

Semi-Annual Progress Report for University Transportation Centers

Reporting Period [April 1, 2025 – September 30, 2025]

- **Federal Agency and Organization Element to which Report is Submitted**
United States Department of Transportation (USDOT), Office of the Assistant Secretary for Research and Technology (OST-R)
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- **Project Title:** University Transportation Center for Railway Safety (UTCRS) – Tier 1 Center
- **Center Director Name, Title and Contact Information**
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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**

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1. ACCOMPLISHMENTS

1.1 What are the major goals of the program?

The UTCRS will support the Infrastructure Investment and Jobs Act (IIJA) research priority of promoting safety of railway transportation systems by innovating new technology, providing critical data, and developing the technical workforce. The center will engage and focus its partners' established expertise and leverage and expand their existing resources to establish comprehensive programs of rail research with results that are relevant, actionable, and accessible to all stakeholders.

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 technologies and materials, condition monitoring, remote sensing, asset management, performance management, and construction methodologies.

The UTCRS will ensure that its work directly benefits 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 fifth reporting period, our major goals were:

- Select and gain approval for the third year of research projects
- Complete work on twenty (20) second year projects
 - Present research results in journal and conference publications
 - Submit reports to industry partners and sponsors
- Educate and develop technical workforce
 - Employ and supervise undergraduate and graduate students for 20 research projects
 - Offer courses in transportation related subjects
 - Offer transportation seminars and workshops by industry and government experts
- Engage the community in rail related activities
 - Run the 2025 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 existing and new partners including labor organizations and corporations
 - Expand cooperation agreements with local railroads
 - Provide testing services for industry and government agencies
 - Work to convert research results into new patent applications

1.2 What was accomplished under these goals?

A summary of our accomplishments is in Table 1, followed by a brief summary of major initiatives and activities during the reporting period. More information is given in Section 4, Outcomes, and Section 5, Impacts.

Table 1 – Accomplishments During the Reporting Period		
Administrative	Status	% Complete
Hold regular meetings of the Executive Committee	Complete	100%
Receive and Review Proposals for 2025CY projects	Complete	100%
Revise 2025CY proposals to more closely align with USDOT priority for results that can be directly transferred to stakeholders	Complete	100%
Seek approval for 2025CY projects from External Advisory Board	Complete	100%
Seek approval for 2025CY projects from USDOT	Complete	100%
Complete 2024CY final reports and submit to TRID database	In progress	75%

Research & Technology Transfer		Status	% Complete
Continued work on twenty (20) UTCRS-funded research projects for 2024-2025. Further details in Section 1.2.2 Research Projects and Section 4 Outcomes		Ongoing	85%
29 new conference and journal publications were accepted and/or published		Complete	100%
8 conference and journal publications previously reported as submitted were published.		Complete	100%
New rail anchor slip test system	Test rig upgrades	Complete	100%
	Regular data production runs	Ongoing	75%
Two (2) new static load calibration rigs for new railcar load sensors	Calibration rig construction	Complete	100%
	Regular data production runs	Ongoing	75%
Development of new lateral loading capability for single bearing test rig	Construction of lateral load attachment	Complete	100%
	Regular data production runs	Ongoing	90%
Construction of a new single bearing test rig (SBT) with advanced capabilities		In progress	20%
Construction of a new four bearing test rig (4BT) to expand capabilities		In progress	45%
Endurance testing of reconditioned bearings (MxV Rail funded)		Completed	100%
Performance testing of inactive bearings (CSX, NTSB, and MxV Rail collaboration)		Ongoing	75%
Evaluation of onboard condition monitoring systems for commercial applications. (Hum Industrial Technologies, Inc. funded)		Ongoing	75%
Public database of bearing test data, automatically updated from testers	Hardware Acquisition/Development	Completed	100%
	Software Development	Ongoing	60%
	Database Online	Completed	100%
	Continuous data uploads	Ongoing	90%
New funded project with Oak Ridge National Labs, for testing and calibration of vibration and temperature sensors (See 1.2.2 below).		First Phase Completed	100%
Pre-Award and start-up activities (planning, hiring, acquisition) for a funded FRA CRISI program to integrate UTCRS-developed onboard sensing technologies into railroad operations. (See 1.2.1 below).		Ongoing	90%
Education & Workforce Development		Status	% Complete
Supported 93 graduate/undergraduate students involved in UTCRS activities		Completed	100%
Center-affiliated faculty taught 13 undergraduate and 8 graduate courses in transportation-related subjects, enrolling at least 782 students		Completed	100%
2025 summer transportation internships (MxV Rail) for three students		Completed	100%
2025 summer transportation internships (ENSCO, TTC) for two students		Completed	100%
2025 summer research experiences (REU) for four undergraduate students		Completed	100%
2025 summer research internships for two high school students		Completed	100%
Engagement & Outreach		Status	% Complete
Conducted the 2025 UTCRS STEM Summer Camps and Teacher Workshop		Completed	100%
Onsite visits to UTCRS facilities by personnel from Class I railroads, short lines, and equipment manufacturers.		Ongoing	75%
UTCRS Website updates		Ongoing	95%

