The Fourth Annual DHS University Network Summit
Panel 22 - Transportation System Resiliency
Enabling Technologies for Resilient Transportation

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The Transportation Security Challenge

- Large interconnected networks with many infrastructure components
- Potential cascading effects due to loss of a single component
- Requires integrated risk assessment & management at both the network & component levels
Enabling Technologies

1. Advanced Materials
   • Material synthesis
   • Material characterization
   • Material level modeling

2. Network & Structural Modeling & Simulation
   • Verification & validation
   • All-hazards modeling
   • Predictive capabilities

3. Network & Structural Monitoring
   • Sensor technology
   • Sensor network design
   • Damage detection

What are existing capabilities & gaps? What are short and long term goals?
Enabling Technologies & Security = Prevent + Protect + Respond + Recover

Protect
• Transportation network simulation to design networks for maximum resiliency
• Verified simulation capability for all-hazards design of infrastructure components
• Hardening of strategic infrastructure components via advanced materials
• Optimized sensor networks at both the network & component levels

Respond
• Network sensing provides real-time information for network level decision making
• Structural monitoring & sensing provides real-time assessment of damage
• Reliable real-time information for evacuation and emergency response
• Integrate network & structural simulations with real-time sensing

Recover
• Post incident assessment of network adaptability & structural damage
• Integrate network sensing & simulation to evaluate & verify recovery strategies
• Integrate structural sensing & simulations to verify damage assessment
• Perform simulation to evaluate and implement structural repairs
Goal: Maximize transportation network resiliency through real-time monitoring and intelligent response.

Objectives: Model vulnerability, optimize sensor placement, develop data routing strategies.

Approach
1. Vulnerability-Driven Sensor Placement
   - Vulnerability Modeling - Assess the risk level of each link
   - Sensor Placement - Utilize this information in optimizing sensor locations
2. Data Routing
   - Route collected data to appropriate stations

Game Theory Based Vulnerability Analysis
Strengthening and Modeling of Earth Embankments Under High Loads
M. Chrysochoou, D. Basu and A. Bagtzoglou

Motivation: Soil-structure interaction important in many applications
Goal: Soil strengthening & soil modeling for extreme loads
Approach:
• Chemical strengthening with fly ash (under utilized material) + quantitative mineralogy = predictive design & enhanced properties (+500%)
• Soil constitutive model + material characterization = soil-structure interaction modeling for high rate loads
Mechanical Characterization of UHPC for Resilient Transportation Infrastructure
A. Zofka, M. Accorsi and J. Mahoney

Motivation: Revolutionary advances in concrete technology in last decade
Goal: Develop modeling & simulation capabilities for thermo-mechanical behavior of ultra-high performance concrete (UHPC) structures
Approach: Thermo-mechanical testing + constitutive modeling
Advanced Composite Materials for Blast and Fire Resistance
R. Hebert, B. Huey, G. Rossetti, J.H. Kim - University of Connecticut
Richard Riman - Rutgers University
Arun Shukla - University of Rhode Island

**Motivation:** Existing solutions for blast loading are not suitable for elevated temperatures; conversely, existing solution for fire resistance are not blast resistant.

**Goal:** Development of new composite sandwich materials with combined blast & fire resistance.

**Approach:** Metallic, oxide & ceramic materials & sandwich architectures, material synthesis and characterization, microstructural analysis, high temperature & blast loading, material level modeling
Integrated Sensing and Control System Development for Bridge Structures
R. Christenson and J. Tang

**Goal:** Develop and demonstrate an integrated framework of sensing and control of bridge structures

**Approach:** Integrated sensing & control methodology, scaled bridge test bed, novel impedance sensor system, magneto-rheological fluid dampers (control), modal & impact testing, numerical modeling & simulation

**Bridge Test Bed**
- Impedance Sensors
- MRF Dampers
- Permanent Magnet Shaker
- Drop Weight Testing

**Impedance Sensors**

**MRF Dampers**
Conclusions:
• Strong national need for next-generation resilient infrastructure
• Utilize existing and emerging technologies
• Strong need for basic research and development
• Area that is ripe for innovation!

Thank you