



Winter 2017

## INSPIRE Newsletter Winter 2017

Missouri University of Science and Technology. INSPIRE - University Transportation Center

Follow this and additional works at: <https://scholarsmine.mst.edu/inspire-newsletters>



Part of the [Structural Engineering Commons](#)

---

### Recommended Citation

Missouri University of Science and Technology. INSPIRE - University Transportation Center, "INSPIRE Newsletter Winter 2017" (2017). *INSPIRE Newsletters*. 2.  
<https://scholarsmine.mst.edu/inspire-newsletters/2>

This Newsletter is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in INSPIRE Newsletters by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact [scholarsmine@mst.edu](mailto:scholarsmine@mst.edu).

**TIER 1 UNIVERSITY  
TRANSPORTATION CENTER**

Sponsored by the Office of the Assistant Secretary for Research and Technology in the U.S. Department of Transportation



# INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

VOL. 1 | ISSUE 2 | WINTER  
INSPIRE-UTC Biannual Publication

## In this issue:

- Director's Message
- News
- Research Highlights
- Technology Transfer
- Outreach
- Upcoming Events

Awarded in December of 2016 by the U.S. Department of Transportation, the five-year **INSPIRE UTC** is a Tier 1 University Transportation Center with a research priority of preserving the existing transportation system as part of the UTC Program (<https://www.transportation.gov/utc/2016-utc-grantees>) that was authorized under the Fixing America's Surface Transportation Act.

### CONSORTIUM MEMBERS



## Director's Message

Happy New Year! It has been six months since the publication of our last newsletter. During this period, many exciting things have happened within the INSPIRE University Transportation Center (UTC).

Twelve research projects were awarded in Year 1 to six research-focused partner institutions. Most of the project PIs have recruited students and started off their research work with satisfactory progress. The awarded projects are posted on the Center's web page (<http://inspire-utc.mst.edu/researchprojects/>) for general access and information within the research community world-wide.

12 RESEARCH  
PROJECTS  
AWARDED

In addition to technical research efforts, the INSPIRE UTC recently conducted two technical webinars for the professional community, and two educational workshops for children in the local community. Through technology transfer and educational outreach, we aim to increase knowledge of advanced technology applications in bridge inspection and maintenance. The focus of the Center's efforts in education, training and outreach has been the awareness and buildup of a robotics cohort and a future transportation workforce, the two topics in the heart of the INSPIRE UTC.

This newsletter features two technical articles: (1) lab-on-sensor for structural behavior evaluation, and (2) microwave characterization of material and structural properties. Pioneered by INSPIRE UTC investigators, both subjects have been extensively investigated in laboratory and tested at bridge sites. Together, they are promising in delivering mission-critical data that transportation engineers can directly use in their rehabilitation design of existing bridges.

To strengthen university-industry partnerships, the INSPIRE UTC and Missouri Department of Transportation met several times and discussed the current practice in bridge inspection, identified the potential uses of advanced technologies to be developed at the Center, and explored new opportunities to engage engineers in INSPIRE UTC research projects and workforce development activities.

The INSPIRE UTC is preparing to award 12 research projects in Year 2. Each project proposal was evaluated by at least two external reviewers: one affiliated with DOT and the other from academia. All reviewers graciously devoted their spare time to reading proposals and providing constructive comments. I would like to express my sincere gratitude for their professional contribution to the INSPIRE UTC mission.

I invite you to read through the featured articles and news reports in this publication. If you have any questions, comments, or suggestions, please email us at [inspire-utc@mst.edu](mailto:inspire-utc@mst.edu).

**Genda Chen**, Ph.D., P.E., F. ASCE

Professor and Robert W. Abbett Distinguished Chair in Civil Engineering, Missouri S&T  
Director of the INSPIRE UTC

## EXTERNAL ADVISORY COMMITTEE

INSPIRE UTC's External Advisory Committee (EAC) will guide the Center throughout the development and validation of advanced and applied sensors, nondestructive evaluation (NDE), robot, and data logistics/ analytics technologies targeted to practical solutions for the inspection and maintenance of existing bridges. The EAC expects to participate in two teleconferences a year to review the Center's progresses and serve on the Center's executive team for proposal review and recommendations. The EAC will provide input to the establishment of ambitious yet practical target performance criteria for various measurement technologies and autonomous systems to be developed over a period of five years.



**Hoda Azari, Ph.D.**  
Azari is NDE Program Manager of the Turner-Fairbank Highway Research Center at Federal Highway Administration.



**Bill Stone, P.E.**  
Stone is the Research Administrator at the Missouri Department of Transportation.



**Michael Collins, P.E.**  
Collins is a Bridge Asset Management Engineer with the Colorado Department of Transportation.



**Paul D. Thompson**  
Thompson is an internationally-recognized expert on management systems, engineering economics, and transportation asset management.



**Kevin D. Hicks, P.E.**  
Hicks is the Assistant Vice President of Engineering Design for Union Pacific Railroad Company in Omaha, NE.