1.2.1 New FRA Sponsored Collaboration

As described in the previous reporting period, UTCRS is part of a consortium approved for funding through the Federal Rail Administration (FRA) CRISI program, for a total of \$9.7 million of which the UTCRS portion is \$4.5 million. The consortium is led by the Brotherhood of Railroad Signalmen (BRS), and includes UTCRS, Hum Industrial Technologies, Inc., and ENSCO-TTC. The goal is to integrate onboard sensing into railroad operations, including performance testing against existing wayside technologies, development of new wireless communication capabilities for onboard sensors, integration of onboard sensor data and warnings into positive train control (PTC) systems and automated warning systems, and training of rail industry

professionals on installation and operation. During the reporting period UTCRS hosted the August 25-26, 2025, kickoff meeting attended by all consortium partners, plus attendees from the FRA, and subcontractors Tidal Basin and Signal Training Solutions. During the same period, UTCRS hired full-time technical staff, purchased equipment to make field measurements on wireless system performance, and initiated component acquisition and building modifications for two new bearing test rigs to be devoted to the project.

1.2.2 New Collaboration with Oak Ridge National Laboratory (ORNL)

ORNL is developing a bearing vibration and temperature monitoring system intended for specialty railcars transporting spent nuclear fuel. In the previous reporting period, an agreement was signed with ORNL to provide benchmark testing of their system against our laboratory instrumentation. In the current reporting period, UTCRS received and installed the ORNL system and completed an initial program of measurements at varying speeds and loads. The UTCRS team is assisting ORNL in assessing and optimizing their system.

1.2.3 Expanding Capabilities and Services

UTCRS is working to upgrade our test facilities and expand services that can be offered to industry and government. During this reporting period, UTCRS:

- Built two static load rigs to pre-condition and calibrate load sensors, using industry funding.
- Built new high-powered blowers which allow us to meet AAR standards for windspeed in endurance testing of bearings.
- Added lateral loading capability to our single bearing tester (SBT). This enables accurate emulation of the forces bearings, axles, and adapters undergo when railcars go around curves.
- Started work on two new testers, one advanced SBT with improved wheel and track impact replication, and one four bearing tester (4BT) to expand capability for regular testing.
- Added a spectrum analyzer and signal generator to test wireless system performance in the rail environment.
- Did preparatory work for installation of a new 20-ft track panel provided by BNSF (Class I railroad). This new facility will enable studies of longitudinal and lateral resistance of track, ties, and ballast.

1.2.4 UTCRS Sponsored Research Projects

There were twenty (20) research projects funded for 2024CY, listed in Table 2a along with current project status. 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.

Eighteen (18) research projects for 2025CY, listed in Table 2b, have been reviewed and received final approval from USDOT. Eleven projects have industrial and/or government agency partners, and twelve early-career academic professionals are PIs or co-PIs. Selected highlights from UTCRS sponsored research are mentioned in Section 4. Problem statements and goals for each project can be found in the Exhibit D links in Tables 2a and 2b. Final reports for completed projects are available on the UTCRS website.

Table 2a – 2024CY Research Projects	Status
1. <u>(Infrastructure) Advanced Model for Predicting Buckling in Rails</u>	Completed, draft report submitted.
2. <u>(Infrastructure) Computational Model for Predicting Fracture in Rails Subjected to Long-Term Cyclic Fatigue Loading</u>	Completed, draft report submitted.
3. <u>(Infrastructure) Continuously Welded Rail Longitudinal Resistance Modeling</u>	Completed, draft report submitted.
4. <u>(Infrastructure) Experimental Determination of Crack Growth in Rails Subjected to Long-Term Cyclic Fatigue Loading</u>	Completed, draft report submitted.
5. <u>(Infrastructure) Experimental Determination of Track Friction Coefficients</u>	Completed, draft report submitted.

