Faculty Team for Structural Integrity, Vibration and Control

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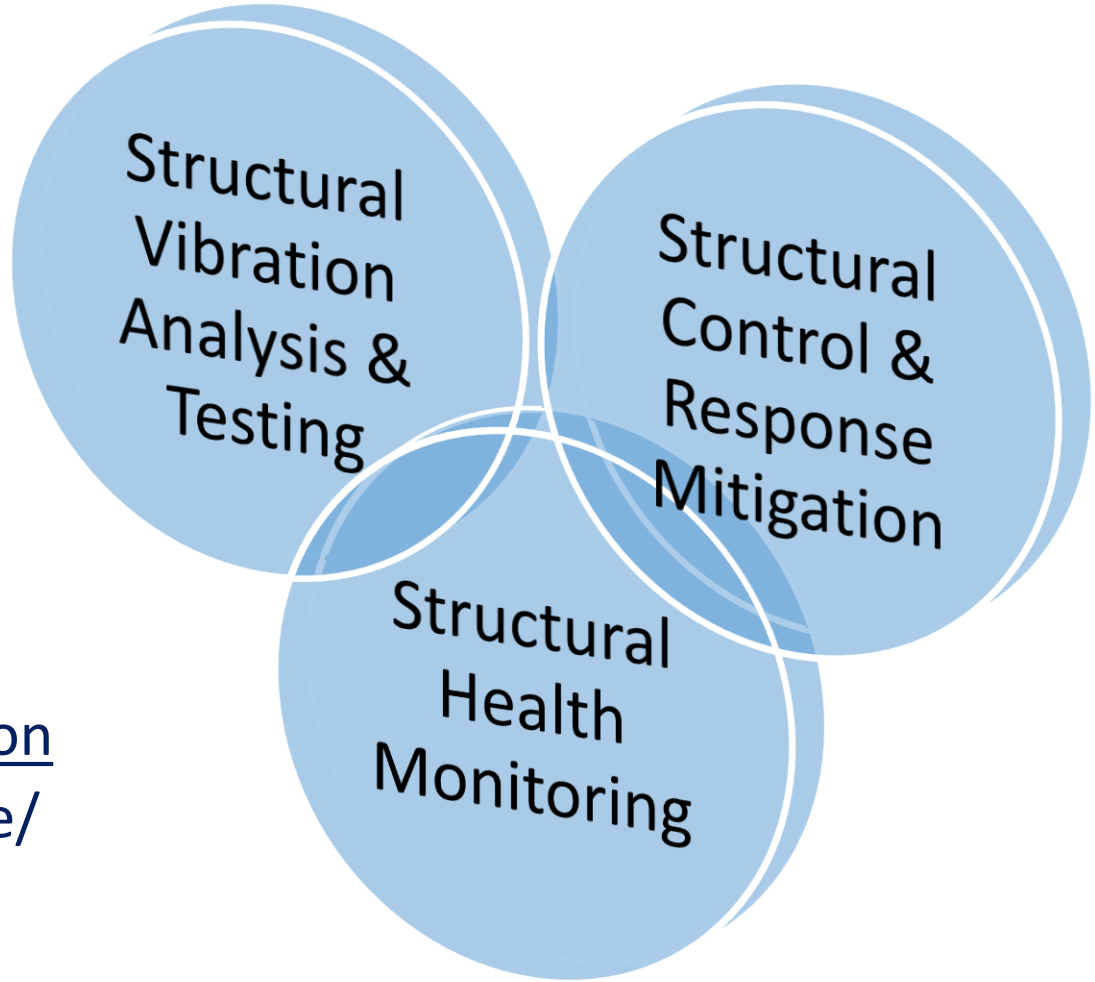
Structural Integrity, Vibration and Control

Capabilities

- Structural vibration testing and analysis: broad force levels & bandwidth; high velocities; vibration-based system identification and uncertainty quantification
- Passive, active and semiactive structural control: devices and control strategies
- Structural health monitoring for damage detection and fatigue analysis: ultrasonic wave/ impedance/ vibration based; novel sensory system development

