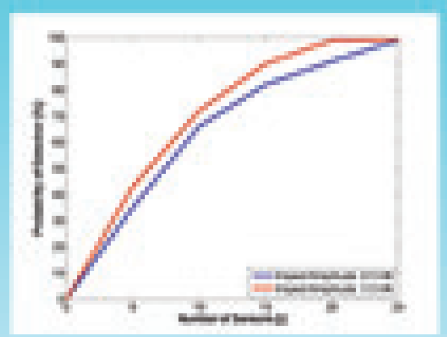
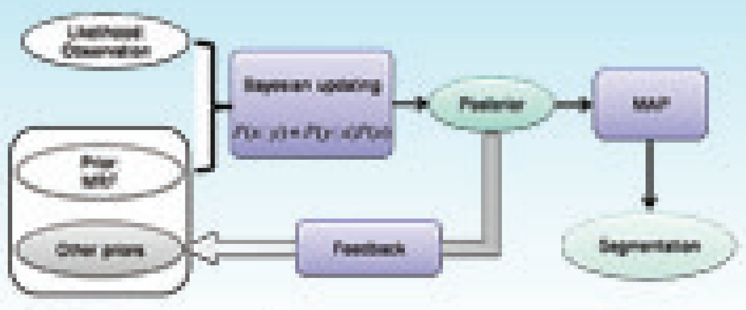
Integrated Diagnosis and Prognosis of Airframe Structural Damage

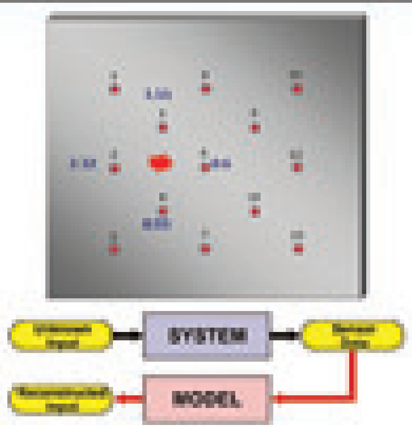
Sensor Network Optimization
- Determine probability of detection (POD) for a given configuration
- Estimate minimum number of sensors at optimal locations to achieve a given POD



Sensor Data Integration
- Use Bayesian statistics to combine data from multiple sensors and for multiple frequencies for better accuracy

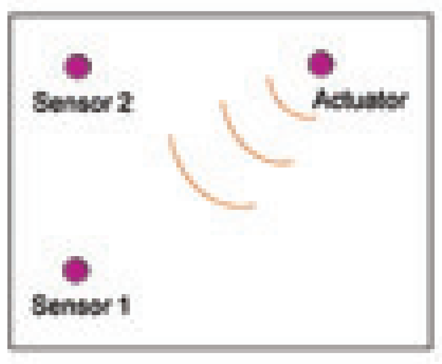


Passive Impact Diagnosis
- Perform inverse analysis of signals from piezoelectric sensors
- Analyze sensor signal to reconstruct impact force and location

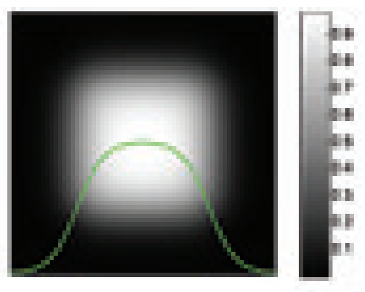


Material Property Analysis
- Perform structure-specific compensation of material properties due to aging effects
- Apply Paris's Law and Bayesian updating to fit material properties, given observed crack length and loading history
- Enable more accurate, structure-specific life predictions

Waveform Simulation
- Apply Spectral Element Method to simulate temperature effects on wave propagation in metal plates
- Runs faster with less memory than FEM: better for wave propagation

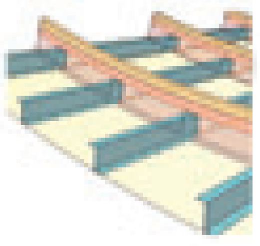


Diagnostic Imaging
- Use frequency-wavenumber(f-k) migration for diagnostic damage images
- Derive probability distribution function (PDF) of damage size from image density



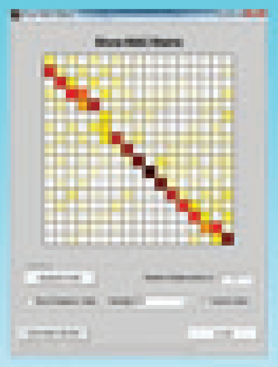
Progressive Failure Analysis
- Employ Finite Element Analysis (FEA) and fracture mechanics to estimate damage propagation, residual strength, and remaining life
- Estimate damage propagation under static loading, cyclic loading, and impact loading

