INTERMEDIATE PROJECT PRESENTATION:
Hidden cracks/defects detection in aircrafts

Department of Civil Engineering
North Dakota State University

Outline of the Project

➢ 1. Sensor deployment

➢ 2. Diagnostic signal generation

➢ 3. Signal processing

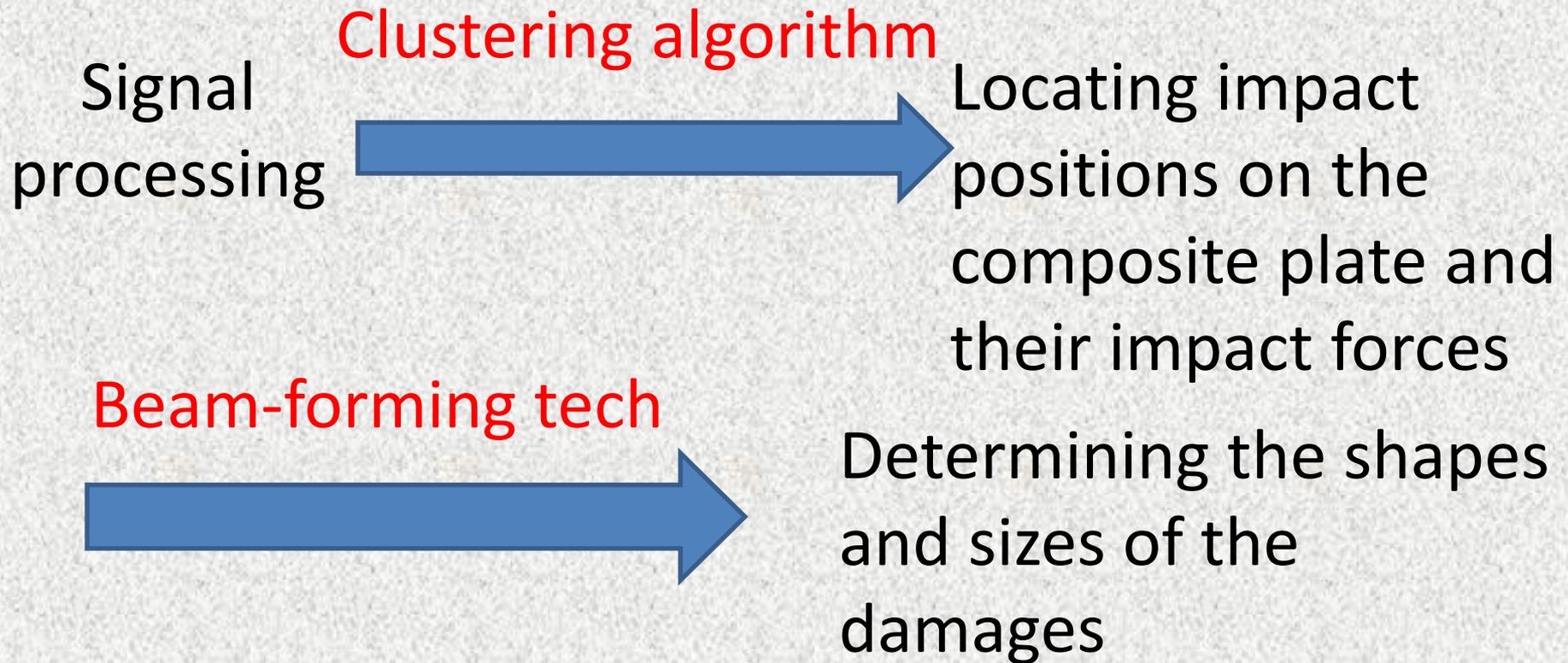➢ 4. Experimental demonstration

Sensor Deployment & Signal Generation

Sensor Deployment

➢ Mechanical strain gages bonded to plate surfaces

➢ Fiber optical gratings used as sensors

Diagnostic Signal Generation

➢ Interrogation wave generation through PZT actuators

   ➢ Agilent 33220A wave generator

➢ Impact hammer