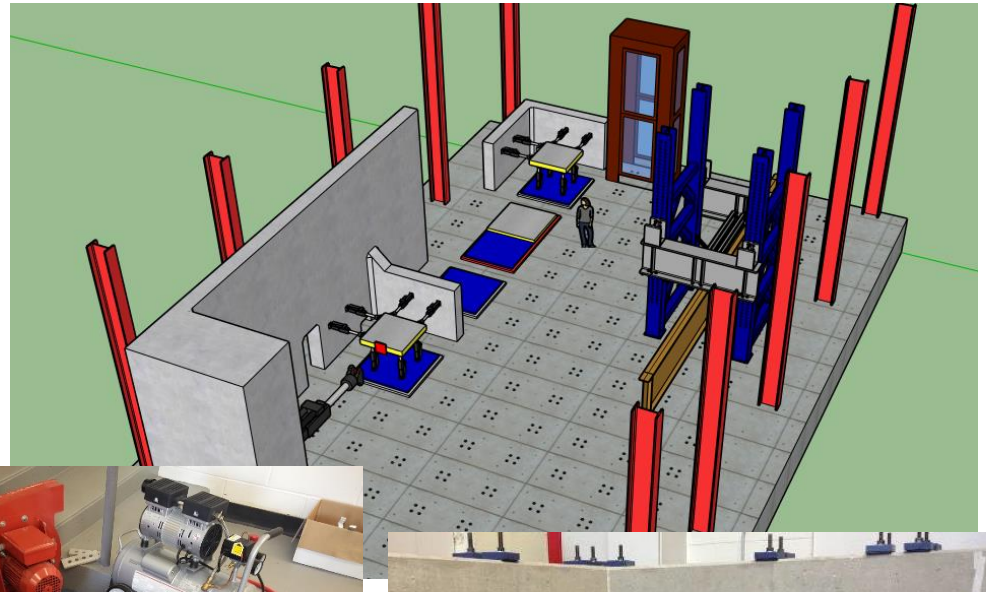


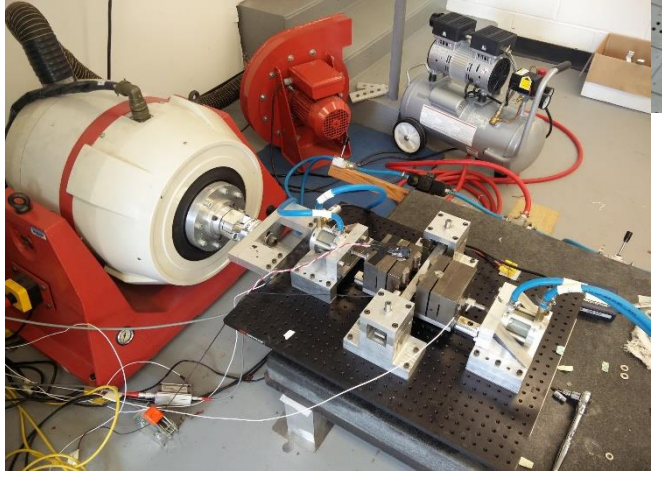
Theoretical, Numerical and Experimental Capabilities

Structural Integrity, Vibration and Control

Available facilities

- Two (2) six-degree-of-freedom shake tables (1 ton payloads, 2g accel);
- a uniaxial shake table (1 ton payload 1g accel);
- High-speed 110 kip actuator (80 in/sec);
- One 110 kip actuator; and two (2) 5 kip actuators;
- Five (5) LDS electrodynamic shakers
- 400 & 40 kip universal test machines;
- Collaborative robots
- Directed energy testbeds
- Data acquisition and sensors

