

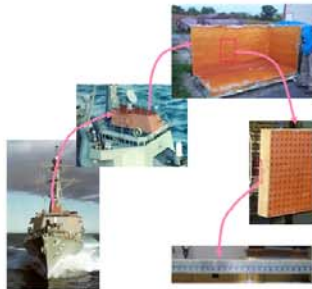
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## OBJECTIVE

- Global and local nondestructive inspection of large-scale composite structures.
- Automation of the vibration actuation and acquisition as well as data processing

## APPROACH



- Glass/Vinyl-ester composite beam
- Sandwich panel
- CIRT corner structure

## MOTIVATION

- Previous technique that excites every grid point and measures dynamic responses at several sensor locations:
  - Long test time and labor intensive
  - Requires high skill levels for testing and data reduction
- New technique uses MEMS sensor on every grid point with single point excitation:
  - One-shot experiment
  - Enables full automation with an automated actuator
  - Enables real time health monitoring for on-time repair of damaged structures

## DAMAGE DETECTION ALGORITHM

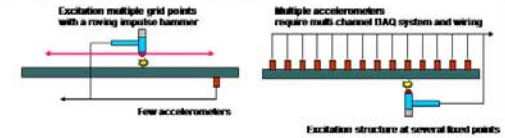
- Two-dimensional Gapped Smoothing Method:  
Structural Irregularity Index = Operating Curvature Shape - Smoothed Curvature Shape

## FUNDAMENTAL THEORY

- Reciprocity principle: Frequency Response Function with response at  $j$  and excitation  $k$  is the same as that with response at  $k$  and excitation  $j$  ( $H_{kj} = H_{jk}$ )

## PROCEDURE

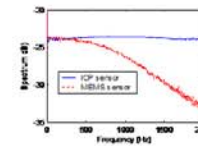
- Multi-excitation vs. multi-sensors



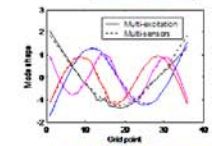
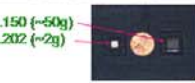
- Sensor type: Analog Device MEMS accelerometers (~\$10-15 per piece)

ADXL150 (~50g)  
ADXL202 (~2g)

- Preliminary tests

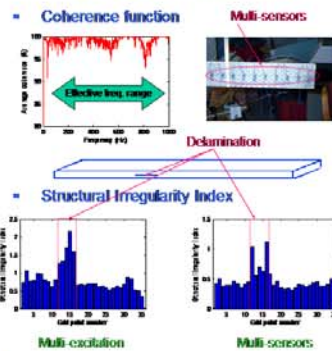


Sensor response of ICP and MEMS sensors

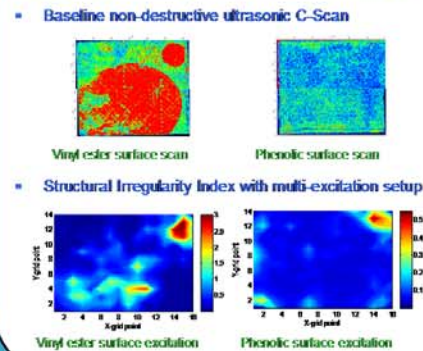


Mode shape comparison of Multi-excitation and multi-sensors configurations

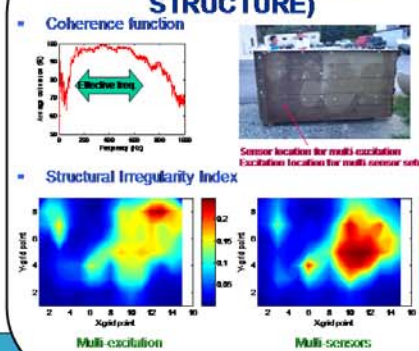
## RESULTS I (BEAM)



## RESULTS II (SANDWICH PANEL)



## RESULTS III (CORNER STRUCTURE)



## CONCLUSIONS

- Validated low cost MEMS accelerometers
- Successfully applied 2D GSM to large-scale NAVY structures
- Showed similar results between multi-excitation and multi-sensors setup
- Selected effective frequency range by coherence function

## FUTURE WORK

- Full automation with automated excitation such as piezoelectric actuators
- Integration of data acquisition, processing, reduction, and post processing
- Quantitative estimation of stiffness reduction in the damaged region

## ACKNOWLEDGEMENTS

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