Signal Processing

Signal processing

Clustering algorithm →

Locating impact positions on the composite plate and their impact forces

Beam-forming tech →

Determining the shapes and sizes of the damages

Finding Impact Locations Through Clustering

Tab. 1 Input data for clustering investigation

X	1	1	1	1	1	2	2	2	2	2	3	3
Y	1	2	3	4	5	1	2	3	4	5	1	2
Peak	-28	7	11	-10	16	-13	-7	6	-32	-4	3	-2

| 3	3	3	4	4	4	4	4	5	5	5	5	5
3	4	5	1	2	3	4	5	1	2	3	4	5
1	0	-9	2	3	-6	5	-16	24	8	-18	-10	32
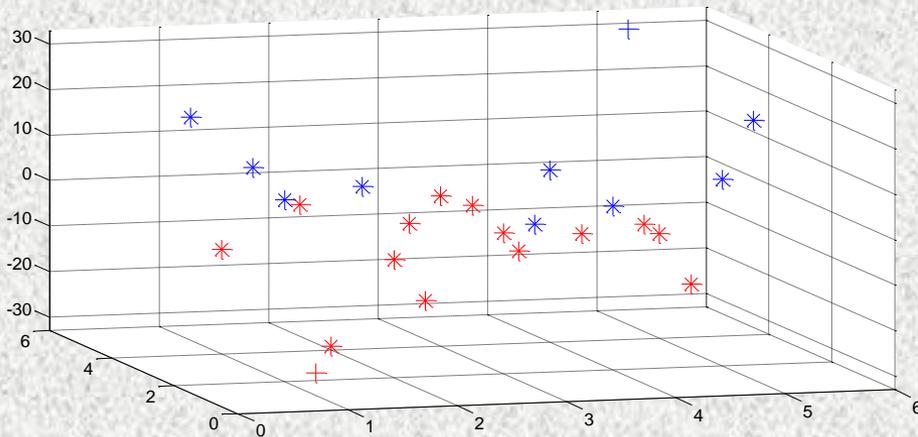
Hierarchy clustering
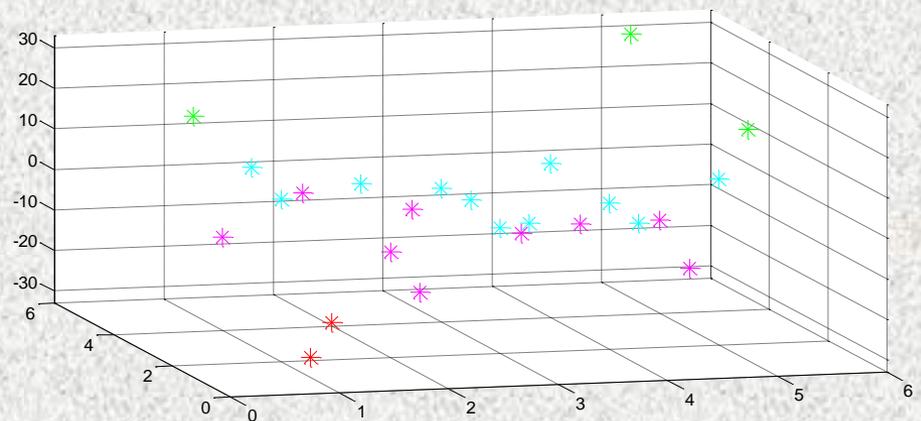
K-means clustering