Design Optimization
- Decrease panel thickness through continuous monitoring to optimize lifecycle cost and reduce inspection times
- Enable use of thinner panels with SHM
- Save up to 25% cost/weight reduction

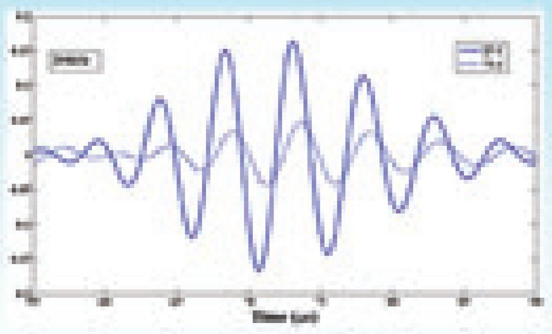


Diagnostic Optimization → **Passive Diagnosis** → **Active Diagnosis** → **Lifetime Estimation**

System Calibration
- Predict dynamic behavior of the system
- Characterize and model frequency response of the system
- Minimize error between simulation and experimental data

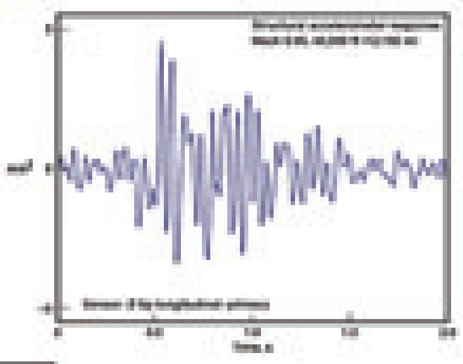


Environmental Compensation
- Compensate for temperature-dependent changes in structural and material properties and transducer characteristics



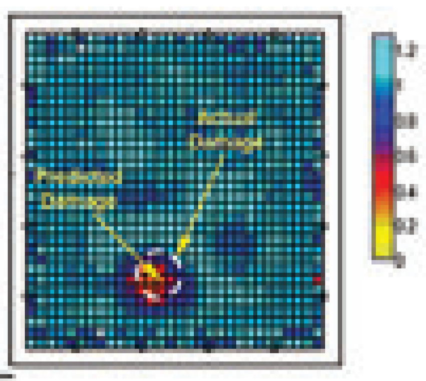
Sensory Alloys
- Developed jointly with NASA AAD
- Combine molecular dynamics, multiscale, and micromechanics methods
- Develop sensory material for diagnosing damage initiation

System Identification Methods
- Analyze structural dynamics to estimate process parameters
- Identify parameters that best describe observed system response and structural health

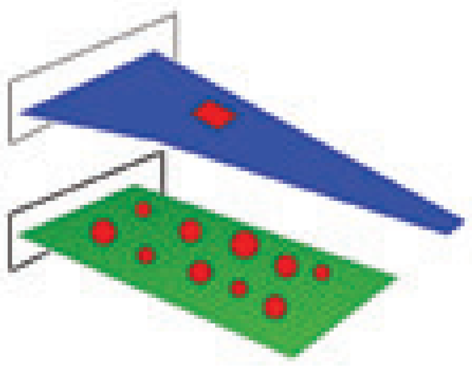


Empirical Methods
- Use empirical methods to estimate structural damage using strain measurements
- Analyze structural response to dynamic loading
- Compare against undamaged response to diagnose damage

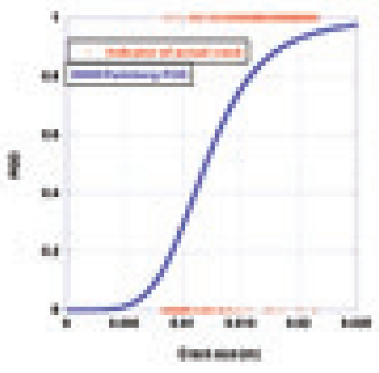
Electrical Impedance Diagnosis
- Developed jointly with NASA IRAC
- Develop neural network/FEM models to estimate damage
- Use material as the sensor to reduce cost/weight, use on existing aircraft



Reduced Order Modeling
- Developed jointly with NASA IRAC
- Estimate aeroelastic and structural constraints with equivalent plate
- Use rapid modeling for stiffness matching and geometric scaling



Integrated Diagnosis and Prognosis
- Produce high-fidelity estimate of remaining life from low-fidelity sensor diagnosis
- Estimate crack size/remaining life from POD using fracture mechanics



Smart Structures & Materials Laboratory

INTEGRATED VEHICLE HEALTH MANAGEMENT

Honeywell