

Semi-Annual Progress Report for University Transportation Centers

Reporting Period [April 1, 2024 – September 30, 2024]

- **Federal Agency and Organization Element to which Report is Submitted**
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- **Project Title:** University Transportation Center for Railway Safety (UTCRS) – Tier 1 Center
- **Center Director Name, Title and Contact Information**
Constantine Tarawneh, Ph.D., Louis A. Beecherl, Jr. Endowed Professor of Engineering,
Email: constantine.tarawneh@utrgv.edu; Phone (956) 665-2607; Mobile (956) 867-5907
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The University of Texas Rio Grande Valley (UTRGV)
1201 West University Drive, Edinburg, TX 78539-2999
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- **Signature of Submitting Official**

Constantine L.

Constantine Tarawneh, Ph.D., Louis A Beecherl, Jr. Endowed Professor of Engineering
Director, University Transportation Center for Railway Safety (UTCRS)

1. ACCOMPLISHMENTS

1.1 What are the major goals of the program?

The UTCRS will develop knowledge, diverse human resources, and innovative technology in support of the Infrastructure Investment and Jobs Act (IIJA) research priority of promoting safety of railway transportation systems. The center will engage and focus its partners' established expertise and leverage and expand their existing resources to establish comprehensive programs of rail research, education, technology transfer and implementation, workforce development, and community outreach.

The UTCRS aims to reduce the number of accidents and equipment failures in rail transportation systems, leading to reduced fatalities and injuries. Economic losses to stakeholders will be reduced by improving the safety and durability of rail transportation infrastructure. This will be accomplished through the development of new technologies and materials, condition monitoring, remote sensing, asset management, performance management, and construction methodologies.

The UTCRS will ensure the relevance of its work to the US rail industry by working in continuous consultation with an External Advisory Board of industry leaders, and by seeking collaborations with Class I railroads, local railroads, rail equipment manufacturers, labor unions, and state and federal agencies.

For this third reporting period, our major goals were:

- Complete the review and approval of proposals for the second year of research projects
- Complete execution of seventeen (17) first year projects
 - Present research in journal and conference publications and to industrial partners
 - Complete final project reports and enter into TRID
- Initiate work on twenty (20) second year research projects
 - Prepare Exhibit D for each project and enter into the Research in Progress (RIP) database
- Educate students and develop technical workforce
 - Hire undergraduate and graduate students for 20 research projects
 - Conduct a summer Bridge to Engineering program with local community college partner
 - Arrange summer research and internship experiences for high school and undergraduate students
 - Offer courses in transportation related subjects
 - Offer transportation seminars and workshops by industry and government experts
- Engage the community in rail related activities
 - Conduct 2024 UTCRS STEM Summer Camps, STEM Teacher Workshop, and RET Program
 - Provide consultation for industry and government agencies
- Seek, expand, and develop opportunities for collaboration and technology transfer
 - Engage with new partners including labor organizations and corporations
 - Work to convert research results into new patent applications
- Host the 2024 Council of University Transportation Centers (CUTC) Summer Meeting
 - Coordinate with CUTC leadership and USDoT staff
 - Finalize program, registration, venue, tours, and logistics

1.2 What was accomplished under these goals?

A summary of our accomplishments is in the following table:

Table 1 – Accomplishments During the Reporting Period		
Administrative	Status	% Complete
Hold regular meetings of the Executive Committee	Complete	100%
Review of twenty (20) 2024CY research proposals by External Advisory Board	Complete	100%
Final review and approval of 2024CY proposals by UTCRS Director	Complete	100%
2024CY subawards to consortium institutions	Complete	100%

Submission of Exhibit D for each project and entry into RIP database		Complete	100%
Collect final research reports for 2023CY projects		In progress	94%
Entry of final reports into TRID database		Initiated	6%
Hosted 2024 CUTC Summer Meeting with 133 attendees		Complete	100%
Research & Technology Transfer		Status	% Complete
Completed work on seventeen (17) UTCRS-funded research projects for 2023-2024. Further details in Section 1.2.2 Research Projects and Section 4 Outcomes		Complete	100%
14 new conference and journal publications were accepted and/or published		Complete	100%
15 conference and journal publications previously reported as submitted are now accepted and/or published		Complete	100%
25 students and 12 faculty co-authored papers for the 2024 ASME Joint Rail Conference (JRC)		Complete	100%
Organized and sponsored a Student Poster Session at the 2024 ASME JRC to highlight the research of the undergraduate and graduate students of the UTCRS		Complete	100%
Development of a new rail anchor slip test system	Test rig construction	Complete	100%
	Regular data production runs	Ongoing	75%
Development of new lateral loading capability for single bearing test rig		In progress	50%
Endurance testing of reconditioned bearings (MxV Rail funded)		Ongoing	50%
Performance testing of inactive bearings (CSX, NTSB, and MxV Rail collaboration)		Ongoing	67%
Evaluation of onboard condition monitoring systems for commercial applications. (Hum Industrial Technologies, Inc. funded)		Ongoing	50%
Online models for lubricant remaining service life and bearing vibration and temperature thresholds available on UTCRS website, open public access		Completed	100%
Public database of bearing test data, automatically updated from testers	Hardware Acquisition/Development	Completed	100%
	Software Development	In progress	50%
Continued existing agreements for cooperation with industry partners including MxV Rail, CSX Transportation, BNSF, ENSCO, Inc., RSAE Labs, and Hum		Ongoing	80%
Submitted major collaborative proposal to FRA CRISI program to integrate UTCRS-developed onboard sensing technologies in railroad operations. Lead is Brotherhood of Railroad Signalmen (BRS), and partners are ENSCO, Inc., and Hum		Approved	100%
Education & Workforce Development		Status	% Complete
Supported 100 graduate/undergraduate students involved in UTCRS activities		Complete	100%
Center-affiliated faculty taught 15 undergraduate and 10 graduate courses in transportation-related subjects, enrolling at least 528 students in 2023-2024		Ongoing	70%
Arranged 2024 summer transportation internships (MxV Rail) for 5 students		Completed	100%
Arranged 2024 summer research experiences (REU) for 5 undergraduates		Completed	100%
Arranged 2024 summer internships for 5 High School students at the UTCRS		Completed	100%
Engagement & Outreach		Status	% Complete
UTCRS 2024 Summer Camps with 1183 K-12 students (717 Elementary, 344 Middle School, and 122 High School)		Completed	100%
UTCRS 2024 Research Experiences for Teachers (RET) with 12 participants		Completed	100%
Preparations for the 2025 UTCRS STEM Summer Camps and Teacher Workshop		Ongoing	15%
Onsite visits to UTCRS facilities by personnel from USDoT, FRA, NSF, NTSB, BNSF, Hum, CSX, Rio Valley Switching Company (RVSC) – Short line, MxV Rail		Completed	100%
UTCRS Website updates		Ongoing	95%

1.2.1 New FRA Sponsored Collaboration

In 2024, UTCRS partnered with the Brotherhood of Railroad Signalmen (BRS), Hum Industrial Technologies, Inc. (Hum), and ENSCO, Inc., to propose a major effort to integrate onboard sensing into railroad

operations. This includes performance testing against existing wayside technologies at the Transportation Technology Center (TTC) test track operated by ENSCO, Inc., development of new communication capabilities for onboard sensors, integration of onboard sensors into positive train control (PTC) systems and automated warning systems, and training of rail industry professionals on installation and operation. The project has been approved for funding through the Federal Rail Administration CRISI program, for a total of \$9.7 million of which the UTCRS portion is \$4 million. Formal funding begins in January 2025, but technical and planning meetings and equipment acquisition are already underway.