6. (Infrastructure) Temperature Effects on Rail Anchor Slip Force	Completed, draft report submitted.
7. (Infrastructure) Rapid Detection of Track Changes from Onboard Data Acquisition Records: Year 2	Completed, draft report submitted.
8. (Mechanical) Development of a Multi-Resonant Impact-Driven Energy Harvester (MRI-DEH) for Electrification of Rural Rail Crossings	Completed, draft report submitted.
9. (Mechanical) Effect of Long-Term Inactivity on Railcar Bearing Lubricant Performance	Completed, draft report submitted.
10. (Mechanical) FAST® Loop Comparison of Onboard Condition Monitoring Versus Wayside Detection Systems	No cost extension to 12/31/2025
11. (Mechanical) Lateral Load Effect on Railway Tapered Roller Bearing Performance	No cost extension to 12/31/2025
12. (Mechanical) Non-Contact Energy Harvesting for Rural Grade Crossings – Year 2	No cost extension to 12/31/2025
13. (Mechanical) Track Intrusion Detection and Track Integrity Evaluation: Year 2	Completed, draft report submitted.
14. (Mechanical) Ultrasonic Inspection of Reconditioned Railroad Bearing Components – Year 2	No cost extension to 12/31/2025
15. (Operations) Enhanced Datasets and AI Models for Monitoring of Grade Crossings	Completed, draft report submitted.
16. (Operations) Federated Learning for Railway Safety Analysis and Prediction	No cost extension to 12/31/2025
17. (Operations) Intelligent Aerial Drones for Traversability Assessment of Railroad Tracks: Year 2	Completed, draft report submitted.
18. (Operations) Non-Motorist Safety at Highway-Rail Grade Crossings: Developing a Crash Prediction Model with Integrated Non-Motorist Exposure	No cost extension to 12/31/2025
19. (Operations) Optimizing Emergency Response: Intelligent Routing Decision Support System for First Responders at Rail Crossings	No cost extension to 12/31/2025
20. (Operations) Towards Building a Foundation AI Model for Railway Safety	Completed, draft report submitted.

Table 2b – 2025CY Research Projects	Status
1. (Infrastructure) Advanced Model for Predicting Buckling in Rails	In progress
2. (Infrastructure) Computational Model for Predicting Fracture in Rails Subjected to Long-Term Cyclic Fatigue Loading	In progress
3. (Infrastructure) Temperature-Induced Cyclic Loading Effects on Rail Anchor Slip Force	In progress
4. (Infrastructure) Buckling and Breakage Prevention in Continuous Welded Rail (CWR) Using Improved Longitudinal Resistance Modeling Software	In progress
5. (Infrastructure) Evaluating Ballast Performance with Freeze/Thaw Cycles	In progress
6. (Infrastructure) Experimental Determination of Crack Growth in Rails Subjected to Long-Term Cyclic Fatigue Loading	In progress
7. (Infrastructure) Rapid Detection of Track Changes from In-Motion Data Acquisition Records: Lab Setup and Field Implementation - Year 3	In progress
8. (Infrastructure) Experimental Determination of Rail Fracture Properties	In progress
9. (Mechanical) Comparison of Onboard Condition Monitoring System Mounting Location for Freight Railcar Bearing Defect Detection Using Vibration Signatures	In progress
10. (Mechanical) Effect of Long-Term Inactivity on Railcar Bearing Lubricant and Seal Function	In progress
11. (Mechanical) Laboratory and Field Testing of an Impact-Driven Multi-Resonant Energy Harvester for Electrical Power Generation in Rail-Track Systems – Phase II, Year 2	In progress