Experimental Demonstration

➢ Use flat composite plate specimens as aircraft fuselage

➢ Implement proper boundary conditions

  ➢ Cantilever or simply supported

➢ Simulate impacts events using an impact hammer

➢ Collect signals through oscilloscope and optical sensor interrogator

Use Composite Plate as Aircraft Fuselage
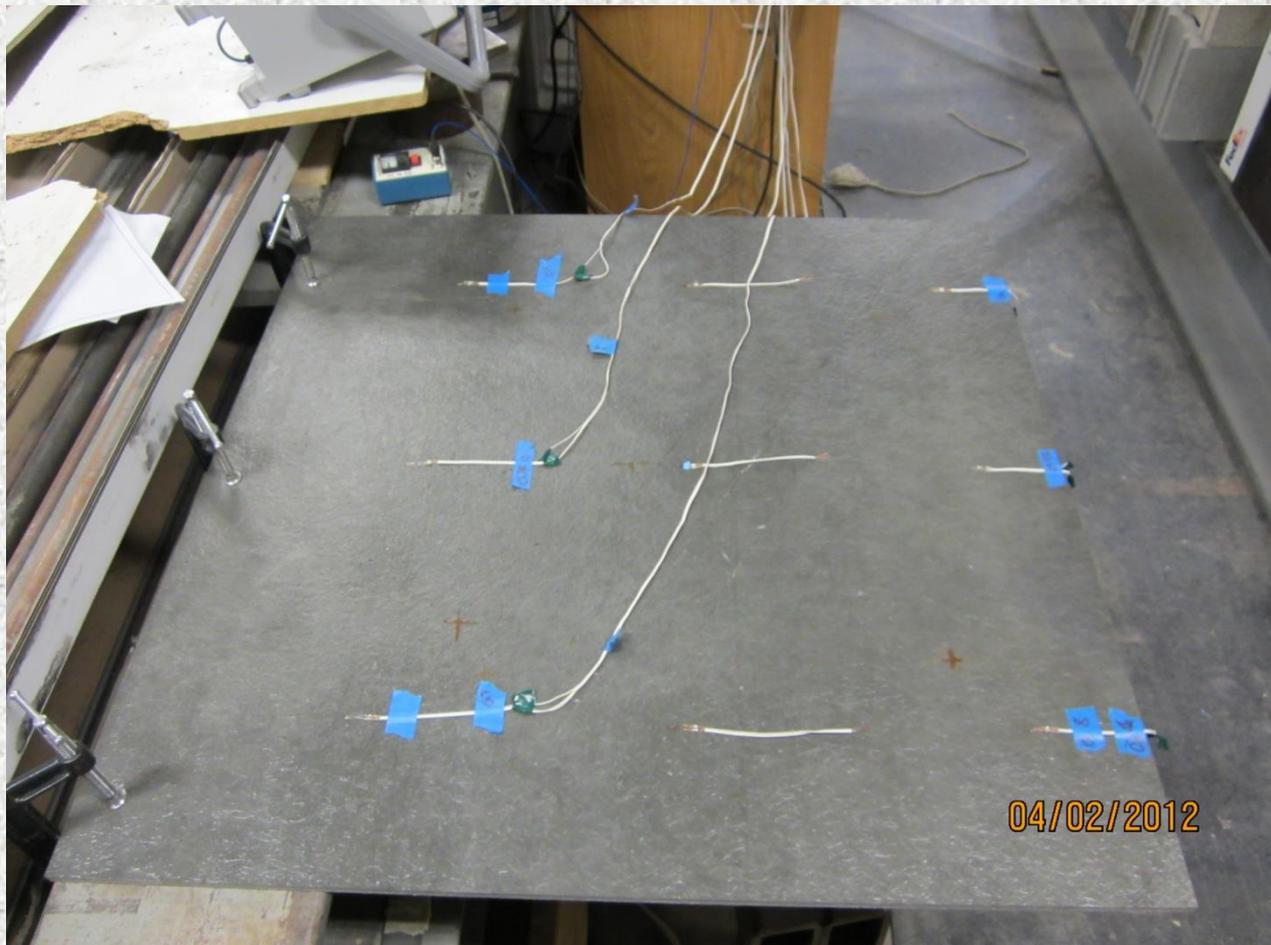
Use Impact Hammer as Excitation Devices