1.2.2 Advisory Board

UTCRS established an External Advisory Board (EAB) that gives direction to our research and operations. They review all research proposals, and have taken an active role in suggesting new research topics and revising the focus of existing ones. Three of the new 2024CY projects originated at least in part from the EAB: the study of inactive bearings, the rail anchor slip testing, and the upcoming field validation of onboard sensors in direct comparison with wayside detectors.

In 2024, we added two additional members to the board. Mr. Joey Rhine is a mechanical subject matter expert and investigator for the National Transportation Safety Board (NTSB). He has previous experience with the US Navy, Union Pacific railroad, and the Federal Railroad Administration. Mr. Quinn Norman, Vice President – Headquarters for the BRS also joined our EAB. The BRS is a labor organization that manages over 10,000 rail employees in North America. The full membership of the advisory board is:

- Kari L. Gonzales (chair), President and CEO of MxV Rail
- Kim Bowling, Director of Wayside Diagnostics, CSX Transportation
- Alan E. Caligari, President and CEO, MERMEC, Inc.
- Gary Fry, Vice President, Fry Technical Services
- Amy Hamilton, Principal Engineer, Trinity Industries
- Joey Rhine, Investigator and subject matter specialist, NTSB
- R. Quinn Norman, Vice President – Headquarters, Brotherhood of Railroad Signalmen (BRS)

1.2.3 UTCRS Sponsored Research Projects

Twenty (20) new research projects have been selected for 2024CY. The 2024CY project titles with links to project descriptions are given in Table 3. Exhibit D project descriptions are posted on the UTCRS website (<https://www.utrgv.edu/railwaysafety/research/index.htm>). A record of completed 2023CY projects is available at the same link.

Nine projects have industrial partners providing technical support, access to data, or in-kind contributions of equipment or samples. Eleven early-career academic professionals (assistant professors, lecturers, and research fellows) are PIs or co-PIs on ten different funded projects for 2024CY.

Table 2 – New 2024CY Research Projects funded by UTCRS

1.	(Infrastructure) Advanced Model for Predicting Buckling in Rails https://www.utrgv.edu/railwaysafety/files/documents/research/infrastructure/exhibit-d-utcrs-tamu-rail-buckling-proposal-allen-2024.pdf
2.	(Infrastructure) Computational Model for Predicting Fracture in Rails Subjected to Long-Term Cyclic Fatigue Loading https://www.utrgv.edu/railwaysafety/files/documents/research/infrastructure/exhibit-d-utcrs-tamu-modeling-rail-cracking-allen-2024.pdf
3.	(Infrastructure) Continuously Welded Rail Longitudinal Resistance Modeling https://www.utrgv.edu/railwaysafety/files/documents/research/infrastructure/exhibit-d-utcrs-utrgv-cwr-longitudinal-resistance-modeling-zhou-2024.pdf
4.	(Infrastructure) Experimental Determination of Crack Growth in Rails Subjected to Long-Term Cyclic Fatigue Loading https://www.utrgv.edu/railwaysafety/files/documents/research/infrastructure/exhibit-d-utcrs-tamu-experimental-crack-growth-allen-2024.pdf

5. (Infrastructure) Experimental Determination of Track Friction Coefficients https://www.utrgv.edu/railwaysafety/ files/documents/research/infrastructure/exhibit-d utcrs tamu track friction coefficients cordes 2024.pdf
6. (Infrastructure) Temperature Effects on Rail Anchor Slip Force https://www.utrgv.edu/railwaysafety/ files/documents/research/infrastructure/exhibit-d utcrs utrgv temperature effects on rail anchor slip force rahmaninezhad 2024.pdf
7. (Infrastructure) Rapid Detection of Track Changes from Onboard Data Acquisition Records: Year 2 https://www.utrgv.edu/railwaysafety/ files/documents/research/infrastructure/exhibit-d utcrs usc track stiffness detection rizados 2024.pdf
8. (Mechanical) Development of a Multi-Resonant Impact-Driven Energy Harvester (MRI-DEH) for Electrification of Rural Rail Crossings https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs utrgv impact driven energy harvester amjadian 2024.pdf
9. (Mechanical) Effect of Long-Term Inactivity on Railcar Bearing Lubricant Performance https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs utrgv inactive railroad bearing lubricant performance jones 2024.pdf
10. (Mechanical) FAST® Loop Comparison of Onboard Condition Monitoring Versus Wayside Detection Systems https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs utrgv field test onboard vs wayside foltz 2024.pdf
11. (Mechanical) Lateral Load Effect on Railway Tapered Roller Bearing Performance https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs utrgv lateral load effects on railway bearing performance fuentes 2024.pdf
12. (Mechanical) Non-Contact Energy Harvesting for Rural Grade Crossings – Year 2 https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs unl energy harvesting turner 2024.pdf
13. (Mechanical) Track Intrusion Detection and Track Integrity Evaluation: Year 2 https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs usc track intrusion detection and track integrity evaluation qian 2024.pdf
14. (Mechanical) Ultrasonic Inspection of Reconditioned Railroad Bearing Components – Year 2 https://www.utrgv.edu/railwaysafety/ files/documents/research/mechanical/exhibit-d utcrs unl ultrasonic bearing inspection turner 2024.pdf
15. (Operations) Enhanced Datasets and AI Models for Monitoring of Grade Crossings https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs utrgv grade crossing ai models ali 2024.pdf
16. (Operations) Federated Learning for Railway Safety Analysis and Prediction https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs utrgv federated learning for railway safety prediction xu 2024.pdf
17. (Operations) Intelligent Aerial Drones for Traversability Assessment of Railroad Tracks: Year 2 https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs usc intelligent drones for track traversability assessment vitzilaos 2024.pdf
18. (Operations) Non-Motorist Safety at Highway-Rail Grade Crossings: Developing a Crash Prediction Model with Integrated Non-Motorist Exposure https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs unl rail crossing safety khattak 2024.pdf
19. (Operations) Optimizing Emergency Response: Intelligent Routing Decision Support System for First Responders at Rail Crossings https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs usc optimizing emergency response chen 2024.pdf
20. (Operations) Towards Building a Foundation AI Model for Railway Safety https://www.utrgv.edu/railwaysafety/ files/documents/research/operations/exhibit-d utcrs ucr foundation ai model for railway safety 2024.pdf

1.2.4 Student Researchers and B²E Program

The performance indicator tables associated with the report show the number of student researchers employed at the UTCRS during the reporting period. A total of 83 students were employed from federal and matching funds. This includes 14 students (7 in 2023 and 7 in 2024) students in the Bridge to Engineering (B²E) Program. Additionally, the UTCRS provided 5 High School students the opportunity to engage in a summer research internship opportunity working alongside students and faculty at UTRGV.

Table 3 – Student Researchers Employed at UTCRS		
Student Researcher Classification	From All Sources	Federal Funds
Undergraduate Research Assistants	50	33
Masters’ Research Assistants	15	11
Doctoral Research Assistants	18	16
Totals	83	60

1.2.5 CUTC Summer Meeting

UTCRC hosted the 2024 Council of University Transportation Centers Summer meeting, held in South Padre Island, TX on June 10-12, 2024. The event was attended by 133 individuals representing transportation centers, USDOT staff, and guest speakers/panelists from industry and government.