**Bojidar Yanev, Ph.D., P.E.**  
Yanev is Executive Director of the Bridge Inspection and Management at the New York City Department of Transportation, Adjunct Professor at Columbia University and New York University, and author of the book Bridge Management published by John Wiley, 2007.



**Michael Premo**  
Premo is the Assistant Chief Structures Engineer of Inspection at the Nevada Department of Transportation.

## CHANCELLOR'S MESSAGE



I enjoyed meeting many of the INSPIRE consortium members and partners during our kick-off meeting last September. Missouri S&T's newest University Transportation Center represents an outstanding opportunity to build on the collective strengths of our member institutions in a highly collaborative way. At Missouri S&T, we are committed to supporting INSPIRE's vision to transform our nation's infrastructure through innovative research. In so doing, the INSPIRE consortium will provide a value that serves the economic and social wellbeing of Missouri and beyond. To all members of INSPIRE, and to our partners in state and federal government, I thank you for your commitment to this bold vision.

Sincerely,

**Christopher Maples**  
Missouri S&T Interim Chancellor





## INSPIRE UTC kick-off meeting

Inspecting and Preserving Infrastructure through Robotic Exploration University Transportation Center (INSPIRE UTC) hosted a kick-off meeting Sept. 1, 2017, with representatives from the U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology. Attendees included INSPIRE UTC associate directors from Missouri S&T, City College of New York, Georgia Institute of Technology and University of Nevada-Reno, external advisory committee members, and the Missouri S&T leadership team and grant management support staff.

Following the meeting, a demonstration of the unmanned aerial vehicles used for robotic bridge inspection, was led



by the S&T MinerFly research support team. Participants toured INSPIRE's new suite of offices, along with the Applied Microwave Nondestructive Testing Lab, the System and Process Assessment Research Lab, the High-bay Structural Engineering Research Lab and the MinerFly Lab.

Following the demonstration and tour, S&T held a luncheon to celebrate the launch of the new center. Guests included University of Missouri System President **Dr. Mun Choi**; Missouri S&T Interim Chancellor **Dr. Chris Maples**; Missouri Department of Transportation Director **Patrick McKenna** and Research Administrator **William Stone**; Missouri Highways and Transportation Commission Vice Chair **Greg Smith**; state Senator **Dr. Dan Brown**, whose district includes Rolla; and University of Missouri Curator **David Steelman**. Each spoke on the importance of the UTC mission and INSPIRE's potential impact on improving the maintenance and preservation of Missouri's transportation infrastructure and potentially promoting economic development in the Midwest region.

## Klegseth named UTC Outstanding Student of the Year

**Matthew Klegseth**, a doctoral student in civil engineering, has been named a University Transportation Center Outstanding Student of the Year by the U.S. Department of Transportation (DOT).



**Matthew Klegseth**

Klegseth is working with the INSPIRE UTC while working on his dissertation, which examines the inspection and preservation of infrastructure through robotic exploration. His advisor is **Dr. Genda Chen**.

Klegseth received his award on Jan. 6, 2018, in Washington D.C. at the annual winter meeting of DOT's Transportation Research Board. The award criteria includes accomplishments in areas such as technical merit and research capability; academic performance; and leadership.

For more information about DOT's Outstanding Student of the Year Award, visit <https://www.transportation.gov/utc/2017-outstanding-students-year-0>.

## TRB meeting held

The Transportation Research Board (TRB) 97th Annual Meeting was held Jan. 7-11, 2018 in Washington, D.C. This program attracts more than 13,000 transportation professionals from around the world, including researchers from the INSPIRE UTC. For more information, visit: <http://www.trb.org/AnnualMeeting/AnnualMeeting.aspx>

## LAB-ON-SENSOR FOR STRUCTURAL BEHAVIOR EVALUATION

Since 2000, **Dr. Genda Chen** and his team have explored and developed a suite of 'lab-on-sensor' concepts that resulted in direct measurements of mission-critical data such as crack location and width, maximum scour depth, and corrosion-induced steel mass loss. This data is directly applicable in the rehabilitation design and maintenance of existing bridges. The 'lab-on-sensor' design theory for each structural behavior includes three steps (extension, calibration and correlation):

### 3 STEPS

- 1 The mechanical or electrochemical behavior observed in a structural member is extended to a nearby sensor with a special mechanism, such as nano iron particles in the case of corrosion monitoring.
- 2 The measured parameter based on the sensing principle (application specific) is calibrated with the behavior of the sensor mechanism.
- 3 The behavior of the sensor mechanism determined from the sensor data and the calibration curve is correlated with the behavior of the structural member instrumented and monitored.

Due to the extension of structural behavior, the 'lab-on-sensor' can memorize the most severe damage or worst deterioration scenario that has ever occurred since the installation of the sensor. This unique feature enables dual measurements of a single parameter (e.g., crack) during and after an earthquake event, increasing the reliability of mission-critical data collection in applications.

For crack detection and assessment, a topology-based coax cable was invented with a spirally wrapped outer conductor and its electromagnetic wave transmission theory was developed to enable the use of coax cable as a continuous strain/crack sensor in engineering structures. Two sensors were applied to a bridge in Dallas County, Mo., as shown in Fig. 1.