➢ Impact Hammer
   ➢ Used to simulate impact
   ➢ Has sensor on the tip
   ➢ Sends impact signals to ocsilliscope
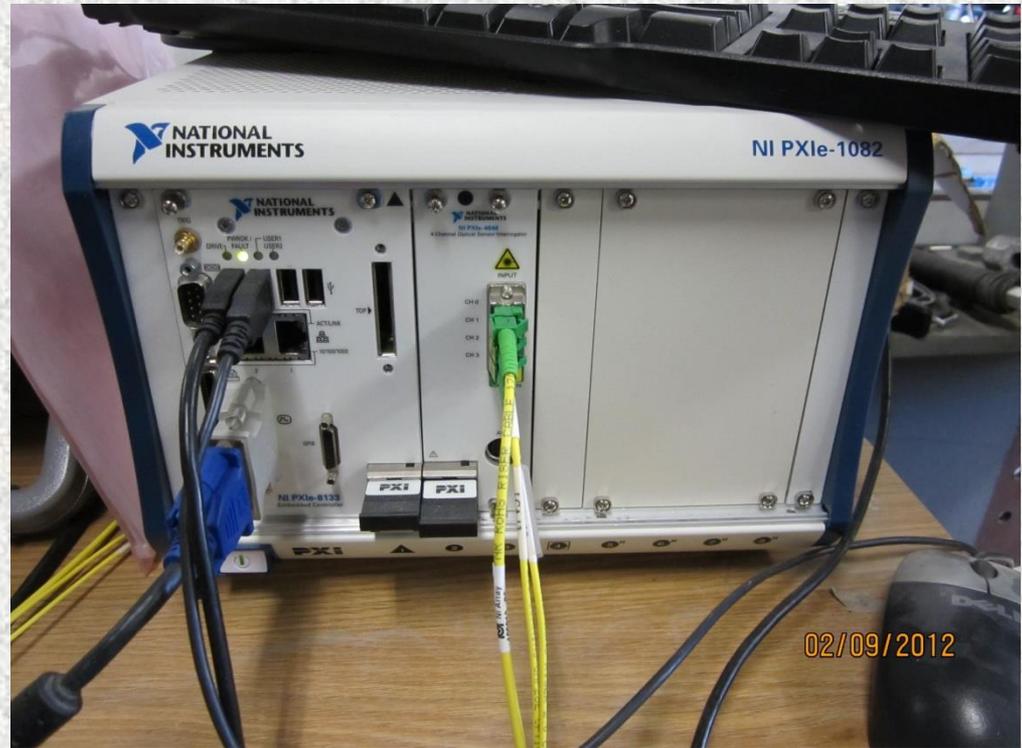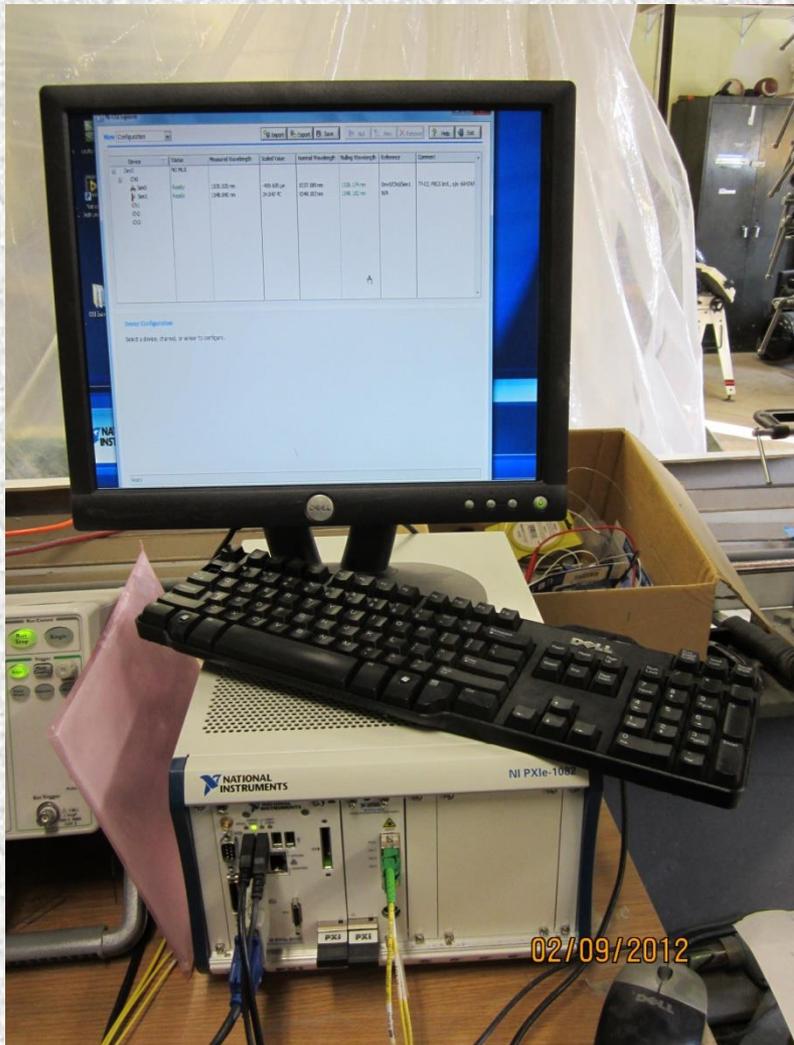
Signal Collection