Meeting Webpage Link: <https://www.utrgv.edu/railwaysafety/technology/2024-cutc/index.htm>

Meeting Picture Gallery: <https://railwayportfolio.myportfolio.com/cutc-2024>

1.3 How have the results been disseminated?

1.3.1 Professional Community

Publications: For the professional community, the primary dissemination is through publications. During this reporting cycle, we have published 19 conference papers and presentations and 4 journal papers, and submitted three more journal papers that are currently under review. A list of all publications is given in Table 5. UTCRS had a large presence at the 2024 ASME Joint Rail Conference and is preparing for a similar showing at the International Heavy Haul Association (IHHA) conference in 2025 with 17 abstracts submitted by UTCRS faculty and students.

Memberships: UTCRS personnel have been actively engaged in technical committees, panels, and industry organizations. The following list is cumulative since June 2023:

- Dr. Constantine Tarawneh testified before the National Transportation Safety Board (NTSB) at the East Palestine hearings, specifically representing UTCRS as an expert on bearing-related train derailments and wayside detection systems (<https://www.nts.gov/news/events/Pages/East-Palestine-Hearing-Event.aspx>). He was the University Outreach Chair for the 2024 ASME Joint Rail Conference and also Chair of the Rail Safety and Security Track Session. He served as: (1) a member of the TRB Railroad Operating Technologies Committee (AR030), (2) a member of the Council of University Transportation Centers (CUTC) Executive Committee, (3) one of the four Directors of the Research and Education Division (RED) within the American Road and Transportation Builders Association (ARTBA), (4) campus manager for the Dwight David Eisenhower Transportation Fellowship Program (DDETFP) Local Competition held at UTRGV annually, and (5) member of the CUTC Student Awards Selection Committee. He was a Guest Editor of a special issue for the Journal of Sustainability entitled “Sustainable Study of Railway Engineering and Rail Transportation.” https://www.mdpi.com/journal/sustainability/special_issues/3UDYW6JUXR

- Dr. Dimitris Rizos was Chair of the 2024 Joint Rail Conference. He is also (1) a TRB AR050 member, (2) member of AREMA Committee 24 Education and Training, (3) Academic Co-Chair of the REES 2024 Executive Committee, and (4) Academic Editor of the Journal of Advances in Civil Engineering
- Dr. Yu Qian is on Technical Committee (TC) 202, International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) and is part of the AAR Substructure Technical Advisory Group (TAG). He is Communication Coordinator for TRB committee AR060. He was Organizing Committee Chair for the 2024 GeoShanghai International Conference, member of the Technical Committee of the 7th International Conference on Transportation Infrastructure and Materials, and is Associate Editor for Smart and Resilient Transportation, as well as a member of several editorial boards.
- Dr. Nikolaos Vitzilaios was Program Chair for the 2024 International Conference on Unmanned Aircraft Systems, and is on the Board of Directors, South Carolina interagency Drone Users Consortium
- Dr. Vagelis Papalexakis is co-editor-in-chief or associate editor for multiple journals. Dr. Papalexakis was also co-Chair for the 2024 SIAM International Conference on Data Mining (SDM) 2024, and co-Chair for 2024 IEEE Data Science and Advanced Analytics (DSAA).

1.3.2 General Community

UTCRS reaches the general community through news media, online presence, campus events, and direct contacts.

- Dr. Tarawneh gave expert interviews with numerous local, regional, national, and international media outlets on the East Palestine incident, again specifically representing UTCRS. Some of these outlets included [CNN](#), [Washington Post](#), [Bloomberg News](#), [trains.com](#), [Pittsburg Post-Gazette](#), [FREIGHTWAVES](#), [JURIST](#), [MEAWW.COM](#), [Ideastream Public Media](#), [Akron Beacon Journal](#), as well as news segments with [Scripps News Morning Rush](#), and [Bloomberg Markets: The Close](#) (watch starting time frame 31:30 into the show).
- The Federal Railroad Administration (FRA) issued a [Safety Advisory 2023-01; Evaluation of Policies and Procedures Related to the Use and Maintenance of Hot Bearing Wayside Detectors](#), featuring one of the journal articles published by a UTCRS research team led by Dr. Tarawneh.
- UTRGV published a story on FRA Administrator Amit Bose's visit during the 2024 UTCRS STEM Summer Camps Closing Ceremony where he delivered the keynote speech: <https://www.utrgv.edu/newsroom/2024/08/2/head-of-federal-railroad-administration-visits-utrgv-summer-camps.htm>
- The McAllen Monitor published a [feature article](#) on Gary Montelongo, who was working for UTCRS as a high-school intern. More details are provided in Sections 4 of this report.
- The McAllen Monitor published a [feature article](#) on how UTRGV's railway safety center has inspired students over the past decade. The story was published in two parts reaching a wide audience.
- The UTCRS website has photos (<https://www.utrgv.edu/railwaysafety/news/gallery/index.htm>) and news, particularly about K-12 events such as UTCRS STEM Summer Camps and teacher workshops, awards received by UTCRS students, and trips such as the annual TRB meeting. Our main website (<https://www.utrgv.edu/railwaysafety/>) gives a more in-depth look intended for both professionals and the general public.

1.4 What do you plan to do during the next reporting period to accomplish the goals?

Our objectives for the next reporting period (October 1, 2024 – March 31, 2025) include:

- **Administrative**
 - Meet all USDOT and UTC reporting requirements
 - Release a Call for Proposals for 2025CY UTCRS Research Projects
 - Receive, process, and present 2025CY project proposals to Advisory Board

- Attend January 2025 CUTC winter meeting
- Roll out beta version of public access to our data
- Work with other universities and FRA to organize an annual Rail Conference that brings together academia, federal and state agencies, rail industry, and workforce organizations
- **Research**
 - Continue work on approved 2024CY research projects
 - Continue to engage with industrial partners and engage in technology transfer. Our largest new project is the FRA CRISI-funded collaboration mentioned in Section 1.2.2
 - Submit manuscripts for journal and conference publications
 - Use expanded UTCRS facilities to improve service to industry and increase pace of research
- **Education and Workforce Development**
 - Employ and train undergraduate and graduate student researchers
 - Continue offering students opportunities to take on professional responsibilities by directly interacting with industry partners of the UTCRS
 - Offer transportation-related courses for the Fall 2024 and Spring 2025 semesters
 - Recruit students for the 2025 Bridge to Engineering (B2E) program
- **Engagement and Outreach**
 - Contact school districts for early registration for 2025 UTCRS STEM Summer Camps
 - Build on our existing relationships with rail labor organizations

Our strategies to ensure the accomplishment of these objectives include the following:

- Hold regular (at least monthly) meetings of the Executive Committee
- Hold regular (at least twice per year) meetings with our External Advisory Board
- Hold bi-weekly meetings of faculty with research students to provide guidance
- Have students present at bi-weekly meetings to build confidence and professionalism
- Make sure faculty and students are aware of conference deadlines and other opportunities to publish and present their work to peers and industry professionals
- Make sure all PIs are aware of reporting and data management requirements
- Solicit more industry projects in which students can engage with engineering professionals
- Give students leadership roles in mentoring and outreach
- Create a productive, collaborative work environment where initiative by young researchers is encouraged, facilities are accessible, and adequate resources are available
- Respond promptly to inquiries from school districts and community partners