12. (Mechanical) Non-Contact Energy Harvesting for Rural Grade Crossings – Year 3	In progress
13. (Mechanical) Ultrasonic Inspection of Reconditioned Railroad Bearing Components – Year 3	In progress
14. (Operations) Quantifying Traffic at Highway-Rail Grade Crossings Using Artificial Intelligence	In progress
15. (Operations) Design of Dynamic Train Crossing Estimation and Real-Time Traffic Control Systems for Grade Crossing Safety	In progress
16. (Operations) Intelligent Aerial Drones for Railroad Track Traversability Assessment, Intrusion Detection and Integrity Evaluation	In progress
17. (Operations) Multi-modal AI Agents for Railway Safety	In progress
18. (Operations) Non-Motorist Safety at Highway-Rail Grade Crossings: Developing a Crash Prediction Model with Integrated Non-Motorist Exposure – Year 3	In progress

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 36 conference and journal publications, as shown in Table 5. This list does not include eleven abstracts for the 2025 International Heavy Haul Association (IHHA) conference already reported as accepted in the previous report; these will be presented in November 2025. UTCRS is planning a major presence at the 2026 IEEE-VTS INNOVARail Conference. The center is one of the sponsoring organizations, and center researchers have submitted 25 abstracts.

Memberships: UTCRS personnel have been actively engaged in technical committees, panels, and industry organizations. The following is a list of activities during this reporting period:

- **Constantine Tarawneh (UTRGV)** served as: (1) a member of the TRB Railroad Operating Technologies Committee (AR030), (2) a member and treasurer 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, (5) member of the CUTC Student Awards Selection Committee, (6) Guest Editor of a special issue for the Journal of Sustainability, (7) Reviewer and Session Chair for the 14th World Congress on Railway Research (WCRR 2025), and (8) member of the organizing committee and technical chair for the inaugural 2026 IEEE-VTS INNOVARail Conference, which is one of the largest rail-focused conferences in North America.
- **Heinrich Foltz (UTRGV)** is Guest Editor for Applied Science special issue on “Technical Advances in Railway Systems: Condition Monitoring, Smart Control and Optimization.”
- **Dimitris Rizos (USC)** is on the technical committees AREMA 24, TRB AR060, and is the academic Co-coordinator for the AREMA Railway Engineering Education Symposium and scientific committee of the 2026 INNOVARail conference. He also served as the Academic Editor for the Journal of Advances in Civil Engineering.
- **Yu Qian (USC)** is on Technical Committee (TC) 202, International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), and the AAR Substructure Technical Advisory Group (TAG). He serves as Communication Coordinator for TRB committee AR060, Associate Editor for the Journal of Smart and Resilient Transportation, and is on the editorial boards of High-Speed Railway, Intelligent Transportation Infrastructure, and Transportation Geotechnics.
- **Nikolaos Vitzilaios (USC)** served as the General Chair for the 2025 International Conference on Unmanned Aircraft Systems (Charlotte NC, May 13-16, 2025), is on the Board of Directors of the South Carolina interagency Drone Users Consortium (SCiDUC), and is Associate Editor for the

Journal of Intelligent & Robotic Systems, IEEE Robotics and Automation Letters, and 2026 IEEE International Conference on Robotics & Automation.

- **Yuche Chen (USC)** is a member of the Editorial Board for Transportation Research Part D, serves as research coordinator for the Transportation Research Board Committee on Transportation Environment and Ecology AEP 70.
- **Evangelos Papalexakis (UCR)** served as General Chair for the 2025 SIAM International Conference on Data Mining (SDM), PhD forum co-chair for the 2025 IEEE International Conference on Data Mining (ICDM), SIAM SDM Steering Committee Chair, Logistics Chair for the 2025 IEEE International Conference on Data Science and Advanced Analytics (DSAA) Conference, and was Elsevier Big Data Research co-editor-in-chief.
- **Aemal Khattak (UNL)** is an editorial board member of the Transportation Research Board and Area Editor with the Journal of Transportation Safety and Security.
- **Joseph Turner (UNL)** serves as the Associate Technical Editor for “Research in Nondestructive Evaluation”, program committee for the American Society of Nondestructive Testing (ASNT) research symposium, member of the Council of Fellows (ASNT), ASNT Council on Emerging Technologies as Chair of Advanced Manufacturing Working Group, and a member of the Acoustical Society of America (ASA) Technical Committee for Physical Acoustics.
- **Carl Nelson (UNL)** is joint Editor in Chief of ASME Journal of Medical Devices, Associate Editor for Robotica and Mechanism & Machine Theory, conference organizing committees for Design of Medical Devices Conference and ASME IDETC, member of external advisory board for BYU-I mechanical engineering program.