➢Oscilloscope

   ➢Collect data from impact hammer

➢Dataq Instruments

   ➢Collect data from the mechanical strain gages

➢Optical Sensor Interrogator

   ➢Collect strain data from optical grating sensors

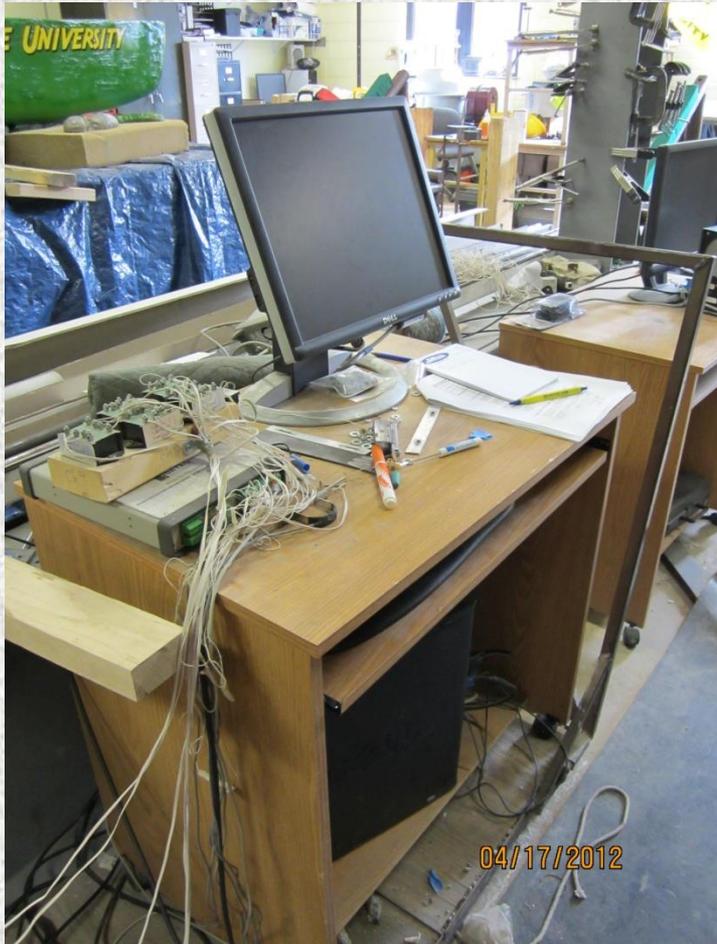# Use Oscilloscope as Impact Signal Collection
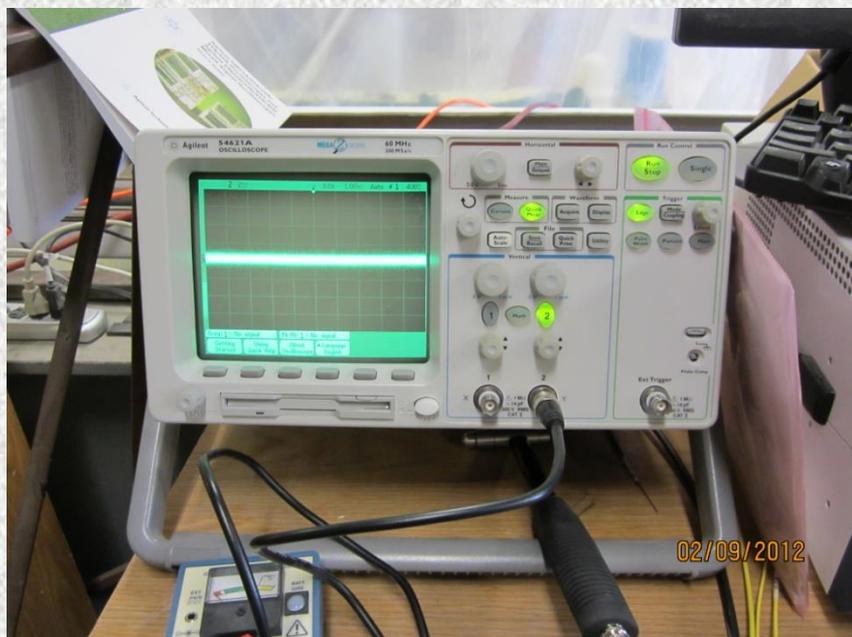
Agilent 54621A

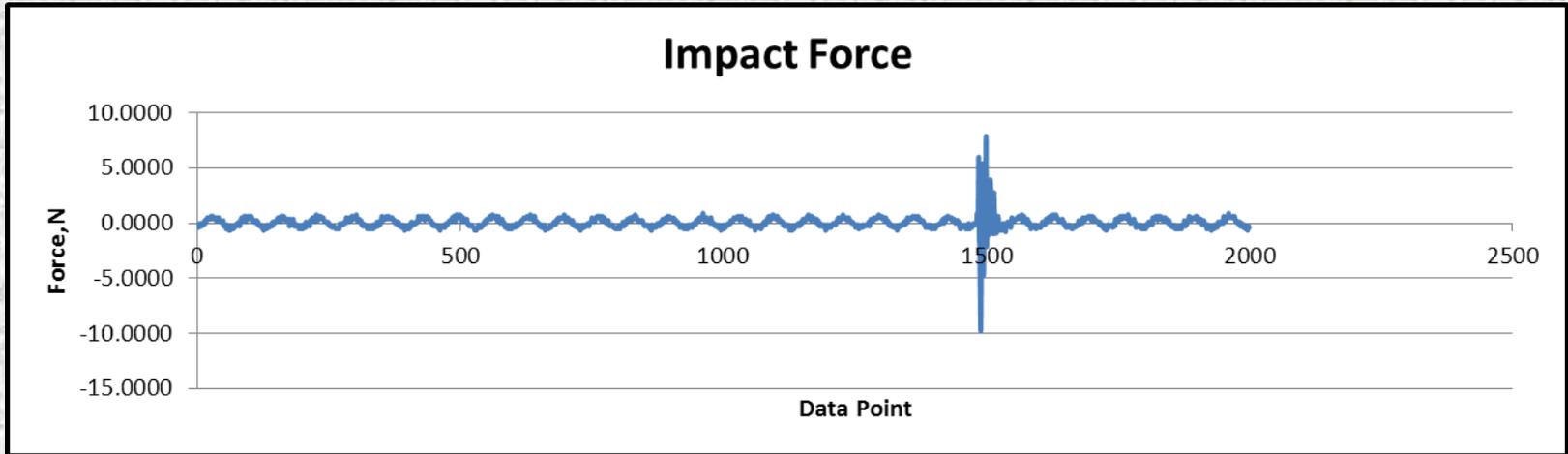# Use Optical Sensor Interrogator as Strain Signal Collection

