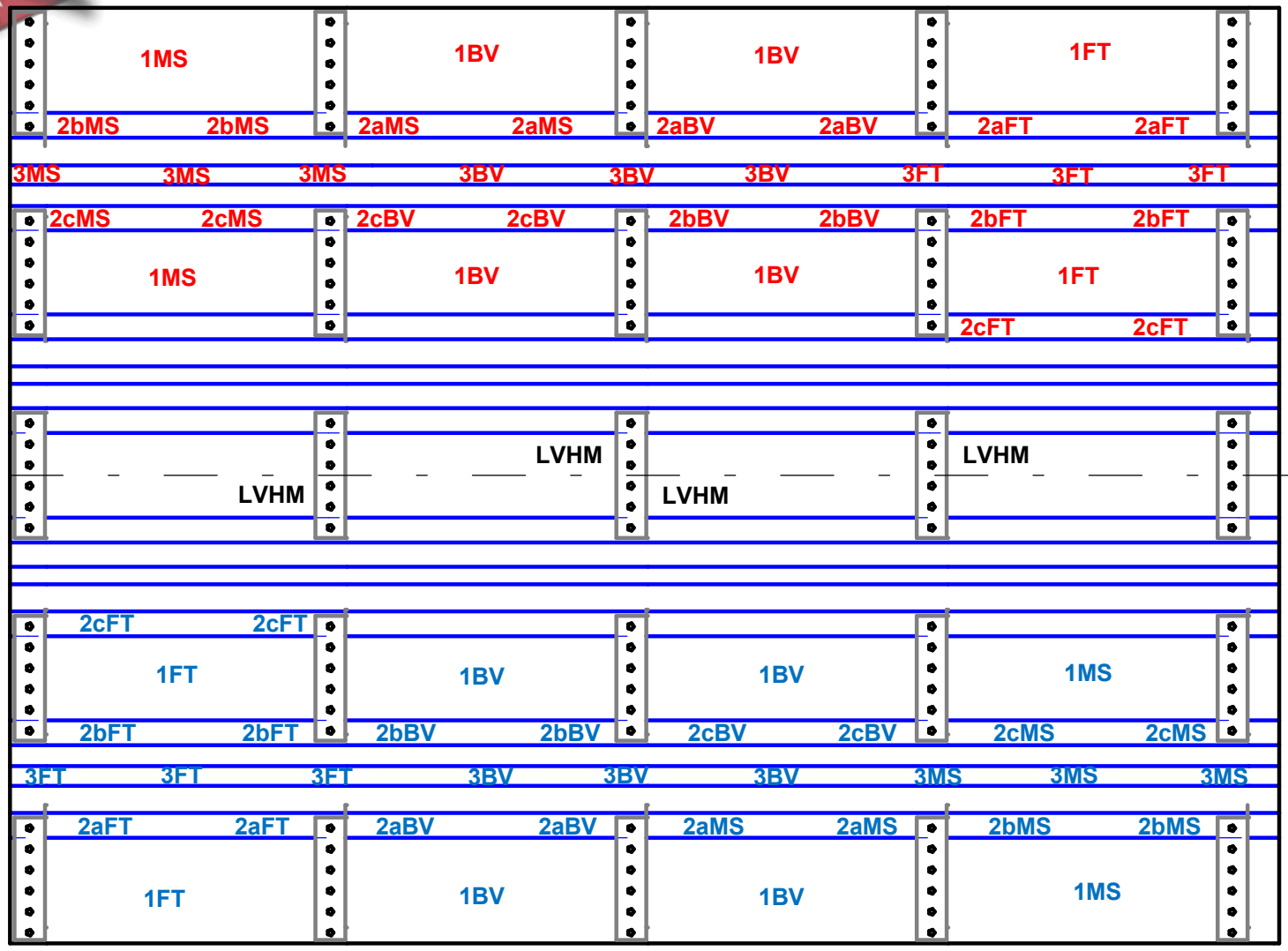

Z1
Z2
Z3
Z4
B1
B2
B3
B4
B5

Proposed Impact Matrix

Location		Failure Threshold Energy		Barely Visible Imp Damage		Manufacturer Specification		Low-Velocity High-Mass
		Ice	Metal	Ice	Metal	Ice	Metal	
1	Skin	1 FT	1 FT	1 BV	1 BV	1 MS	1 MS	LVHM
2a	Stringer	2a FT	2a FT	2a BV	2a BV	2a MS	2a MS	LVHM
2b	Stringer	2b FT	2b FT	2b BV	2b BV	2b MS	2b MS	
2c	Stringer	2c FT	2c FT	2c BV	2c BV	2c MS	2c MS	
3	B/T Stringer	3 FT	3 FT	3 BV	3 BV	3 MS	3 MS	
4	Shear-Tie	4 FT	4 FT	4 BV	4 BV	4 MS	4 MS	LVHM