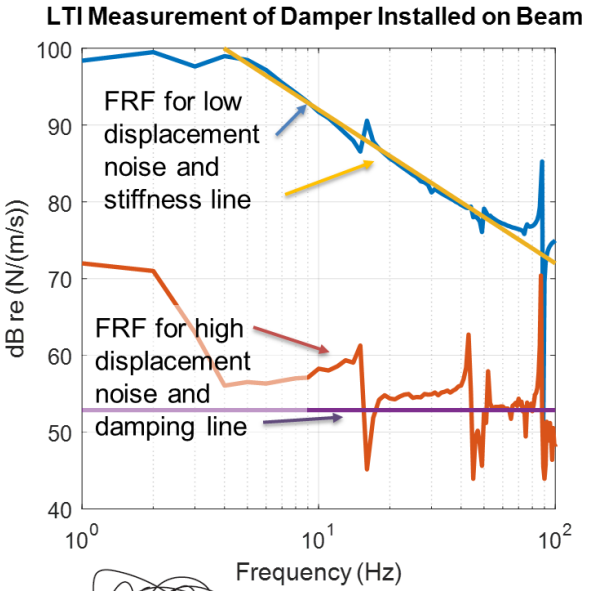


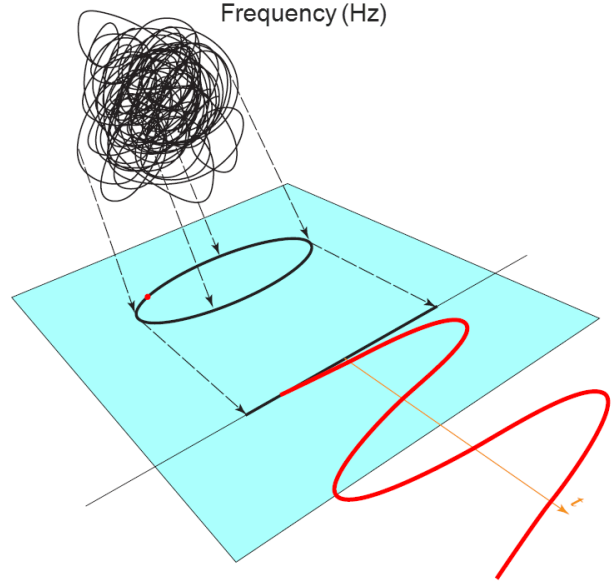


Structural Integrity, Vibration and Control

Structural vibration analysis & testing

- Modeling of complex and nonlinear structural systems
  - parameter identification; time varying systems
- Multivariate and nonlinear time series analysis.
  Smooth projective nonlinear noise reduction.
- Smooth linear subspace based reduced order models (SROMs) valid for a range of system parameters, loading scenarios, and operating conditions
  - can enable large parametric studies for complex structures reducing simulation times several orders of magnitude