Fig. 1: The Dallas County Bridge with two instrumented sensors



For steel corrosion detection and assessment, nano iron (Fe) particles were coated on a long-period fiber grating (LPFG) sensor and functioned as a mechanism of the LPFG sensor in experiencing the same electrochemical process/corrosion phenomenon as a nearby steel member. The resonant wavelength of the iron-coated LPFG sensor linearly changed with the mass loss of iron particles in two stages of corrosion before and after moisture has completely penetrated through the thickness of the iron coating. This calibration curve can be used to determine the mass loss of a steel member when instrumented with a nearby LPFG sensor.

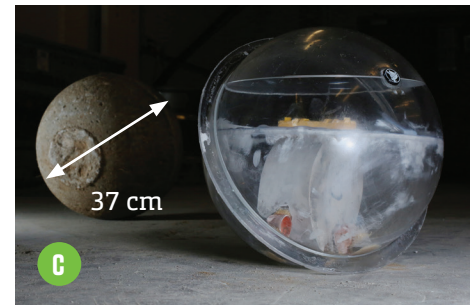
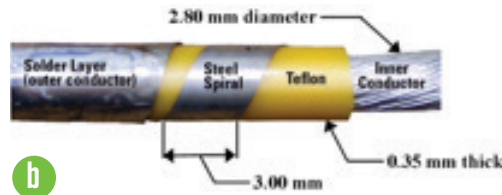
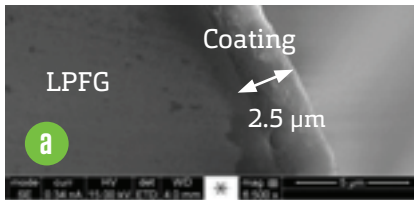
For foundation scour detection and assessment, a smart rock with one or two embedded magnet(s) or electronics for wireless communication was developed and calibrated in laboratory, and deployed around the foundation of the in-service Roubidoux Creek Bridge on I-44W Highway as shown in Fig. 2. The smart rock as a field agent rolls down the slope of a scour hole as it develops under strong current

and is positioned via remote magnetic field measurements to determine the maximum scour depth. The smart rock is an integral part of the scour process around its nearby bridge foundation.



Fig. 2 The Roubidoux Creek Bridge with smart rock (SR1) installation

Fig. 3 compares an LPFG corrosion sensor coated with nano iron and silica particles after being heated, a coax cable crack sensor, and a smart rock with one embedded magnet. Their diameters are in the order of 100  $\mu\text{m}$  to 10 cm. Their measurement principles are quite different as briefly discussed previously.

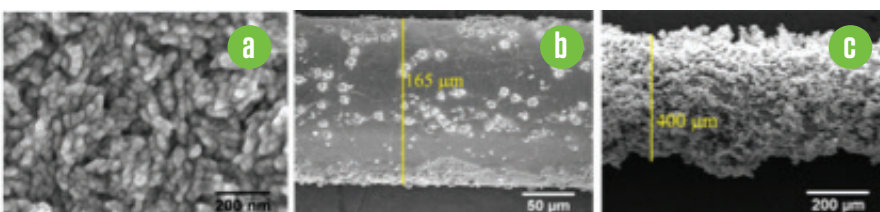


**Fig. 3** Lab-on-sensor in various scales for corrosion, crack, and scour monitoring

a. Nano iron particles coated corrosion sensor  
b. Coax cable crack sensor  
c. Smart rock with magnet

To further illustrate the concept of 'lab-on-sensor' design, an LPFG sensor (cladding mode LP08) with a grating period of 387  $\mu\text{m}$  and a total length of approximately 40 mm was cleansed, deposited with an approximately 0.8  $\mu\text{m}$  thick silver film, and electroplated in a solution to produce an outer 20  $\mu\text{m}$  thick Fe-C layer. As shown in Fig. 4(a), the Fe-C layer has a porous, dendritic structure of round particles with approximately 27 nm in diameter. Figs. 4(b) and 4(c) show the surface morphologies of the Fe-C coated LPFG sensor prior to corrosion test and after 24 hours of immersion in 3.5 wt.% NaCl solution. On the surface of the LPFG sensor, the scattered grains as shown in Fig. 4(b) represent the pitting corrosion products formed in air during preparation for scanning electron microscope (SEM) imaging. After 24 hours of immersion in salt solution, the LPFG surface was covered with a significant amount of corrosion products, increasing the outer diameter from 165  $\mu\text{m}$  to 400  $\mu\text{m}$  as shown in Fig. 4(c).

a. Fe-C layer microstructure; b. Fe-C coated LPFG prior to test; c. The LPFG after test