2. PARTICIPANTS AND COLLABORATING INSTITUTIONS

2.1 What organizations have been involved as partners?

Table 4 – Participants and Collaborating Institutions	
Organization and Location	Contribution
University of Texas Rio Grande Valley (UTRGV) Edinburg, TX	Consortium Institution and Project Lead Extensive facilities for railway research with a focus on railcar bearings and sensors. Financial and in-kind support for eight research projects totaling \$410,957
University of South Carolina (USC) Columbia, SC	Consortium Institution Extensive facilities for railway research with a focus on infrastructure inspection. Financial and in-kind support for four research projects totaling \$111,191

University of Nebraska – Lincoln (UNL) Lincoln, NE	Consortium Institution Extensive facilities for railway research with a focus on intelligent transportation systems. Financial and in-kind support for three research projects totaling \$147,500
Texas A&M University (TAMU) College Station, TX	Consortium Institution Extensive railway research facilities at the Center for Infrastructure Renewal (TAMU-CIR). Financial and in-kind support for four research projects totaling \$241,203
University of California Riverside (UCR) Riverside, CA	Consortium Institution Computing facilities made available for UTCRS research include a Lambda Vector Server with three NVIDIA RTX A6000 GPUs. Financial and in-kind support for one research project totaling \$47,500
South Texas College (STC) McAllen, TX	Consortium Institution STC operates the UTCRS Bridge to Engineering (B2E) program, including recruitment, selection, and orientation prior to transfer
MxV Rail Pueblo, CO	Industry Collaborator Technical support and consultation for UTCRS research projects, including the rail buckling and rail fatigue modeling projects at TAMU, as well as the rail anchor slip force testing and next generation onboard sensor development at UTRGV. MxV Rail will make railcars available for UTCRS instrumentation and host UTCRS student researchers at their Pueblo facility (in-kind cost share)
Transportation Technology Center (TTC) Operated by ENSCO, Inc. Pueblo, CO	FRA Testing Facility – Industry Collaborator ENSCO, Inc., is a partner on the newly funded FRA CRISI award. They will facilitate testing of new technologies in their TTC facility
Hum Industrial Technology, Inc. St. Louis, MO	Industry Sponsor Hum Industrial financially sponsors onboard sensor research carried out at UTCRS. They also provide in-kind contribution of their wireless sensors and gateways, and Hum technical personnel provide onsite technical support and collaboration at UTRGV
CSX Transportation Jacksonville, FL	Industry Collaborator CSX is a primary partner for the inactive rail bearing study. They will locate and provide UTCRS with bearings that have experienced long periods of inaction and/or unusual weather conditions
BNSF Railway Fort Worth, TX	Industry Collaborator BNSF is our main partner and inspiration for the rail anchor slip measurement project. They provide technical support and consultation and will supply samples and materials for testing (in-kind cost share)
The Timken Company North Canton, OH	Industry Collaborator Timken is a partner in the inactive rail bearing study and will identify and provide samples as well as ensure that testing protocols adhere to bearing manufacturer standards and Association of American Railroad (AAR) guidelines
Rio Valley Switching Company (RVSC) McAllen, TX	Industry Collaborator RVSC will provide access to their grade crossings in support of the AI-enabled vibration sensor project
RSAE Labs Panama City, FL	Industry Sponsor RSAE Labs has contracted the UTCRS to perform a study of available rolling stock condition monitoring systems currently in use and requirements for onboard sensor communication

Brotherhood of Railroad Signalmen (BRS) Front Royal, Virginia	Labor Organization Collaborator BRS represents over 10,000 technical professionals working on railway signals, including hazard detection and positive train control. BRS and UTCRS are collaborating on an FRA CRISI funded project to develop and integrate our technologies into the existing railway signals framework
National Transportation Safety Board (NTSB) Washington, DC	Government Agency Collaborator NTSB is the driver for the inactive bearing study that is investigating the effects of long periods of inactivity on bearing performance
Schaeffler Group Fort Mill, SC	Industry Sponsor Schaeffler financially sponsors AAR certification tests conducted at UTCRS on our bearing test rigs
Vanguard Academy Edinburg, TX	Community Collaborator Vanguard Academy has been participating in the annual UTCRS STEM Summer Camps for over 7 years. UTCRS also runs a 3-day solar car competition for middle school students every Fall and Spring semester
Region One Education Service Center Edinburg, TX	Community Collaborator The Region One Education Service Center assists school districts in South Texas. UTCRS works with Region One to develop teacher training programs and workshops
IDEA Public Schools Weslaco, TX	Community Collaborator IDEA Public Schools participate in the annual UTCRS STEM Camps
La Joya Independent School District La Joya, TX	Community Collaborator La Joya ISD participates in the annual UTCRS STEM Summer Camps
Weslaco Independent School District Weslaco, TX	Community Collaborator Weslaco ISD participates in the annual UTCRS STEM Camps
Pharr-San Juan-Alamo ISD Pharr, San Juan, Alamo, TX	Community Collaborator PSJA ISD participates in the annual UTCRS STEM Summer Camps
Monte Alto ISD Monte Alto, TX	Community Collaborator Monte Alto ISD participates in the annual UTCRS STEM Camps
Valley View ISD Pharr, TX	Community Collaborator Valley View ISD participates in the annual UTCRS STEM Camps
Edcouch-Elsa ISD Edcouch, Elsa, TX	Community Collaborator Edcouch-Elsa ISD participates in the annual UTCRS STEM Camps
Sharyland ISD Mission, TX	Community Collaborator Sharyland ISD participates in the annual UTCRS STEM Camps
La Feria ISD La Feria, TX	Community Collaborator La Feria ISD participates in the annual UTCRS STEM Summer Camps
Los Fresnos CISD Los Fresnos, TX	Community Collaborator Los Fresnos CISD participates in the annual UTCRS STEM Camps
Mercedes ISD Mercedes, TX	Community Collaborator Mercedes ISD participates in the annual UTCRS STEM Camps
Progreso ISD Progreso, TX	Community Collaborator Progreso ISD participates in the annual UTCRS STEM Camps

3. OUTPUTS

3.1 Publications, conference papers, and presentations

A list of journal and conference submissions and publications during the current reporting period is given in Table 5. For completeness, this is a cumulative list that shows the progress of publications through the stages of submission, revision, acceptance, and publication. A UTCRS focus for 2024-2025 submissions will

be the joint conference sponsored by the International Heavy Haul Association (IHHA) and World Congress on Railway Research (WCRR) to be held in 2025 in Colorado Springs, CO, in November 2025.