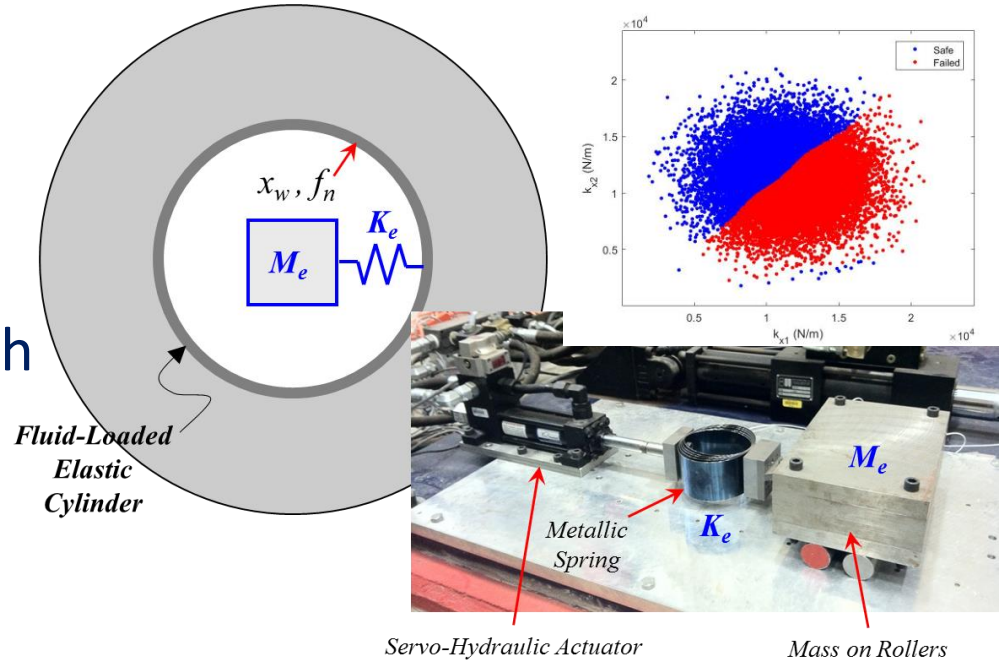


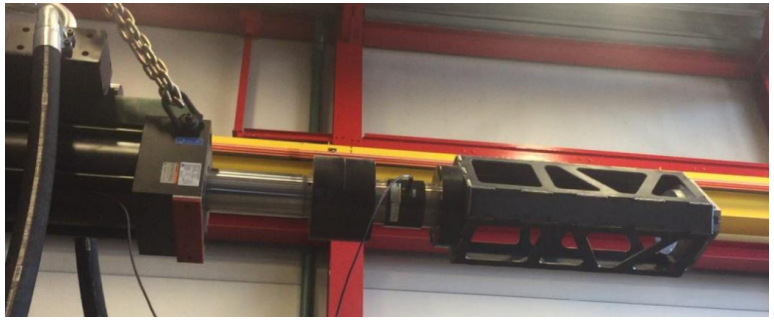


Structural Integrity, Vibration and Control

Structural vibration analysis & testing

- Real-time Hybrid Substructuring
  - Combining physical testing of component with a numerical model of the remainder of the structure and fluid loading
  - Vibration and acoustics to shock applications





- Machine-learning based Uncertainty Analysis
  - Highly efficient Gaussian processes approach to predict response variation under uncertainty
  - Bayesian inference based parametric identification and model updating

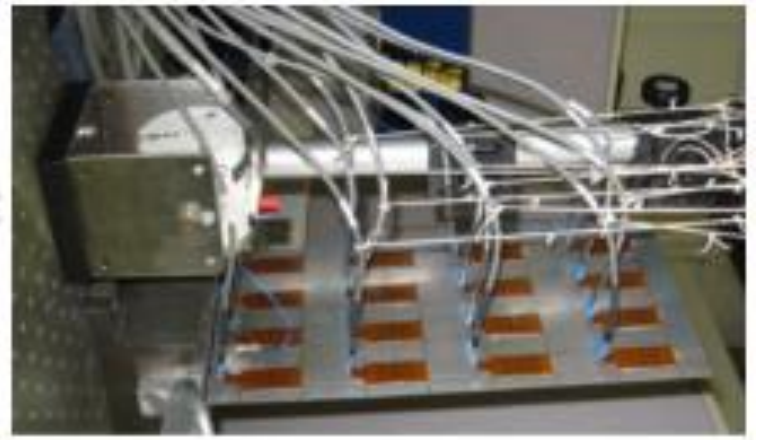
Structural Integrity, Vibration and Control

Structural Control: mitigation of unwanted and excessive vibration

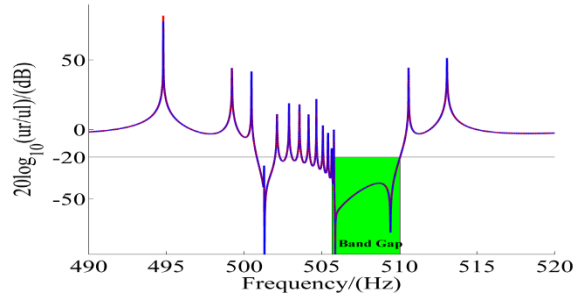
- Active, passive, semi-active isolation and control **devices**
  - From mass dampers and isolators to piezoelectric transducers and magneto-rheological fluid dampers

