**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 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 five major and four minor partners.

The five 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 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).
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.

INSPIRE 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
An Interactive System for Training and Assisting Bridge Inspectors in Inspection Video Data Analytics
Simulation Training to Work With Bridge Inspection Robots

SENSING AND NONDESTRUCTIVE EVALUATION
In-Line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications
Probability of Detection in Corrosion Monitoring with FE-C Coated LPFG Sensors
Autonomous Ultrasonic Thickness Measurement by a Magnet-Wheeled Robot
UAV-Enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring
Health Inspection of Concrete Pavement and Bridge Members Exposed to Freeze-Thaw Service Environments
Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces

AUTONOMOUS SYSTEM
A Field Deployable Wall-Climbing Robot for Bridge Inspection Using Vision and Impact Sounding Techniques
Mobile-Manipulating UAVs for Sensor Installation, Bridge Inspection and Maintenance
Augmenting Bridge Inspection With Augmented Reality and Haptics-Based Aerial Manipulation
Bridge Inspection Robot Deployment Systems (BIRDS)
Augmenting Bridge Inspection with Augmented Reality and Haptics-Based Aerial Manipulation
Robot-Assisted Underwater Acoustic Imaging for Bridge Scour Evaluation
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
Nondestructive Data Driven Motion Planning for Inspection Robots
Robot-Assisted Underwater Acoustic Imaging for Bridge Scour Evaluation
Integration of Aerial Manipulation, Haptics-Based Human-in-the-Loop Control, and Augmented Reality for Bridge Deck Hosing

INSPECTION AND MAINTENANCE
“Smart Sounding System” for Autonomous Evaluation of Concrete and Metallic Structures
Re-Inventing the Bridge Inspection Program
Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems

RETROFIT AND RESILIENCE
Data-Driven Risk-Informed Bridge Asset Management and Prioritization Across Transportation Networks
Bridge Resilience Assessment with INSPIRE Data