Table 5 – Journal and Conference Publications			
Citation	Type	Status at Last Report	Status in Current Report
1. BL Gedney, R Naseri, S Al Kharousi and DC Rizos (2024) “B-Spline signature responses in structural change detection: method development” Structural Health Monitoring. https://doi.org/10.1177/14759217241265444	Journal	Under revision	Published
2. S Byrraju, DC Rizos, M Sutton, N Li (2024) “Enhancing Railway Safety Through Satellite-Based Monitoring for Rockfall Potential” ASME/IEEE Joint Rail Conference 87776, V001T01A003	Conference	Accepted	Published
3. BL Gedney, R Naseri, DC Rizos (2024), “Investigating the Use of B-Spline Signature Responses to Detect Internal Rail Defects” ASME/IEEE Joint Rail Conference 87776, V001T01A006	Conference	Accepted	Published
4. R Naseri, BL Gedney, H Asgari, DC Rizos (2024), “A Hybrid Rail Surface Spot Irregularities (RSSI) Detection Algorithm Based on Onboard Measurements” ASME/IEEE Joint Rail Conference 87776, V001T01A010	Conference	Accepted	Published
5. DC Rizos, B Stinson, C Penna, B Gedney, R Naseri (2024) “Performance of a Mobile, Non-Contacting, Reference-Free Prototype System for RNT and Rail Stress Measurements” ASME/IEEE Joint Rail Conference 87776, V001T01A012	Conference	Accepted	Published
6. Lewandowski, K. & Vitzilaios, N. (2024). UAV-Based Railroad Line Detection. Proceedings of the 2024 ASME/IEEE Joint Rail Conference (JRC2024), May 13-15, Columbia SC, USA.	Conference	Accepted	Published
7. E. Villalobos, H. Lugo, B. Cheng, M. Gutierrez, C. Tarawneh, P. Xu, J. Chen, and E. E. Papalexakis, “Spectral Clustering in Railway Crossing Accidents Analysis,” 2024 ASME Joint Rail Conference; V001T05A011; https://doi.org/10.1115/JRC2024-130028	Conference	Accepted	Published
8. E. Villalobos, C. Tarawneh, J. Chen, E. E. Papalexakis, and P. Xu, “Kernel Ridge Regression in Predicting Railway Crossing Accidents,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A013; https://doi.org/10.1115/JRC2024-130036	Conference	Accepted	Published
9. C. Tarawneh, A. Martinez, M. Adame, S. Garcia, J. Pams, C. Pena, “Healthy and Defective Railroad Tapered Roller Bearing Temperature Metrics,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A007; https://doi.org/10.1115/JRC2024-128512	Conference	Accepted	Published
10. D. Capitanachi, G. De Leon, C. Rodriguez, C. Tarawneh, H. Foltz, “Powering Onboard Bearing Health Monitoring Sensor with Thermoelectric Generators Under Non-Uniform Temperatures,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A006; https://doi.org/10.1115/JRC2024-125943	Conference	Accepted	Published
11. A.D.S. Trinidad, S. Gutierrez, C. Pena, D. Aguila, C. Tarawneh, “Experimental Investigation of Lateral Loading Effects on the	Conference	Accepted	Published

Railway Tapered Roller Bearings Performance,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A008 https://doi.org/10.1115/JRC2024-129462			
12. K. Quaye, P. Xu, D. Dera, H. Foltz, C. Tarawneh, A. Diaz, “Feature Extraction from Vibration Signatures Acquired from Railroad Bearing Onboard Condition Monitoring Sensor Modules,” 2024 ASME Joint Rail Conference. JRC 2024; V001T01A013; https://doi.org/10.1115/JRC2024-130045	Conference	Accepted	Published
13. S. Saberi, G. Whetstone, and D.H. Allen, “Multiscale Computational Modeling of Subsurface Cracking in Railhead: Insights into Fatigue Life”, ASME 2024 Joint Rail Conference. JRC 2024; V001T05A002; https://doi.org/10.1115/JRC2024-122412	Conference Presentation	Accepted	Published
14. C. Tarawneh, B. Wilson, B. Porter, L. Cantu, “Historical Implications of Wayside Detector Systems and their Ability to Detect Hot Bearing Derailments,” 2024 ASME Joint Rail Conference. JRC 2024; V001T07A002 https://doi.org/10.1115/JRC2024-125389	Conference	Accepted	Published
15. J. Rodriguez, S. Zhou, C. Tarawneh, T. Salazar-Flores, H. Gorabi, S.M. Rahmaninezhad, “Development of Rail Anchor Testing Through Literature Review of CWR Buckling Resistance Evaluation,” 2024 ASME Joint Rail Conference, JRC 2024; V001T01A002; https://doi.org/10.1115/JRC2024-122151	Conference	Accepted	Published
16. J. Pams, C. Tarawneh, J. Montoya, B. Wilson, L. Cantu, H. Alkhaldi, “Railroad Track and Wheel Defect Detection with Onboard Condition Monitoring System,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A009; https://doi.org/10.1115/JRC2024-129911	Conference	Accepted	Published
17. D. Espinoza, G. Ali, C. Tarawneh, “AI-Based Hazard Detection for Railway Crossings,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A004; https://doi.org/10.1115/JRC2024-124640	Conference	Accepted	Published
18. J. Pams, C. Tarawneh, D. Rocha, B. Wilson, L. Cantu, H. Alkhaldi, A. Diaz, “Optimized Vibration-Based Health Metrics for Freight Rail Bearings,” 2024 ASME Joint Rail Conference. JRC 2024; V001T05A010; https://doi.org/10.1115/JRC2024-129917	Conference	Accepted	Published
19. M. Amjadian, Md M. Rahman, C. Tarawneh, V. Villarreal, D. Rocha, "AI-Enabled Vibration Sensing System for Early Detection of Trains at Active Highway-Rail Grade Crossings", 2024 ASME Joint Rail Conference. JRC 2024; V001T01A008 https://doi.org/10.1115/JRC2024-124517	Conference	Accepted	Published
20. Long, S., Yang, T., Qian, Y., Wu, Y. V, Xu, F., Tang, Q., and Guo, F G. (2024) “GPR Imagery Based Internal Defect Evaluation System for Railroad Tunnel Lining Using Real-time Instance Segmentation” IEEE Sensor Journal. IF = 4.325 https://doi.org/10.1109/JSEN.2024.3456093	Journal	N/A	Published
21. Wu, Y.V, Meng, F., Qin, Y., Qian, Y.*, Liu, Z., Geng, Y., and Zhao, W. (2024) “Automated anomaly detection of catenary split pins using unsupervised learning” Automation in	Journal	N/A	Published

Construction, IF = 10.517 https://doi.org/10.1016/j.autcon.2024.105589			
22. Tang, Y.G, Wang, Y. and Qian, Y.*(2024), " Railroad missing components detection via cascade region-based convolutional neural network with predefined proposal templates " Computer-Aided Civil and Infrastructure Engineering. IF = 9.6 (https://doi/epdf/10.1111/mice.13279)	Journal	N/A	Published
23. D. Ahn, U. Singh Saini, E. E. Papalexakis, A. Payani, "Neural Additive Tensor Decomposition for Sparse Tensors," 33rd ACM International Conference on Information and Knowledge Management (CIKM), Boise, Idaho, Oct. 2024.	Conference	N/A	Accepted
24. Lewandowski, K. & Vitzilaios, N. (2024). UAV-Based Railway Tracking and Following. IEEE Transactions on Intelligent Transportation Systems.	Journal	N/A	Submitted
25. R. Naseri, B. Gedney, H. Asgari, and DC Rizos (2024) "A Hybrid Signal Processing Approach for Rail Surface Irregularity Detection Using Onboard Axle Box Acceleration Sensors" Structural Health Monitoring", Mechanical Systems and Signal Processing	Journal	N/A	Submitted
26. S. Byraju, D.C. Rizos, MA Sutton, and N. Li (2024) "A Site Classification System for the Implementation of Multi-Temporal SAR for Geohazard Initiation Potential on the Railway Right of Way", Transportation Research Record: Journal of the Transportation Research Board	Journal	N/A	Submitted