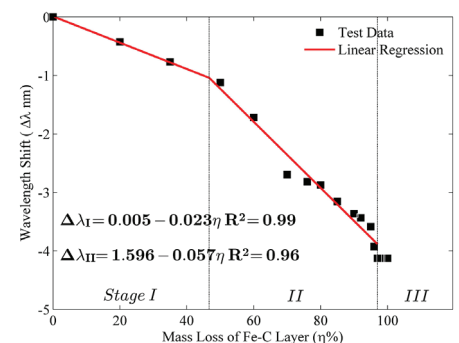


**Fig. 4** SEM images of Fe-C layer and LPFG sensor



**FOR MORE INFORMATION CONTACT:**  
**Dr. Genda Chen, Ph.D., P.E., F. ASCE**  
Robert W. Abnett Distinguished Professor of  
Civil Engineering, Missouri S&T  
Director of the INSPIRE UTC  
573-341-6114 | gchen@mst.edu

When the Fe-C coated sensor was submerged in 3.5wt.% NaCl solution, both the transmission spectrum and electrochemical impedance spectroscopy (EIS) were acquired up to 24 hours. The corrosion rate taken from the EIS tests was converted to steel mass loss over time. Fig. 5 shows the wavelength of the LPFG sensor as a function of the steel mass loss over time (normalized by the initial mass). The two straight lines in the wavelength-mass plot likely represent the chloride penetration process through Fe-C and Ag pores and the active corrosion process, respectively. The two stages could enable sensing of chloride and mass loss in application.



**Fig. 5** Calibration curve of a Fe-C coated LPFG sensor



## MICROWAVE MATERIALS CHARACTERIZATION AND IMAGING FOR STRUCTURAL HEALTH MONITORING

Microwave frequency range spans ~300 MHz to 30 GHz, corresponding to a wavelength range of 1000 mm to 10 mm. The relatively small wavelengths and large bandwidths associated with these signals make them a great candidate for inspection of construction materials and structures, and for materials characterization and imaging. Signals at these frequencies readily penetrate inside of dielectric materials and composites and interact with: (a) their materials characteristics, and (b) inner structures. Water molecule is dipolar and possesses a relatively large complex dielectric constant, which is also highly sensitive to the presence of ions that increase its electrical conductivity (i.e., chlorides) and temperature. Consequently, for the former, chemical (i.e., curing, evolution of alkali-silica gel, etc.) and physical (i.e., increased microcracking and porosity, etc.) changes in construction materials affect their complex dielectric constant. This can then be measured, and through analytical and empirical dielectric mixing formulae, be correlated to those changes. For the latter, presence of delamination in a bridge deck and pavement, permeation of moisture behind retaining walls or corrosion of reinforcing steel bars (rebar) cause changes in the structure which can then be imaged with various microwave imaging techniques. This is made possible both as a result of chemical and physical changes in the structure which interact with the interrogating signal and alter the properties of reflected signal which is then used to form images indicating these changes. One of the more critical trade-off issues in these processes is between the need for microwave signal penetration into concrete vs. frequency of operation (for characterization and imaging). Dielectric of concrete, particularly when moist, has a relatively high loss factor (i.e., it absorbs microwave energy well).

As such, lower microwave frequencies are suitable to achieve reasonable penetration. However, image resolution degrades as a function of decrease in operating frequency. Therefore, a balance

needs to be reached when using these techniques, particularly for imaging inside of cement-based materials.

Over the last 25 years significant research efforts have been expended on various aspects of this type of nondestructive testing and evaluation (NDT&E) applications. Some of the potential applications of microwaves for structural health monitoring and NDT&E include (but are not limited to):

- cure-state monitoring in cement-based materials (i.e., cement paste, mortar and concrete)
- determination of water-to-cement ratio (w/c) in fresh cement paste, water-to-cement ratio (w/c), sand-to-cement ratio (s/c) and coarse aggregate-to-cement ratio (ca/c) in hardened (cured) concrete
- detection and evaluation of chloride added to the mixing water of cement-based materials
- detection of cyclical chloride ingress in cement-based materials
- detection and sizing of delamination between FRP composites and cement-based materials such as CFRP-strengthened bridge concrete bridge members
- detection of alkali-silica (ASR) gel development and progression
- high-resolution synthetic aperture radar (SAR) imaging of corroded steel rebar



### FOR MORE INFORMATION CONTACT:

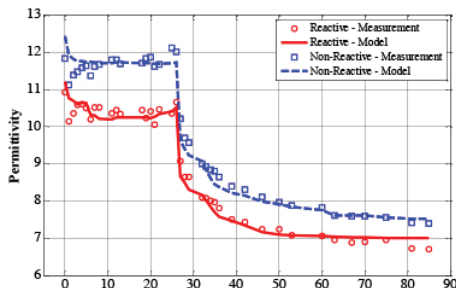
**Dr. Reza Zoughi**

Applied Microwave Nondestructive Testing Laboratory  
Electrical and Computer Engineering Department  
Missouri University of Science & Technology  
Rolla, Mo. 64509

