

## TIER 1 UNIVERSITY TRANSPORTATION CENTER

Awarded in December of 2016 by the Office of the Assistant Secretary for Research and Technology in the U.S. Department of Transportation, the five-year INSPIRE Center is focused on the preservation of existing transportation systems under the Fixing America's Surface Transportation Act.



# INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

## BOLD VISION

In the next 30 years, our highway and railway system will face challenges ranging from aging infrastructure and increasing congestion to declining revenues due to reduced fuel tax and increasing service interruption. Cheaper, faster, and safer inspection and preservation tools are needed to maintain our nation's ground transportation system in a state of good repair.

Currently, bridges and tunnels are visually inspected and manually maintained under traffic control with the aid of heavy lifting and access equipment. In the future, with successful development and implementation of robotic platforms such as structural crawlers, unmanned aerial vehicles (UAVs), and multi-modal flying and climbing robots, these structures will be evaluated and sometimes maintained underneath bridge decks with no access equipment and no traffic control, reducing labor hours, avoiding rental, transportation and mobilization costs of equipment, saving fuel and indirect costs associated with service interruption, alleviating traffic congestion, and promoting work zone safety.

## 5 YEAR GOAL

The 5 year goal of the INSPIRE UTC is to transform in at least two demonstration cases from manual to automated inspection and preservation of bridges with sensors, nondestructive evaluation (NDE) devices, multi-modal robots, and data analytics, thus providing cost-effective, consistent, and reliable solutions in bridge condition assessment and maintenance, and to develop diverse transportation workforces mastering the advanced technologies.

## INTERDISCIPLINARY RESEARCH

Faculty from civil, electrical, and mechanical engineering, engineering management and computer science are collaborating to achieve the goal of the center.

Key technologies include mobile manipulating UAVs, structural crawlers, lab-on-sensor calibrations and standardizations, hyperspectral and microwave

imaging, risk-based inspections, data-driven preservation strategies, and resilience analysis methods.

The developed technologies can be applied to potentially amend inspection regulation for fracture critical members and re-invent an integrated inspection and preservation decision process from performance monitoring through emerging risk identification to support planning of preservation actions.

## CONSORTIUM MEMBERS

The INSPIRE UTC is a diverse, experienced, and geographically distributed consortium of six major and four minor partners.

The six major partner institutions support all research activities. They include: Missouri University of Science and Technology (Missouri S&T) as Lead Institution, City College of New York (CCNY), Georgia Institute of Technology (GT), University of Colorado, Boulder (CU), University of Nevada, Las Vegas (UNLV), and University of Nevada, Reno (UNR). Major partners have interdisciplinary expertise in civil engineering, electrical engineering, mechanical engineering, engineering management and computer science.

The four minor partner institutions provide a conduit to develop the next-generation transportation workforce. Located in the state of Missouri, the four minor partners are Lincoln University (LU), St. Louis Community College (STLCC), East Central College (ECC), and Ozarks Technical Community College (OTCC).

### MAJOR MEMBERS



### MINOR MEMBERS



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Inspection and maintenance of bridges requires the use of heavy lifting and access equipment, thus increasing operation time and direct costs. If access to the work area must be made from bridge decks, the indirect cost associated with road closure multiplies. In such a case, travelers are frustrated with traffic congestion and, both the travelers and inspectors are subjected to a safety concern on high volume highways. The advanced technologies developed at the INSPIRE Center may transform the current manual inspection and maintenance to an automated process of bridge preservation that does not affect traffic flow and is more efficient, safe, reliable, and cost-effective.

## RESEARCH OBJECTIVES

- To explore, develop, validate, and demonstrate remotely-controlled robotic platforms for the inspection and preservation of bridges and tunnels, a robot-enabled resilience analysis and intervention framework for post-disaster assessment and recovery of transportation structures, and a simulation-based training and control system for next-generation transportation workforce development.

## EDUCATION OBJECTIVES

- To develop new education materials related to advanced sensing and robotic technologies, such as real-world examples and cases that can reinforce the learning objectives of current curriculums, and interdisciplinary topics for senior design/capstone projects that can promote cooperative learning among students from various disciplines.
- To create new opportunities for knowledge expansion and skill training on non-traditional civil engineering subjects, such as sensing, NDE, and bridge inspection and maintenance with robotics, which can enrich existing civil engineering programs or non-degree certificate programs.
- To connect students with transportation industries and professionals.

## WORKFORCE DEVELOPMENT OBJECTIVES

- To raise the public awareness of changes from adopting advanced technologies and attract new entrants from varying pipelines into transportation-related majors.
- To apply the robot simulator and video games developed as part of the research portfolio for a rapid and innovative workforce training of both current and prospective transportation workforces.

## TECHNOLOGY TRANSFER OBJECTIVES

- To facilitate technology transfer, and assist state and local governments, non-profit entities, and private enterprises in mastering and implementing the developed technologies such as sensors, robots, and image analysis tools.
- To protect intellectual properties with patent applications through the technology transfer and economic development offices and actively seek their licensing with small businesses.
- To disseminate research results through high quality peer-reviewed journals, conference proceedings, and exhibitions at national/international conferences.

## OUTREACH OBJECTIVES

- To raise awareness in the community of the activities of the INSPIRE UTC and the advanced technologies that can be used to help preserve our nation's transportation infrastructure.

## CURRENT RESEARCH PROJECTS

### WORKFORCE DEVELOPMENT

A Training Framework of Robotic Operation and Image Analysis for Decision-making in Bridge Inspection and Preservation

Developing a Robotic Simulator and Video Games for Professional and Public Training

### SENSING AND NONDESTRUCTIVE EVALUATION

UAV-enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring

Battery-free Antenna Sensors for Strain and Crack Monitoring of Bridge Structures

In-line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications

3D Microwave Camera for Concrete Delamination and Steel Corrosion Detection

Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces

### AUTONOMOUS SYSTEM

Mobile-manipulating UAVs for Sensor Installation, Bridge Inspection and Maintenance

Climbing Robots with Automated Deployment of Sensors and NDE Devices for Steel Bridge Inspection

Autonomous Wall-climbing Robots for Inspection and Maintenance of Concrete Bridges

### INSPECTION AND MAINTENANCE

Reinventing the Bridge Inspection Program

Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems

### RETROFIT AND RESILIENCE

Bridge Resilience Assessment with INSPIRE Data