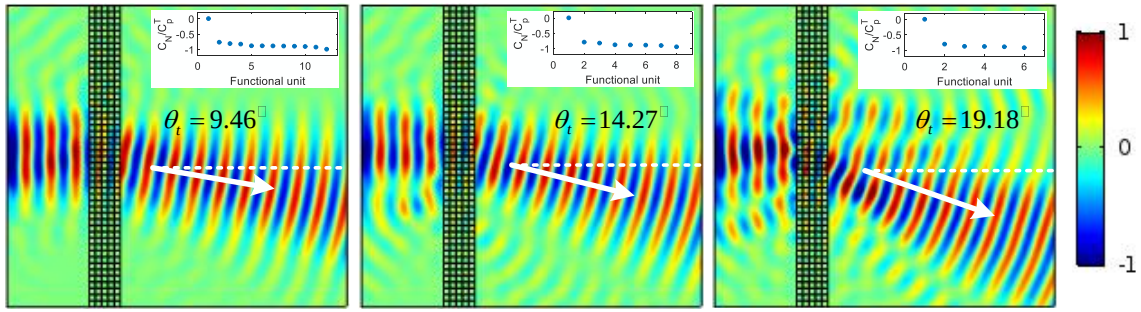
- Active, passive, semi-active isolation and structural control **strategies**
  - Broadband vibration control and isolation
  - Situational awareness and autonomy in undersea environment
  - Quality and fast control in a changing environment, subject to disturbances and sensing limitations.

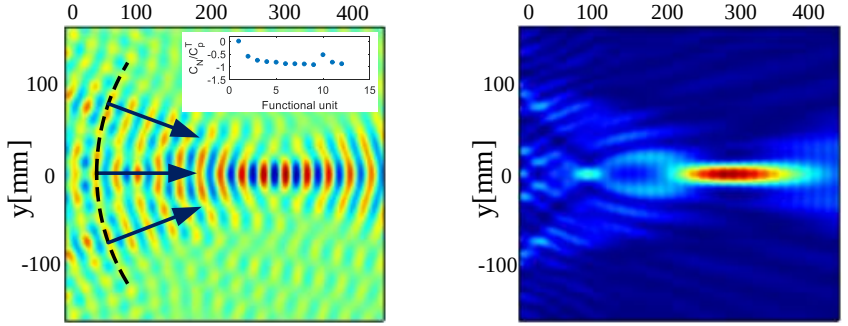
Structural Control: metamaterial and wave / vibration manipulation



- Metamaterial – lattice structure; Piezoelectric metamaterial – conventional structure integrated with periodically arranged piezoelectric transducer with circuitry
  - Can form tunable frequency bandgap – block wave/ vibration propagation within certain frequency ranges
  - Can manipulate wave propagation to enhance acoustic stealthiness and improve fault detection performance

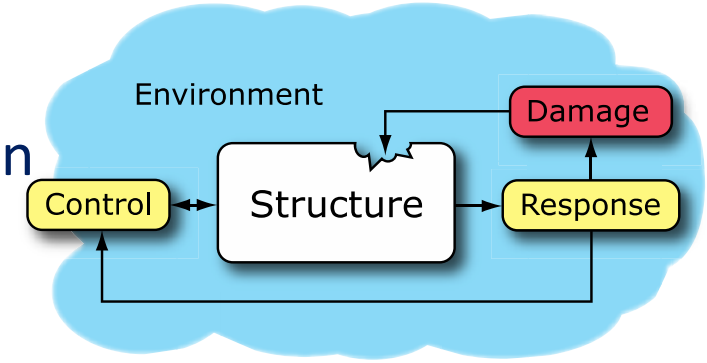




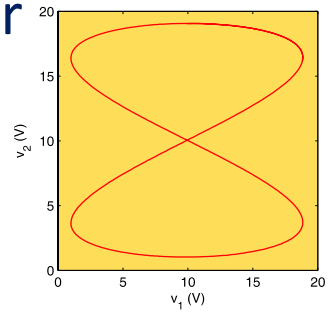


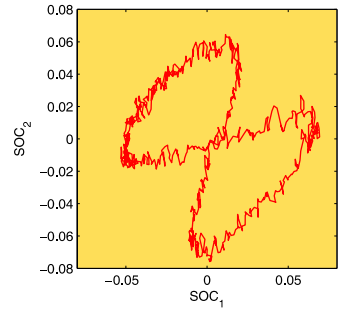
Structural Integrity, Vibration and Control