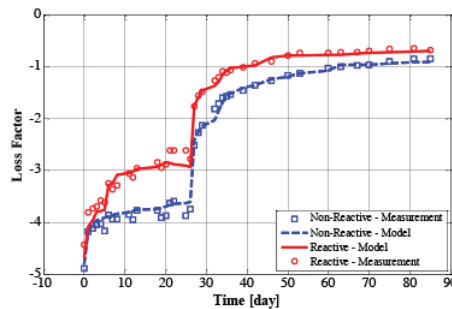
(573) 341-4656 | [zoughi@mst.edu](mailto:zoughi@mst.edu) | <http://amntl.mst.edu/>

In addition, currently there are imaging techniques that enable high-resolution, real-time and on site imaging of cement-based structures for several critical applications. Recent advances in developing these imaging technologies have resulted in systems that are founded on synthetic aperture radar (SAR) imaging approaches and are capable of producing high-resolution 3D images of interior of objects in real-time and the system can be configured in several different ways to accommodate inspection of relatively large structures (i.e., planar (2D) or linear (1D) imaging arrays). Although these imaging systems were not originally developed for inspection of cement-based structures, their key design parameters may be modified to accommodate the requirements of such applications. Several examples of applications of microwave materials characterization and imaging are provided below, along with a list of pertinent and illustrative examples of research in this broad area.

### Measured and modeled dielectric constants

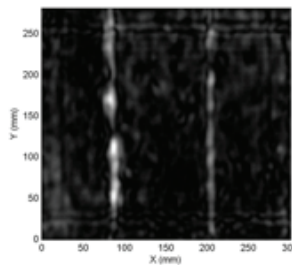


a. permittivity of ASR-reactive and non-reactive samples

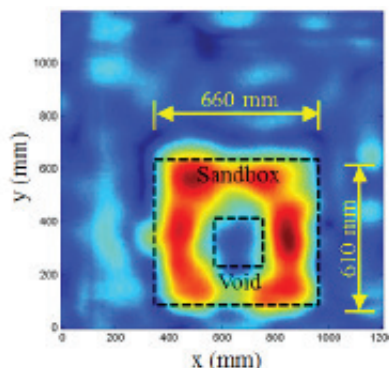


b. loss factor of ASR-reactive and non-reactive samples

Typical microwave image of a concrete specimen with corroded steel rebar.



A sample of retaining wall with a sandbox behind the wall and image slice of back surface with a piece of foam (127 mm × 127 mm × 51 mm) placed in the sandbox.



### RELEVANT REFERENCES

1. Mehdipour, I., R. Zoughi and K. Khayat, "Feasibility of using Near-Field Microwave Reflectometry for Monitoring Autogenous Crack Healing in Cementitious Materials," *Cement and Concrete Composites*, vol. 85, pp. 161-173, 2018.
2. Hashemi, A., K.E. Kurtis, K.M. Donnell and R. Zoughi, "Empirical Multiphase Dielectric Mixing Model for Cement-Based Materials Containing Alkali-Silica Reaction (ASR) Gel," *IEEE Transactions on Instrumentation and Measurement*, vol. 66, no. 9, pp. 2428-2436, September 2017.
3. Mehdipour, I., M. Horst, R. Zoughi and K. Khayat, "Use of Near-Field Microwave Reflectometry to Evaluate Steel Fiber Distribution in Cement-Based Mortars," *Journal of Materials in Civil Engineering (ASCE)*, March 2017 (DOI: 10.1061/ (ASCE) MT.1943-5533.0001850).
4. Bao, Y., M.T. Ghasr, K. Ying, G. Chen and R. Zoughi, "Microwave Synthetic Aperture Radar (SAR) Imaging for Nondestructive Evaluation of Mechanically Stabilized Earth Walls," *Materials Evaluation*, vol. 75, no. 2, pp. 177-184, February 2017.
5. Rashidi, M., M. Knapp, A. Hashemi, J.Y. Kim, K.M. Donnell, R. Zoughi, L. Jacobs and K.E. Kurtis, "Detecting Alkali-Silica Reaction: A Multi-Physics Approach," *Cement and Concrete Composites*, vol. 73, pp. 123-135, October 2016.
6. Ghasr, M.T., Y. LePape, D.B. Scott, and R. Zoughi, "Holographical Microwave Imaging of Corroded Steel Bars in Concrete," *American Concrete Institute (ACI) Materials Journal*, vol. 112, no. 1, pp. 115-124, January 2015.
7. Zoughi, R., M.T. Ghasr, J.S. Popovics and S. Ham, "Comparison of Frequency-Modulated Continuous-Wave (FM-CW) Radar and Impact-Echo Data for Detecting Delamination in Concrete Bridge Decks," *Proceedings of the 40th Annual Review of Progress in Quantitative Nondestructive Evaluation Conference, American Institute of Physics, Conference Proceedings 1581*, vol. 33A, pp. 866-871, 2014.



# HIGHLIGHTS

## Year 2 Projects

The INSPIRE UTC is committed to addressing the research needs and projected research progress outlined in the original center proposal. Both intellectual merits and broader impact to the research topics of the center were emphasized in the review process. Each project proposal went through a formal external review per the process described below. Each Year 2 project proposal was reviewed by at least one external DOT/consulting engineer and one external researcher in the proposed subject area. Every effort was made to avoid the conflict of interest during the review process.