1.3.2 General Community

UTCRS reaches the general community through news media, online presence, campus events, and direct contacts. The activities during the current reporting period are:

- Diego Aguila, a UTCRS graduate student who is working on development and deployment of a novel onboard load sensor, was featured in a video posted by the UTRGV College of Engineering and Computer Science <https://www.linkedin.com/feed/update/urn:li:activity:7363597149143502851/>
- Three UTCRS electrical engineering undergraduate students received **First Place** in the Circuits Competition held during the 2025 IEEE Region 5 Annual Conference and Student Competitions. <https://www.linkedin.com/feed/update/urn:li:activity:7315146400772603905/>
- 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, 2025 – March 1, 2026) include:

- **Administrative**
 - Meet all USDOT and UTC reporting requirements
 - Initiate funding and hiring for 2025CY projects
 - Attend January 2026 UTC meeting in conjunction with TRB
 - Continue cooperation with other universities to organize the 2026 INNOVARail Conference
- **Research**
 - Work on approved 2025CY research projects
 - Complete 2024CY research projects that are on no cost extension

- Continue to engage with industrial partners and engage in technology transfer. Multiple new funded initiatives and agreements are mentioned in Section 1.2.2
- Submit manuscripts for journal and conference publications
- Expand UTCRS test 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
 - Recruit and select the next cohort of undergraduate students who will be participating in summer internships with rail industry partners including Hum, MxV Rail, and ENSCO-TTC
 - Offer transportation-related courses for the Fall 2025 and Spring 2026 semesters
 - Offer webinars and workshops on railway safety technology
- **Engagement and Outreach**
 - Plan and recruit for the 2026 UTCRS STEM Summer Camps
 - Plan and recruit for the 2026 UTCRS Summer Teacher Workshops
 - Build on our existing relationships with rail labor organizations

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

- Communicate with USDOT UTC administration and respond promptly to all guidance
- Hold regular (at least monthly) meetings of the UTCRS 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 mentorship and training
- Have students present at weekly meetings with industry partners 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 including community engagement events
- Create a productive, collaborative work environment where initiative by young researchers is encouraged, facilities are accessible, and adequate resources are available
- Continue to build relationships with school districts and community partners

2. PARTICIPANTS AND COLLABORATING INSTITUTIONS

2.1 What organizations have been involved as partners?

Table 3 – 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 rolling stock and sensors. Financial and in-kind support for research projects (five in CY2023, eight in CY2024, six proposed for CY2025).
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 research projects (five in CY2023, four in CY2024, four proposed for CY2025).
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 research projects (three in CY2023, three in CY2024, three proposed for CY2025).
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 research projects (four in CY2023, four in CY2024, four proposed for CY2025).
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 each year.
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, and rail anchor and reconditioned bearing testing at UTRGV.
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 financially sponsors onboard sensor research carried out at UTCRS and provide in-kind contribution of their wireless sensors and gateways. They also facilitate technology transfer and deployment of our newly developed sensor technologies worldwide.
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 project. They provide technical support and consultation and are supplying a new section of track for an indoor testbed.
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
Ironhorse Resources and Rio Valley Switching Company (RVSC) McAllen, TX	Industry Collaborator Ironhorse Resources is the owner and operator of multiple short lines in Texas, including the RVSC. We have an agreement with Ironhorse to access RVSC facilities for testing and assessment of our sensors, energy harvesting, and grade crossing monitors.
Oak Ridge National Laboratory (ORNL) Oak Ridge, TN	Industry Sponsor ORNL has contracted with UTCRS to provide testing and calibration services for ORNL-developed vibration and temperature sensors for railcars carrying nuclear waste.
RSAE Labs Panama City, FL	Industry Sponsor

	RSAE Labs contracted with 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. This collaboration includes workforce development, trainings, and workshops for students, staff, and railroad workers.
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 and K-12 student recruitment
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
South Texas ISD Edinburg, TX	Community Collaborator South Texas ISD participates in the annual UTCRS STEM Camps
Edinburg CISD Edinburg, TX	Community Collaborator Edinburg CISD participates in the annual UTCRS STEM Camps
Donna ISD Donna, TX	Community Collaborator Donna 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 4. Note that this list only includes new publications and publications that have changed status since the last report (e.g. from accepted to published). UTCRS researchers have submitted more than 80 journal and conference publications since the start of funding in June 2023. All publications can be found on the UTCRS website at <https://www.utrgv.edu/railwaysafety/technology/index.htm>.