3.2 Website(s) or other internet site(s)

3.2.1 Main Website

The main UTCRS website is located at: <https://www.utrgv.edu/railwaysafety/>. The UTCRS website is intended to reflect the full spectrum of research, education, workforce development, technology transfer, outreach activities, trainings, and student opportunities and programs available at UTCRS. During this reporting period, the following changes were made to the website:

- New online calculators: a bearing lubricant model and a bearing temperature and vibration model
- Updated list of publications
- Updated list of projects
- Updated personnel section
- Updated photo galleries with several hundred pictures
- Updated links to news media items about UTCRS
- Updated STEM Curricula available for K-12 teachers nationwide to download and use

UTCRS is committed to rolling out a publicly accessible portal through which data streams from our bearing testers are automatically posted in near-real time (24 hours or less from time of acquisition). The progress toward this goal during this reporting period included: conversion of the data acquisition systems for compatibility with real time data streaming; real time remote video monitoring for each bearing tester; acquisition of 10TB NAS storage to serve as the primary archive; and a beta version of software to automate data transfer from testers to database.

3.2.4 Facebook Page

UTCRS maintains a Facebook page (<https://www.facebook.com/utcrailwaysafety/>) with news and photographs, particularly about summer camps and other outreach events. It is intended to engage a more general audience of students and parents.

3.3 Technologies or techniques

Many of the publications listed in Section 3.1 propose or evaluate new technologies and techniques applicable to railway safety. These include:

- a neural network that can identify missing rail components,
- an ultrasonic method to inspect railcar bearings,
- remote sensing of track degradation from a UAV (see Figure 1),
- detection of wheel defects using an onboard sensor,
- new models for subsurface flaws in rails,
- detection of potential rockfalls from satellite imagery, and
- quantifying rail anchor slip force.

UTCRS consortium members are developing novel instruments and expanding testing capabilities. Some examples include:

- TAMU is developing two new experimental testbeds, one for evaluating nonlinear lateral track resistance, and one for uniaxial cyclic loading of rails with internal defects.
- TAMU has developed an advanced rail-ballast friction lab.
- UTRGV has completed construction of a test rig to measure rail anchor slip force (see Figure 1).
- UTRGV has completed construction of two additional four bearing testers, with associated improvements to HVAC system to maintain AAR test conditions.
- UTRGV is upgrading its test facilities to include real-time remote monitoring and automatic archiving of data.

3.4 Inventions, patent applications, and/or licenses

In the previous report, it was noted that two patent applications were filed by USC:

- Application No: 63/603,182 “Portable Railroad Grade Crossing Monitoring System”
- Application No.: 63/565,581 “Rail Surface Defect Detection from Onboard Vibration Sensors”

During this reporting period, one project PI has submitted a final project report, but asked for a temporary embargo on publication in order to explore the possibility of filing a patent application related to one of the UTCRS funded research projects exploring energy harvesting technologies.

3.5 Other products

- 7 MS theses
- 2 Doctoral dissertations
- 17 final reports from 2023CY research projects

4. OUTCOMES

4.1 Research

This section highlights outcomes from selected UTCRS projects. For complete information on research outcomes, see the Final Reports for the 2023CY projects, available at both the center website (www.utrgv.edu/utcrs) and the Transportation Research International Database (TRID).

4.1.1 On-Board Sensors

The UTCRS-UTRGV team continued their ongoing collaboration with the industry partner Hum Industrial Technology, Inc. New accomplishments for this reporting period include:

- A study of the effectiveness of reduced size thermoelectric generators to power onboard sensors. Our industrial partners have changed their design strategy based on UTCRS results.

- A preliminary study of how indexing of bearing cups with respect to the adapter affects the RMS vibration produced by outer raceway defects. This study is important because it will lead to more accurate thresholds for detecting such defects.
- Experimental results on alternate accelerometers for onboard sensing. This study has the potential to lead to significant (months to years) improvement in sensor battery life.
- New designs for a load sensor that can be embedded in bearing adapter pads. This work has already resulted in improved repeatability and accuracy.

In addition to its work with Hum, UTCRS is conducting its own research into next generation onboard sensors. The focus of this work is to produce a flexible but compact (see Figure 1) modular system that can be used to evaluate new sensing techniques. New accomplishments during this reporting period are:

- Completed hardware prototypes for main sensor board, two different communication daughterboards, and an energy harvesting board.
- A wired (but battery operated and compact) signal processing and data acquisition board suitable for demonstration of enhanced vibration sampling. This system is on schedule for Spring 2025 field tests at facilities such as MxV FAST™ loop or ENSCO's TTC test track.

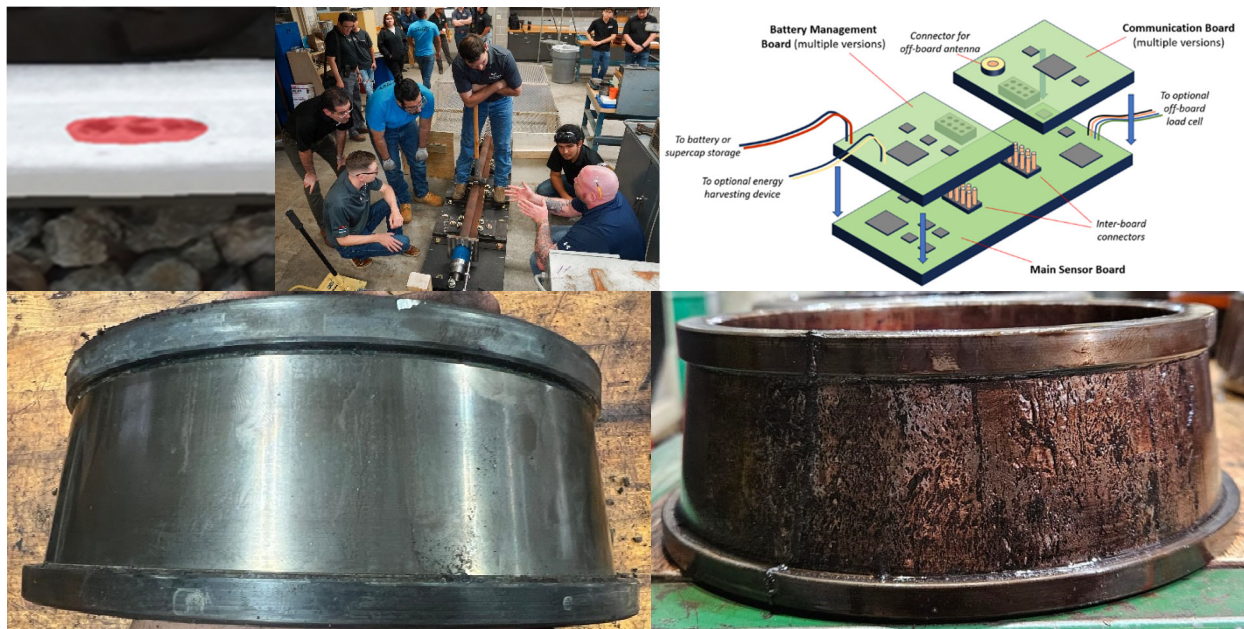


Figure 1: UTCRS Research Highlights. Upper Row: Automatic highlighting of rail defects from a UAV; rail anchor slip testing; modular onboard sensing testbed. (Second row): Comparison of normal and damaged bearing raceways from UTCRS study of inactive bearings.