Projects proposals were reviewed and evaluated per the following criteria. Each reviewer assigned a total score on a scale of 1 (poor) to 100 (excellent). Total scores will be based on 50% technology advances, 35% innovative solutions, and 15% relevance to the goal of the center. The technology advances pertain to understanding of the state of the art, technical soundness and feasibility of the proposed approach, capability to achieve the proposed outcomes within the proposed time frame, and expertise of the project team as applicable to the project. The innovative solutions pertain to importance of the problem addressed, practicality of the proposed solution, and advantages of the proposed solution over existing technologies.

Review results were submitted to the INSPIRE UTC Program Coordinator and funding recommendations were made during an executive meeting with INSPIRE UTC directors and External Advisory Committee members in Dec. 2017. Following completion of this review process, the INSPIRE UTC Director issued final approval of the following research projects for Year 2:

INSPIRE UTC - Year 2 Projects		
Project	Principal Investigator	Co-Principal Investigators
3D Microwave Camera for Concrete Delamination and Steel Corrosion Detection	Dr. Reza Zoughi, Missouri S&T	Dr. Mohammed Tayeb Ghasr and Dr. Genda Chen
A Training Framework of Robotic Operation and Image Analysis for Decision-Making in Bridge Inspection and Preservation	Dr. Ruwen Qin, Missouri S&T	Dr. Genda Chen, Dr. Suzanna Long, Dr. Zhaozheng Yin, and Dr. Sushil Louis
Autonomous Wall-climbing Robots for Inspection and Maintenance of Concrete Bridges	Dr. Jizhong Xiao, The City College of New York	Dr. Anil Agrawal, and Dr. Hung La
Battery-free Antenna Sensors for Strain and Crack Monitoring of Bridge Structures	Dr. Yang Wang, Georgia Institute of Technology	Dr. Reza Zoughi and Dr. Genda Chen
Bridge Resilience Assessment with INSPIRE Data	Dr. Iris Tien, Georgia Institute of Technology	Dr. Reginald DesRoches, and Dr. Genda Chen
Climbing Robots with Automated Deployment of Sensors and NDE Devices for Steel Bridge Inspection	Dr. Hung La, University of Nevada, Reno	Dr. Sushil Louis, Dr. Paul Oh, Dr. Jizhong Xiao, and Dr. Anil Agrawal
Developing a Robotic Simulator and Video Games for Professional and Public Training	Dr. Sushil Louis, University of Nevada, Reno	Dr. Hung La, Dr. Ruwen Qin, and Dr. Suzanna Long
Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces	Dr. Genda Chen, Missouri S&T	Dr. Hongyan Ma, Dr. Zhaozheng Yin, and Dr. Reza Zoughi
Mobile-manipulating UAVs for Sensor Installation, Bridge Inspection and Maintenance	Dr. Paul Oh, University of Nevada, Las Vegas	Dr. Hung La, and Dr. Genda Chen
In-line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications	Dr. Genda Chen, Missouri S&T	Dr. Yang Wang
Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems	Dr. Anil Agrawal, The City University of New York	Dr. Jizhong Xiao, Dr. Genda Chen, and Dr. George Hearn
UAV-enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring	Dr. Genda Chen, Missouri S&T	Dr. Yang Wang

## Year 1 Stats

### RESEARCH AND EDUCATION

**12** COLLABORATIVE PROJECTS funded between multiple institutions

STUDENTS involved in INSPIRE research projects FUNDED by the grant **17**

**6** DOCTORAL STUDENTS supported

NEW COURSES offered with transportation components **4**

### OUTREACH STATS

**13** CONTACT HOURS of outreach, reaching 87 PARTICIPANTS, covering 3 STATES

### TECH TRANSFER

**11,900** viewers/subscribers/contacts/partners

### PUBLISHING

PUBLICATIONS/PRODUCTS by INSPIRE researchers **39**

**3,000+** Publication CITATIONS among researchers

## INSPIRE UTC Webinars



### Lab-on-Sensor for Structural Behavior Monitoring: Theory and Applications

**Presented:** Sept. 28, 2017

**Speaker:** **Dr. Genda Chen**, Ph.D., P.E., F. ASCE, F. SEI  
Missouri University of Science and Technology  
Professor and Robert W. Abnett Distinguished  
Chair in Civil Engineering  
Director, System and Process Assessment  
Research Laboratory (SPAR Lab)  
Director, INSPIRE University Transportation Center  
Associate Director, Mid-America  
Transportation Center (MATC)  
Email: [gchen@mst.edu](mailto:gchen@mst.edu)  
<http://web.mst.edu/~gchen/>  
**Online:** [http://scholarsmine.mst.edu/inspire\\_webinars/](http://scholarsmine.mst.edu/inspire_webinars/)  
<http://inspire-utc.mst.edu/webinars/>

In this presentation, the design and operation characteristics of highway bridges are first reviewed to establish the needs for structural behavior monitoring in order to align monitoring outcomes with daily practices in bridge preservation. The responses of steel- and concrete-grider bridges to earthquake/tsunami events and the deterioration of aging bridges are then introduced to demonstrate the types of structural limits to prevent through monitoring. Next, a lab-on-sensor design theory is presented and applied to detect and assess structural behaviors such as cracking, foundation scour, and steel corrosion.