Proposed Impact Layout



ICE
- FT – Failure Threshold Energy
- BV – Barely Visible Impact Damage
- MS – Manufacture Specification

METAL
- FT – Failure Threshold Energy
- BV – Barely Visible Impact Damage
- MS – Manufacture Specification

LVHM – Low Velocity High Mass

NNSA National Nuclear Security Administration

Sandia National Laboratories

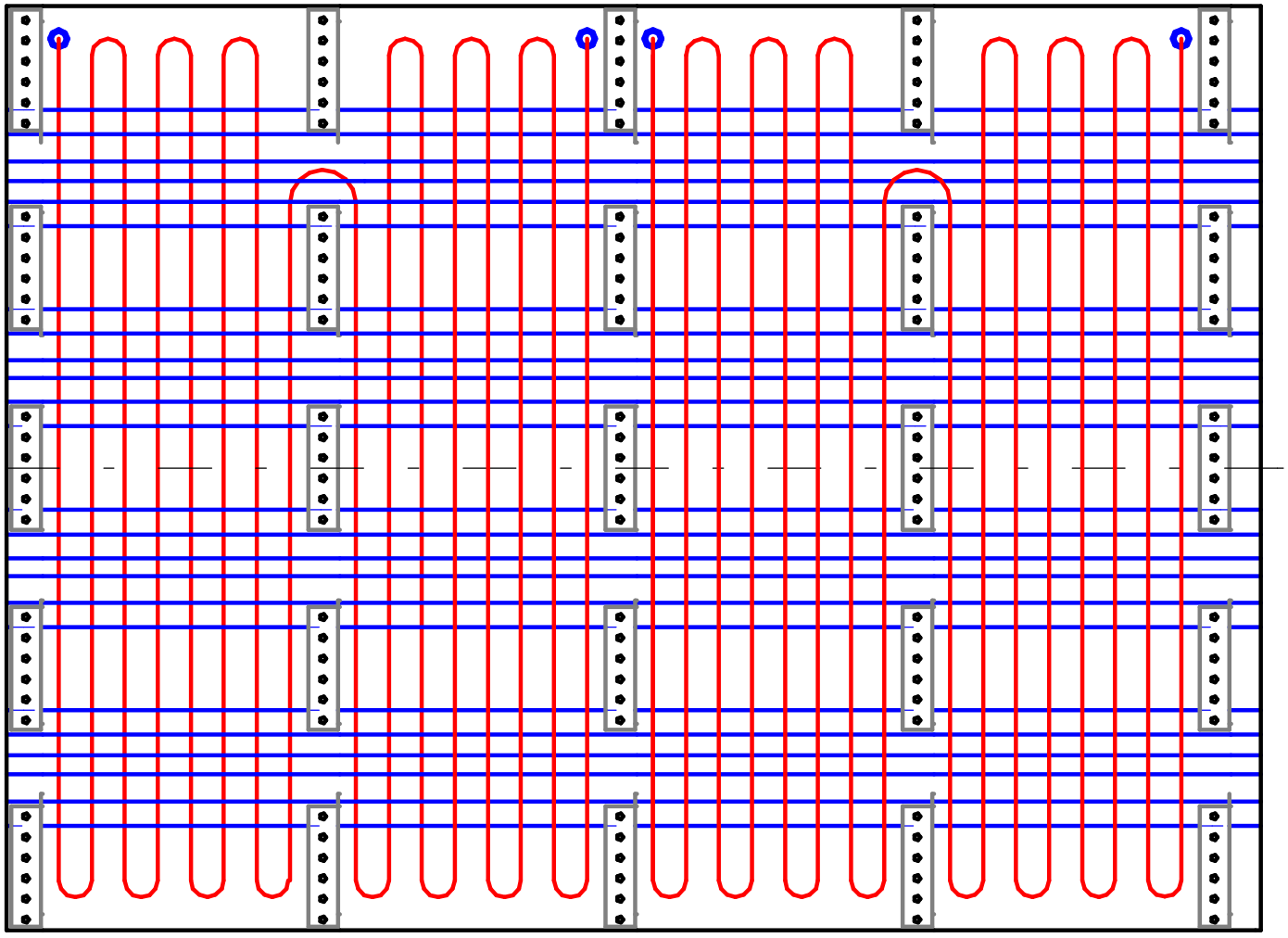
SHM - Embedded Fiber Optic SHM System

Access Optical Backscatter Reflectometer (OBR) as a means of detecting impact damage in full-scale composite fuselage section. Two methods of integration will be assessed: embedded during fabrication and post manufacturing retrofit

Using an inexpensive, telecom grade fiber optic, the OBR uses swept wavelength interferometry (SWI) to measure the Rayleigh backscatter as a function of length in optical fiber with high spatial resolution.

OBR info a picture from lunatechnologies.com/products

SHM - Embedded Fiber Optic SHM System



The entire length of each fiber will be interrogated by measuring Rayleigh backscatter . Methods and layouts to bond the sensor to the other panel are currently being explored.