Use DATAQ Board to Collect Mechanical Strain Gauge Signals

Dataq Intstuments for strain gage data collection.

Simulated Impact Events Through Impact Hammer

Collected signals from oscilloscope

- The data in the figure above shows an impact event in a one second time frame using 2000 data points.
- Typically the impact event is recorded in a span of 0.005 seconds or 10 data points. Typical impact force is 10 N-15 N.

Collected Mechanical Strain Gauge Date
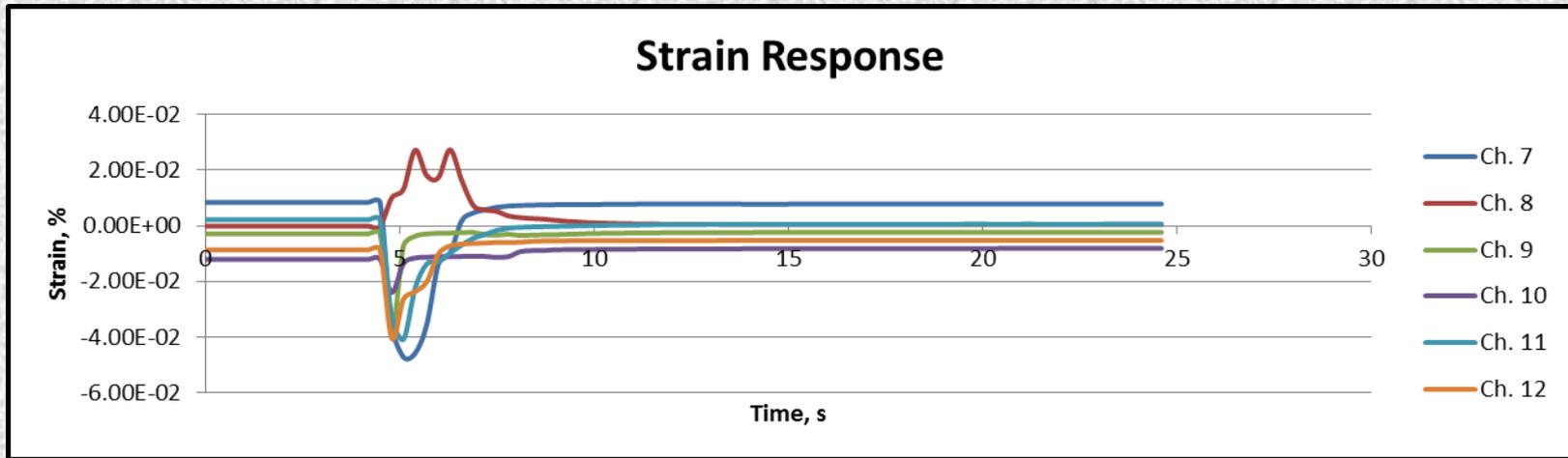
Collected strain gauge data

- The data from the above figure shows the strain response from the six mechanical strain gages attached to the composite plate.
- The strain gage response is dependent on the gage's location on the plate and the location of the impact.