Citation	Type	Status In Previous Report	Status in Current Report
1. S. Ocaña, S. Flores-Osuna, G. Ali, C. Tarawneh, “Estimating highway rehabilitation projects using machine learning,” Construction Research Congress 2026, San Antonio, TX, March 18-21, 2026	Conference	N/A	Accepted
2. G. Gutierrez, G. Ali, C. Tarawneh, “Evaluating the impact of extreme temperature events on the US rail network,” Construction Research Congress 2026, San Antonio, TX, March 18-21, 2026	Conference	N/A	Accepted
3. G. Ali, S. Flores-Osuna, D. Espinoza, F. Chavez, C. Tarawneh, “Detecting hazards at rail grade crossings using computer vision and AI,” Construction Research Congress 2026, San Antonio, TX, March 18-21, 2026	Conference	N/A	Accepted
4. Md I. Monsury, A. Sanchez, M. Amjadian, C. Tarawneh, “Frequency up-conversion electromagnetic energy harvester for generating electrical power from vibration of beams under moving load,” Proc. SPIE 13432, Active and Passive Smart Structures and Integrated Systems XIX, 134321J (5 May 2025); https://doi.org/10.1117/12.3051859	Conference	N/A	Published
5. A. Maldonado, R. Salinas, H. Foltz, C. Tarawneh, “Construction of an Ultra High Frequency (UHF) Yagi-Uda Antenna for Wayside Fault Detection,” 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
6. A. Sanchez Trinidad, J. Montalvo, C. Tarawneh, A. Fuentes, “Examining the Effects of Lateral Loading on Freight Tapered Roller Bearings,” 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
7. C. Davila Hernandez, J. Montalvo, C. Tarawneh, A. Fuentes, B. Wilson, L. Cantu, “Design, Validation, and Fabrication of a Dual-Axis Dynamic Test Rig for Freight Rail Bearing Adapters,” 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
8. D. Aguila, A. Blanton, S. Luna, A. Gonzalez, C. Tarawneh, B. Wilson, “Development and Testing of an Onboard Load Sensor Embedded within Passive Steering Bearing Adapter Pads,” 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
9. S. Flores-Osuna, G. Ali, C. Tarawneh, “Traffic Tracking at Grade Crossings using AI,” 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted

10. D. Cantu, S. Martinez, C. Tarawneh, P. Xu, H. Foltz, D. Timmer, "Feature Extraction from Railroad Bearing Onboard Vibration Sensors Using Machine Learning Models," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
11. D. Hinojosa, R. Salinas, H. Foltz, C. Tarawneh, "Sub-GHz Propagation Along Freight Trains for Wireless Onboard Communications," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
12. D. Vera, J. Encinia, S. M. Rahmaninezhad, C. Tarawneh, A. Fuentes, "Temperature Effect on Rail Anchor Longitudinal Resistance," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
13. E. Cantu, S. Martinez, C. Tarawneh, J. Yang, P. Xu. "Predictive Condition Monitoring of Freight Rail Bearings: A Vibration-Based Machine Learning Approach," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
14. J. Amaro, J. Montalvo, C. Tarawneh, A. Fuentes, E. Marquez. "Implementing Finite Element Modeling to Simulate Longitudinal Resistance in Continuous Welded Rail," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
15. J. Montalvo, S. Garcia, J. Mojica, C. Tarawneh, H. Foltz. "Accelerometer Placement Effect on Measured Vibration Response of Freight Railcar Bearings," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
16. J. Taha-Tijerina, S. Cardenas, R.E. Jones, C. Tarawneh, D. Timmer, "Impact of Long-Term Inactivity on Tribological Performance of Railcar Bearings Greases," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
17. M. Abrego, K. Lopez, A. Serrano, M. Adame, C. Tarawneh, R. Jones, "Effects of Prolonged Inactivity on Railcar Bearing Performance," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
18. R. A. Palacios Jr., C. Tarawneh, H. Foltz, B. Wilson, "Integration of Solar Energy Harvesting on Wireless Onboard Condition Monitoring Systems for Long-Term Power Sustainability," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
19. R. Avila, R. Salinas, H. Foltz, C. Tarawneh, B. Wilson, "A Comparative Study of Analog and Digital Accelerometers: Performance, Signal Integrity, and Application Suitability for the Rail Industry," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
20. S. Flores-Osuna, G. Ali, C. Tarawneh, "Addressing Label Scarcity in Hazard Detection at Rail Grade Crossings using AI," 2026 IEEE INNOVARail Conference, Champaign, IL, May 26-28, 2026	Conference	N/A	Abstract Accepted
21. T. Sucin, N. Vitzilaios, D. Rizos, "Vision-Based UAV Navigation for Autonomous Railway Inspection," 2026 IEEE INNOVARail Conference, Champaign, IL, USA, May 26-28, 2026	Conference	N/A	Abstract Accepted
22. J. Chen and E. E. Papalexakis, "Project or Factorize? A case study of Multiview CCA and PARAFAC2 tensor factorization," Proc. of Asilomar Conf. on Signals, Systems, and Computers. Pacific Grove, CA, Oct. 2024	Conference	N/A	Published