4.1.2 Bearing Testing

UTCRS continues to produce results with significant industry impact in our ongoing bearing test programs. Some of the experiments are funded directly with USDOT funds, and others are funded by industry partners and research collaborators. New results include:

- Additional cycles of the MxV sponsored test of reconditioned bearings. While ongoing, this work has already led to new industry recommendations that disqualify bearings with closely spaced defects from being reconditioned.
- Completion of the first round of UTCRS sponsored test of inactive bearings suggested by NTSB and conducted in collaboration with CSX Transportation. While the sample size was small, one of the first two bearings failed under testing, and post-inspection showed large-scale spalling (see Figure 1Error! Reference source not found.). The results showed that more testing is warranted

and that temperature readings alone do not reflect damage level. A full report can be found on the UTCRS website and on TRID.

4.1.3 Rail Anchor Slip Force Testing

Rail anchor slip force measurement is being conducted in collaboration with engineers from BNSF and MxV Rail. One major objective is to determine the effects of repeated load cycling and re-application on anchor performance. The findings show how anchor effectiveness lessens with successive re-application of the anchor beyond 15 times. The slip testing complements other theoretical and experimental work being performed at UTCRS consortium universities that seek to model rail buckling.

4.1.4 Applications of Artificial Intelligence (AI) in Rail Safety

Artificial intelligence, specifically deep learning through convolution neural network architectures has potential for monitoring grade crossings and identifying potential hazards like vehicles, pedestrians, animals, warning signals, and the status of safety arms. These models require large data sets for learning. UTCRS researchers have harvested images taken from real time video feeds, trained models to identify hazards, and developed new techniques for federated machine learning that can make identification more effective without compromising proprietary data.

4.2 Education, Workforce Development, and Community Engagement

UTCRS continues to offer a wide variety of education, workforce development, and community engagement activities including:

- Regular college courses in transportation-related topics
- On-campus seminars and workshops by visiting industry professionals
- Training students through on-campus jobs as transportation research assistants
- Industry Internships and Research Experiences for Undergraduates (REU)
- Bridge to Engineering (B2E) Program for students from South Texas College (STC)
- High School summer research internships
- STEM summer camps for K-12 students
- Workshops for K-12 teachers to train them on UTCRS developed STEM curricula
- Research Experiences for Teachers (RET)

4.2.1 Transportation-Related College Courses Offered

For the April-September 2024 period, UTCRS-affiliated faculty reported teaching:

- University of Nebraska Lincoln: 1 undergraduate course, 1 graduate course.
- Texas A&M University: 2 undergraduate courses, 2 graduate courses.
- University of South Carolina: 8 undergraduate courses, 6 graduate courses.
- University of Texas Rio Grande Valley: 4 undergraduate courses, 1 graduate course.

4.2.2 Industry Workshops and Seminars

UTCRS-UTRGV has offered several on-campus workshops and seminars open to students and faculty that featured industry experts. These include:

- Kim Bolling (CSX) and Amy Hamilton (Trinity Rail) speaking on their perspectives on working in the rail industry.
- Ryan Medlin and Charity Duran (BNSF) and Stephen Wilk (MxV Rail) offered a classroom seminar on rail buckling and two laboratory workshops on rail anchor installation and measurements.
- Joey Rhine, Gregory Scott, Matthew Thompson, and David Rodriguez (NTSB) offered a seminar on their work investigating rail accidents.
- Jeremy Farr (BRS) offered a seminar on the role of labor organizations in implementing effective safety practices in the rail industry.

4.2.3 Student Employment as Researchers

During the current reporting period alone, UTCRS engaged 83 undergraduate and graduate students in research. This includes students supported directly from federal funding, as well as students supported through non-federal cost share and industry-sponsored projects at the center.

Most research projects had industry partners, giving the students direct connections with working engineers. The students gain technical experience that is rarely found in new college graduates. For example, student employees at UTCRS have taken primary responsibility for professional-level tasks for our industrial sponsors including:

- Conducting bearing durability and accelerated life tests to AAR standards.
- Evaluating energy harvesting systems for commercial field deployment.
- Conducting tests of inactive and reconditioned bearings.
- Bearing teardowns and inspections including preparation of technical reports.
- Monitoring of incoming data streams from on-board sensors on Class I railroads.

Some further facts about UTCRS student researchers:

- Since June 2023, there have been more than 80 instances in which UTCRS student researchers have authored or co-authored journal or conference publications.
- UTCRS-UTRGV student researchers are about one-third female and about 90% Hispanic.
- All UTCRS-UTRGV researchers supported by federal funds are US citizens or permanent residents.



Figure 2: UTCRS-UTRGV team composed of 24 students and 4 faculty attended the 2024 ASME/IEEE Joint Rail Conference and presented 12 papers and 20 research posters. Overall, 45 UTCRS students and faculty attended this conference.

4.2.4 Internships and REUs

Each summer UTCRS facilitates the selection of UTRGV undergraduate student participants in a Research Experience for Undergraduates (REU). Each consortium partner (UNL, USC, TAMU, and UCR) hosts two students and engages them in a 10-week research intensive experience working on UTCRS synergistic projects between UTRGV and the consortium partners. After completion, students return to UTRGV where all are offered the opportunity to continue working at the UTCRS, often in collaboration with the faculty at the consortium partners.

In Summer 2024, UTCRS sent five undergraduate students from UTRGV to work at MxV Rail in Pueblo, Colorado. UTCRS recruited applicants and supplied financial support; MxV Rail made the final selection of interns and assigned them to projects. Additionally, two UTRGV undergraduate students were recruited to go to TAMU for a 10-week REU. Both students elected to pursue their master's studies upon completion of their REU. One student was admitted to an engineering master's program at TAMU working for UTCRS faculty and the other is pursuing his master's at UTRGV.



Figure 3: UTCRS-UTRGV undergraduate students spent 10-weeks at MxV Rail as part of a hands-on research training internship.

4.2.5 Bridge to Engineering (B2E) Program

In Summer 2023 and Summer 2024, the UTCRS hosted seven and eight students, respectively, making the transition from a two-year pre-engineering program at South Texas College (STC) to upper-level engineering at UTRGV. They received research employment, mentoring, and tuition support. This program has been highly successful, with all fifteen of the students progressing toward their degrees, and all continuing employment with the center.

4.2.6 High School Interns

In Summer 2024, the UTCRS hosted five High School Interns, who are assigned to existing teams of college-level student researchers. One of them, Gary Montelongo, was a finalist (one of only thirty nationwide) in the Society of Science Thermo Fisher Scientific Junior Innovators Challenge. A feature article about him was published in the McAllen Monitor (<https://myrgv.com/local-news/2024/10/18/reaching-for-the-stars-la-joya-isd-student-joins-top-young-scientists-in-the-nation/>). Gary was one of only five winners in the Junior Innovators Challenge and received a \$10,000 award for his work on train suspensions systems.