### Drone-Enabled Remote Sensing for Transportation Infrastructure Assessment

**Presented:** Dec. 13, 2017

**Speaker:** **Colin Brooks**, MEM  
Michigan Technical University  
Senior Research Scientist  
Environmental, Transportation and  
Decision Support Lab  
Michigan Tech Research Institute (MTRI)  
Email: [cnbrooks@mtu.edu](mailto:cnbrooks@mtu.edu)  
Website: [www.mtri.org](http://www.mtri.org)  
**Online:** [http://scholarsmine.mst.edu/inspire\\_webinars/](http://scholarsmine.mst.edu/inspire_webinars/)  
<http://inspire-utc.mst.edu/webinars/>

In this presentation, recent applied research led by a Michigan Technological University team is reviewed, with a focus on bridge condition assessment and corridor monitoring. Examples of 3D optical, thermal, and LiDAR data are shown and how analysis methods result in usable information to meet pressing data needs. Finding spalls and delaminations, characterizing cracking, inventory of roadway assets, and related applications will be shown. Achievable resolutions and accuracies will be reviewed and how these data are transformed into asset condition data.

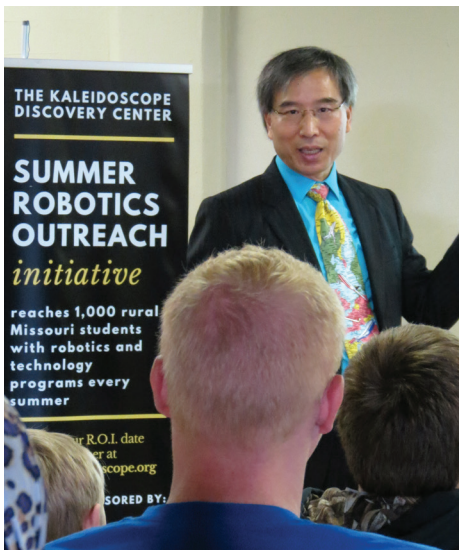
## UNIVERSITY OF NEVADA, RENO VR/AR MEET-UP

The University of Nevada, Reno, introduced 3D simulation and virtual reality technologies during a VR/AR Meet-up event ([https://events.unr.edu/event/vrar\\_meet-up](https://events.unr.edu/event/vrar_meet-up)). These advanced technologies were applied into automated infrastructure inspection research with the goal of transforming the current holistic visual inspection approach into a data-driven decision process in bridge and tunnel management.

## KALEIDOSCOPE DISCOVERY CENTER PRESENTATIONS

In October, **Dr. Genda Chen**, Director of INSPIRE UTC, presented information to the FIRST Lego League (FLL) robotics team and the FLL Junior robotics team at the Kaleidoscope Discovery Center in Rolla, Mo. The presentation was part of the KDC's Saturday seminar series. Approximately 30 students ranging in ages 6-14 and their parents attended.

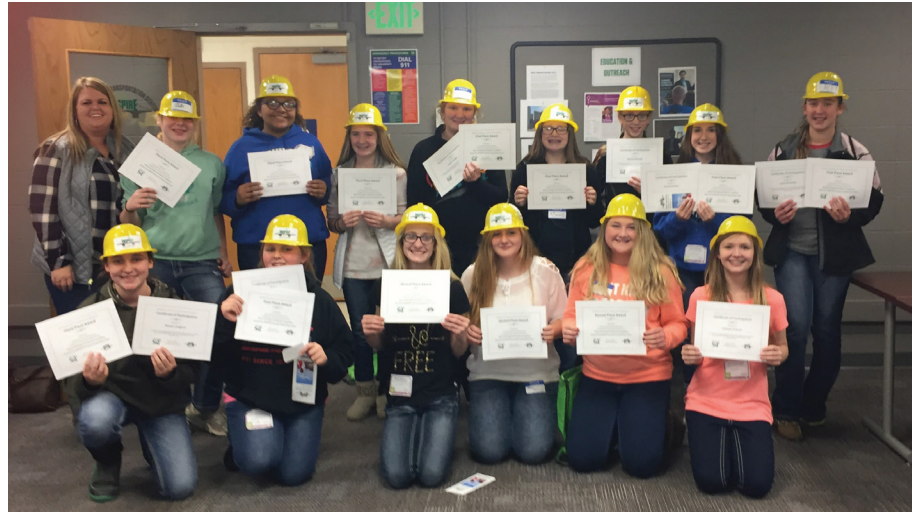
The KDC's mission is to provide opportunities that advance the understanding and appreciation of engineering, science, technology, the environment, arts and math (ESTEAM); through hands-on learning experiences, which inspire everyone to imagine, explore and create a better world.