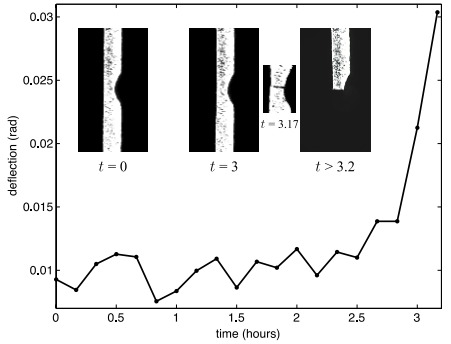
Structural Health Monitoring

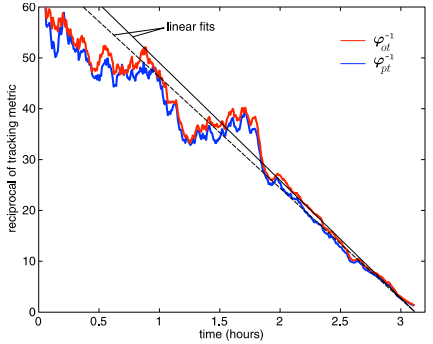


- Vibration-based damage identification, tracking, and prediction based on dynamical systems perspective
- Methodology for identifying, tracking, and reconstructing multivariate hidden slow processes (e.g., damage, parameter drifts, nonstationarity) from the operational vibrations data using phase space warping and smooth orthogonal decomposition.
- Fatigue damage modeling, estimation & prediction under variable/complex loading scenarios.



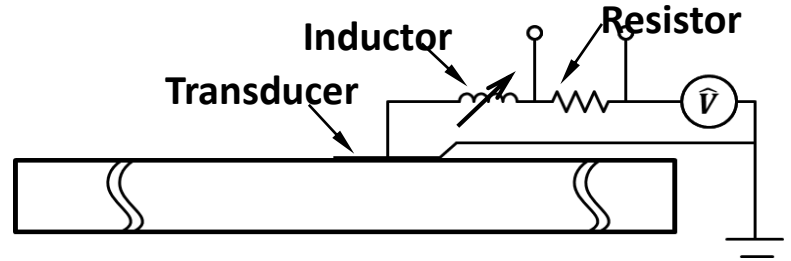


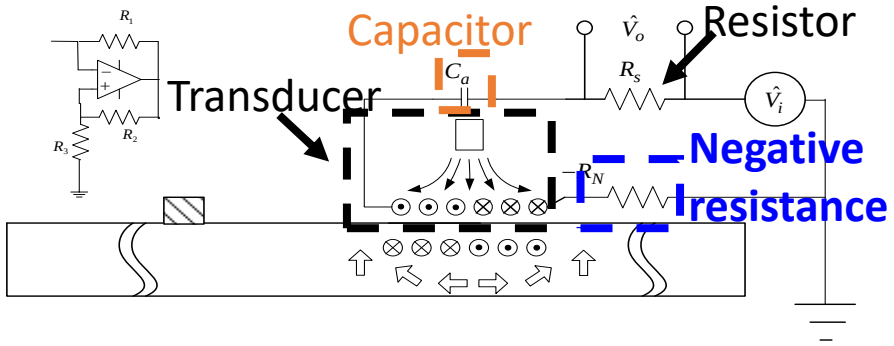




Structural Health Monitoring: new sensory systems and damage identification algorithms

- Piezoelectric circuitry sensing system – highly sensitive ultrasonic wave / impedance / vibration based fault detection; multi-functional to enable self sensing and vibration control simultaneously





- Non-contact magneto-mechanical sensing system – ultrasonic wave / impedance based; movable; can facilitate fault detection during manufacturing

- New algorithms for fault detection and prognosis: combining first principle with advanced data analytics to pinpoint damage and predict fault progression