23. Y. Luo, H. Patel, Y. Fu, D. Ahn, J. Chen, Y. Dong, E. E. Papalexakis, "TRAWL: Tensor Reduced and Approximated Weights for Large Language Models," Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD) Special Sessions: Data Science: Foundations and Applications (DSFA), Sydney Australia, June 2025	Conference	Accepted	Published
24. D. Ahn, J. G. Jang, E. E. Papalexakis, "Improving Group Fairness in Tensor Completion via Imbalance Mitigating Entity Augmentation," Pacific-Asia Conference on Knowledge Discovery and Data Mining. Singapore: Springer Nature Singapore, June 2025	Conference	Accepted	Published
25. H. S. Shahgir, C. Lim, J. Chen, E. E. Papalexakis, Y. Dong, "ExpertGenQA: Open-ended QA generation in Specialized Domains," Empirical Methods in Natural Language Processing (EMNLP) Findings, Suzhou, China, Nov. 2025	Conference	Submitted	Accepted
26. K. Lewandowski, T. Sucin, N. Vitzilaios, "UAV-Based Railway Track Following," International Conference on Unmanned Aircraft Systems, Charlotte, NC, USA, May 14-17, 2025	Conference	Accepted	Published
27. Y. Tang, and Y. Qian, "A Comprehensive Framework for Railway Component Inspection via Hybrid YOLO-RCNN-GNN Architecture," 2025 Transportation Research Board Annual Conference	Conference	N/A	Accepted
28. R. Naseri, B. Gedney, D. Rizos, "Development and Implementation of a Novel Technique for In-Motion Track Change Detection and Identification," 2025 Transportation Research Board Annual Conference	Conference	N/A	Accepted
29. S. Byrraju, D. Rizos, M. Sutton, N. Li, "A Site Classification System for the Implementation of Multi-Temporal SAR for Geohazard Initiation Potential on the Railway Right of Way," 104th Transportation Research Board Annual Meeting 2025	Conference	Under Review	Published
30. Naseri, R., Gedney, B., Asgari, H., Rizos, D. (2025) "Rail Squat Detection Using Hybrid Processing of Axle Box Acceleration Measurements," Results in Engineering Journal (26) https://doi.org/10.1016/j.rineng.2025.105343	Journal	Submitted	Published
31. Lee, M., and Khattak, A.J. (2025) "Motor Vehicle Diversion to Alternate Routes for Improving Safety at Highway-Rail Grade Crossings," Transportation Research Record: Journal of the Transportation Research Board 10.1177/03611981251370344	Journal	N/A	Published
32. Musu, V., Allen, D.H., Fry, G. (2025) "Computational Model for Predicting Lift-Off Induced Buckling in Rail Structures," ASCE J. Engineering Mech.	Journal	Submitted	Accepted
33. Rizos, D., Byrraju, S., Sutton, M.A., Li, N. (2024) "Implementation of Multi-Temporal SAR for Ground Hazard Risk Monitoring on the Railway Right of Way," Transportation Research Record: Journal of the Transportation Research Board	Journal	Submitted	Accepted
34. Tang, Y., and Qian, Y. (2025) "Real-Time Railroad Crossing Surveillance with YOLO-RCNN and Edge Computing," Engineering Applications of Artificial Intelligence	Journal	Submitted	Under Revision
35. Naseri, R., Gedney, B., Rizos, D. (2025) "Rapid Failure Analysis of Train Derailment Potential under Mixed Loading and Track Conditions," Engineering Failure Analysis	Journal	N/A	Under Review