Dr. Chen's presentation introduced to the FLL teams to the challenges associated with current bridge inspection methods, and the importance of improving these methods through the use of the advanced technologies currently being developed by the INSPIRE UTC, such as non-contact sensing, unmanned aerial vehicles and climbing robots used for bridge inspection and maintenance.

For more information visit the KDC at <https://thekaleidoscope.org> and the INSPIRE UTC at <http://inspire-utc.mst.edu>.

## Expanding Your Horizons Conference Workshop



On November 17, 2017, the INSPIRE UTC hosted a transportation-related robotics workshop on the Missouri S&T campus in Rolla, Mo. The workshop, titled "Rescue the Bridge with Robotics" was part of the 2017 Expanding Your Horizons (EYH) Conference.

The EYH conference is an annual conference for 7th and 8th grade girls. It is designed to help participants better understand some of the career choices they can explore in S.T.E.M. (Science, Technology, Engineering and Mathematics) areas. "EYH is a unique opportunity for S&T to make young girls aware of the new opportunities in S.T.E.M. and how they can make a positive impact on solving tomorrow's world challenges.", says **Dr. Anthony Petroy**, Vice Provost for Global Learning at Missouri S&T.

The INSPIRE UTC workshop introduced 30 young female students to the transportation industry in a memorable and fun way. Participants learned that traditional methods used to inspect and maintain bridges are time consuming and costly or even dangerous in some cases. They learned how to use advanced technology to perform inspections and make the process safer and more efficient.

The workshop was presented by **Dr. Ruwen Qin**, associate professor in engineering management and systems engineering; **Dr. Grace Yan**, assistant professor in civil, architectural, and environmental engineering, **Hongya Qu**, a Ph.D. student in civil, architectural, and environmental engineering, and **Amy Gillman**, program coordinator for INSPIRE UTC.



For more information visit:  
<http://pce.mst.edu/youth/eyh/>  
<http://inspire-utc.mst.edu/>





## Missouri State Future City Competition

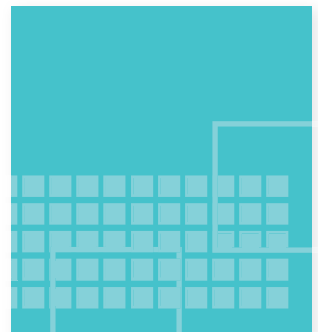
The INSPIRE UTC participated in the Missouri State Future City Competition, hosted by the Kaleidoscope Discovery Center in Rolla, Mo., and Future City Competition-Missouri. The event was held Saturday, Jan. 13, 2018 in Butler-Carlton Civil Engineering Hall on the Missouri S&T campus. The event was free and open to the public.

Future City is a cross-curricular, educational program that gives students the opportunity to do what engineers do — identify problems; brainstorm ideas; design solutions; test; retest and build; and share their results. Future City is an engaging way to build 21st century skills in 6th, 7th and 8th grade students allowing them to imagine, research, design and build cities of the future that showcase their solution to a citywide sustainability issues. The theme was the Age-Friendly City. Teams identified an age-related challenge that exists in today's urban environments and engineered two innovative solutions to the challenge.

The INSPIRE UTC's participation in this event helped to raise awareness among participants, ages 11-14, of UTC activities and the advanced technologies that could be used to help preserve our nation's aging transportation infrastructure.



**For more information visit the following websites:**  
<https://www.facebook.com/kaleidoscopediscoverycenter/>  
<https://futurecity.org/>





## INSPIRE University Transportation Center

Missouri University of Science and Technology  
500 W. 16th St., 112 Engineering Research Lab  
Rolla, MO 65409

### Connect with us.

Phone: 573-341-6114 | Email: [inspire-utc@mst.edu](mailto:inspire-utc@mst.edu)



### FREE INSPIRE UTC WEBINAR

Microwave Materials Characterization and Imaging for Structural Health Monitoring  
**Speaker: Dr. Reza Zoughi, Missouri S&T**  
**11 a.m.-noon Central Time, March 15, 2018**

The relatively small wavelengths and large bandwidths associated with microwave signals make them great candidates for inspection of construction materials and structures, and for materials characterization and imaging. In this webinar, issues related to concrete materials property evaluation and high-resolution imaging will be discussed, and examples will be provided.

**Register online:**

<http://inspire-utc.mst.edu/webinars/>

### SMT and NDT-CE 2018 CONFERENCE

NDE/NDT for Highway and Bridges  
**Aug. 27-29, 2018, New Brunswick, NJ**

This joint conference is where international researchers, manufacturers, service providers, owners of structures and those active in training, validation and standardization of nondestructive evaluation for civil infrastructure will discuss state-of-the-art, as well as innovative NDE technologies, advanced modeling and best practices.

**Abstract submissions due:** April 1, 2018.

**For more information go online:**

[https://www.asnt.org/MajorSiteSections/Events/Upcoming\\_Events/Bridges\\_2018.aspx](https://www.asnt.org/MajorSiteSections/Events/Upcoming_Events/Bridges_2018.aspx)

[inspire-utc.mst.edu](http://inspire-utc.mst.edu)