Modeling the anticipated system in virtual environments through software Abaqus
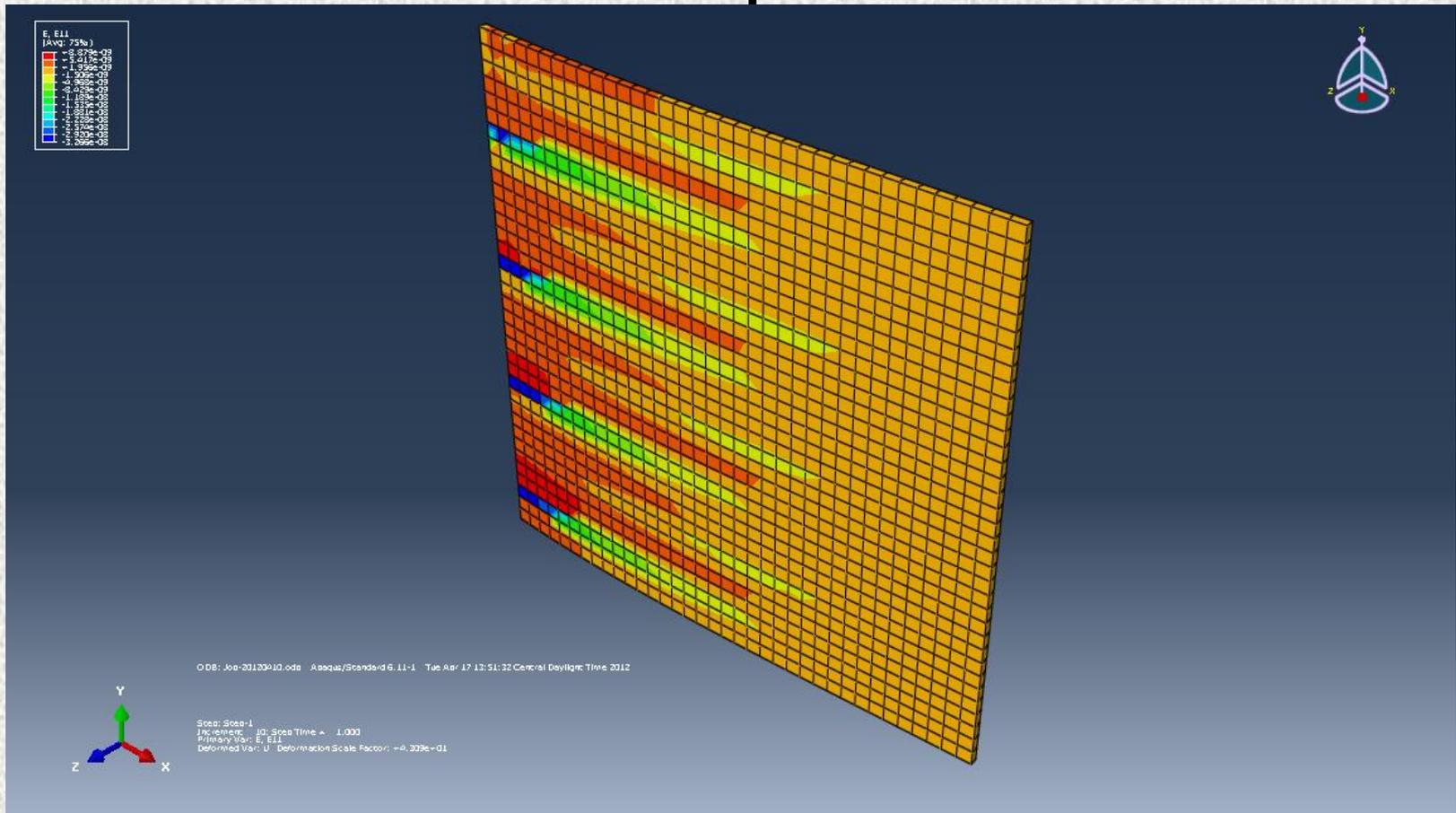
Acknowledgement of the support from ND NASA Space Grant Consortium for this research

Thank you!
Any questions?