4.2.7 STEM Summer Camps

Our largest community engagement activity is the UTCRS Railway Safety Summer Camp, held every summer during the month of June. The Summer 2024 camp hosted:

- 1183 K-12 students total of whom 47% were female and 91% were Hispanic
- 717 elementary students (48% female)
- 344 middle school students (43% female)
- 122 high school students (51% female)

The camps were held over a four-week period in June. The students, all from school districts in the Rio Grande Valley, participated in specially designed educational, week-long STEM camps related to transportation engineering with a strong focus on engineering design, programming, robotics, and sensor technologies. The camps foster a culture of teamwork and confidence building in all activities.

4.2.8 K-12 STEM Teacher Workshop and Research Experiences for Teachers (RET)

The teachers who participated in the summer camps were trained beforehand during a teacher workshop organized and run by UTCRS-UTRGV faculty and staff. These summer camps and teacher workshops have

been increasing awareness of the value of our transportation system and have been linked to a significant increase in student enrollment in the college of engineering and computer science.

The UTCRS hosted 12 K-12 STEM teachers participating in our 5-week RET research and training program. The teachers develop grade-appropriate curricula for elementary, middle school, and high school grades with the assistance of UTCRS-UTRGV faculty and students. The 2024 developed curricula have been posted on the UTCRS website and have been formatted for dissemination.



Figure 4: (Top) UTCRS STEM Summer Camps; (Bottom) FRA Administrator Amit Bose was keynote speaker for closing ceremony

5. IMPACTS

5.1 What is the impact on the effectiveness of the transportation system?

As stated in Section 1, the UTCRS goal is to reduce the number of accidents and equipment failures experienced in rail transportation systems. The projects supported are intended to address a wide variety of safety issues including collisions at grade crossings and on the rail right-of-way, track movement and damage, and bearing and wheel failure. The long-term impact will be a reduction in injuries, fewer service stoppages, and more cost-effective maintenance. Most of our projects are ongoing, but even at this early stage, a number of advances can be identified:

- Reconditioned bearing reliability: UTCRS results presented to the AAR, Class I railroads, and reconditioning facilities have already confirmed that reconditioned bearings with no visually apparent defects can have subsurface defects leading directly to early failure. This work will lead to adoption of new techniques and guidelines to determine bearing suitability for reconditioning.

- Inactive bearing reliability: Early results have identified instances of contaminated or clearly separated lubricant, seal ring failure, ejection of lubricant, rapid progression of defects.
- Experimental data on the holding force of rail anchors, which was a missing factor in rail buckling models.
- Longer sensor life: UTCRS work with industry has led to reductions of power consumption and extended battery life.
- Increased workforce pool: More than 50 students have received direct, hands-on training in rail specific skills like bearing assembly, disassembly, testing and inspection; mounting bearings on axles; mining databases of onboard sensor data to identify potential failures; and data analysis.

5.2 What is the impact of technology transfer on industry and government entities, on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

The UTCRS is currently working on two projects that are of great interest to the NTSB as they relate to the ongoing investigation concerning the East Palestine, OH train derailment. One of the UTCRS projects is investigating the effect of long periods of inactivity on railroad bearings in service, and the other is investigating the efficacy and performance of reconditioned bearings. The results of both projects contributed to the investigation report that was prepared by the NTSB. These projects bring together NTSB with rail industry partners MxV Rail and Timken, a Class I Railroad (CSX Transportation), and the UTCRS. The results impact procedures used to recondition railroad bearings, and operation protocols regarding bearing inactivity in freight rail revenue service. The UTCRS is the only center performing these studies and the results are disseminated through publications, presentations, reports, seminars, webinars, and workshops.

Sensor technologies that were developed by the UTCRS during the MAP 21 UTC Competition were licensed by a start-up company, Hum Industrial Technology, Inc. Products based on UTCRS research are now in commercial service. This collaboration demonstrates how work performed at the UTCRS has led to the formation of Hum, and how workforce development efforts have been successful in placing UTCRS graduates in the rail industry, thus providing both technical and human capital.

The collaboration with Hum has transitioned to the current UTCRS UTC grant, and joint work has been ongoing to deploy sensors in a number of in-service pilot tests on railcars operated by several Class I and short line railroads. UTCRS faculty and students are engaged in sensor optimization and enhancement, development of energy harvesting systems to prolong the service life of the deployed sensors, data monitoring and analysis, and design and fabrication of next iteration of these onboard sensors. This work is expected to revolutionize the way the rail industry monitors the condition of their rolling stock by augmenting current wayside detection systems with advanced onboard technologies that will enhance the safety and reliability of rail operations. Most importantly, the new onboard technologies will result in predictive maintenance practices, thus mitigating costly and inefficient train stoppages and delays.

5.3 What is the impact on the body of scientific knowledge?

During the April-September 2024 reporting period, UTCRS personnel submitted or published papers for publication on a wide range of technical topics. Some examples are:

- Using GPR imagery to find problems in the lining of railroad tunnels.
- Using neural networks to detect missing railroad components.
- New mathematical models for cracking and buckling in railroad tracks.
- Using tensor mining to extract knowledge from rail accident reports.
- New signal processing techniques to detect rail surface irregularities.

Table 5 provides a list of scientific and technical publications by UTCRS researchers that transfer the knowledge and technology developed to the rail industry specifically, and the public in general.

5.4 What is the impact on transportation workforce development?

Since its inception, the UTCRS has engaged over 2000 undergraduate and graduate students in its various research, education, technology transfer, professional development, and community outreach activities. Students develop valuable skill-sets through hands-on projects relevant to the railroad industry, making these students workforce ready upon graduation. These students are drawn from largely Hispanic student population that is statistically underrepresented in the professional transportation field. Over a third of the UTCRS students have been female, approximately double the national average for transportation professionals.

Taking a longer-term view, the UTCRS K-12 outreach efforts are building interest in transportation careers among youth who will enter the workforce over the next 10-15 years. We already have UTCRS research assistants who participated in our earliest (2013-2014) camps as young children. These efforts are also creating a core of teachers and counselors who are aware of transportation opportunities. During Summer 2024 alone, in the current reporting period, we reached over 1183 K-12 students and 65 K-12 educators, which includes 12 teachers who participated in the UTCRS Research Experience for Teachers (RET) Program, an intensive 5-week research immersion and training.

6. CHANGES/PROBLEMS

6.1 Changes in approach and reasons for change

Proposal Review Process: As stated in previous reports, we revised the schedule and process for selecting research proposals and have implemented the new process for the 2024CY cycle of proposals. The new process aligns projects better with industry needs and allows time for more input from our External Advisory Board.

Redirected Research Project: One of the 2023CY projects, “Development of a National Track Database,” was terminated early due to infeasibility. Less than 5% of the allocated funding was spent before the decision to terminate was made, and the remainder was reallocated for a different project. Details are given in the project’s Final Report which can be downloaded from the UTCRS website.

6.2 Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report.

6.3 Changes that have a significant impact on expenditures

Nothing to report.

6.4 Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards

Nothing to report.

6.5 Change of primary performance site location from that originally proposed

Nothing to report.

7. SPECIAL REPORTING REQUIREMENTS

One project PI has submitted a final project report but asked for a temporary embargo on publication in order to explore the possibility of filing a patent application related to one of the UTCRS funded research projects exploring energy harvesting technologies. We seek permission for this request.