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:

- Updated list of publications
- Updated list of projects
- Updated personnel section
- Updated photo galleries
- Updated links to news media items about UTCRS

3.2.2 Online Database for Bearing Test Data

During the last reporting period, UTCRS brought online a test version of a publicly accessible portal for bearing test data. During this reporting period, the first fully functional version of the portal has been released (<http://utcrsdatabase.ad.utrgv.edu/>). This searchable database allows direct access to raw data from over 12 years of research. The new version has automated real time upload of data from tests in progress. Goals for the next reporting period include improved metadata and statistical summary tools.

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 track-mounted device that harvests energy from passing trains in order to power signals at remote grade crossings,
- Synthetic aperture radar to identify hazards on railroad rights-of-way,
- A method for detecting rail squat from onboard measurements,
- New edge computing methods to monitor grade crossings,
- New AI techniques for mining railroad accident reports,
- New rail anchor models that can be used by rail operators to design safe rail tracks, and
- Improvements to modeling of rail buckling and cracking.

UTCRS consortium members are developing novel instruments and expanding testing capabilities. Please see Section 1.2.3 above for listing of recent upgrades, and the accompanying performance indicator tables for a more comprehensive summary.

3.4 Inventions, patent applications, and/or licenses

The following were mentioned in previous reports:

- (USC) "In-Motion System for Track Stiffness Change Detection", Provisional Patent Application: USC ID No. 1765
- (USC) "Autonomous Railroad Intrusion Detection System with UAV imagery", Provisional Patent Application: USC ID No. 1760
- (USC) Patent Application 63/603,182 "Portable Railroad Grade Crossing Monitoring System" is now being offered for licensing at (<http://techfinder.sc.edu/technology/55198>).

- (USC) Patent Application 63/565,581 “Rail Surface Defect Detection from Onboard Vibration Sensors”.
- (UTRGV) Ongoing licensing agreement with Hum Industrial Technologies for UTCRS-UTRGV patented sensor technology.

3.5 Other products

During the reporting period, UTCRS supported students produced

- 4 Master’s Theses
- 3 Doctoral Dissertations

TAMU has an ongoing agreement with MxV Rail to transfer rail bucking models and data.

4. OUTCOMES

4.1 Research

This section highlights outcomes from selected UTCRS projects. For more detailed information on research outcomes, see the Final Reports for the 2024CY projects, which are expected to become available at the center website (www.utrgv.edu/utcrs) and the Transportation Research International Database (TRID) by November 2025.

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:

- First commercial pilot deployment of wireless load sensors for railcars, using hardware developed and produced by UTCRS. These sensors facilitate automated loading and ensure compliance with safety limits for both railcars and tracks. Two versions have been developed, one for U.S. and one for Australian standards. The Australian version was installed on commercial cars in October 2025. The U.S. version is scheduled for test installation on a short line in the Rio Grande Valley in November 2025. See Figure 1 (2nd row).
- A new Bearing Health Index (BHI) model that combines vibration and speed information into a single, easy to understand number that can be used for predictive railcar maintenance. The new BHI has now been implemented on Hum’s online portal and is available to commercial users.
- Transfer of finished designs to Hum for static load rigs used in the production of load sensors. These rigs are used to pre-condition and calibrate the sensors.
- Final validation and transfer of optimized component specifications for photovoltaic energy harvesting for wireless onboard devices. The validation was the result of almost a year of outdoor testing of alternative circuits and weather conditions, in weekly consultation with Hum. The average power available now provides enough power that battery capacity should no longer be the limiting factor in sensor lifetime. The results will be used in the next commercial version of the Hum Boomerang wireless sensor platform.

4.1.2 Recommendations for reconditioned and inactive bearings

During this reporting cycle, UTCRS completed analysis and reporting for the first phases of two major bearing studies:

- The study of reconditioned bearings showed that certain categories of subsurface defects remaining after the raceway surface is reground can lead to early failure. In addition to the final reports, the results have been disseminated in multiple presentations by the UTCRS director, publications at major conferences, and coverage in industry magazines. This study was carried out on UTCRS testers, in consultation with MxV Rail and bearing manufacturers, and has resulted in new recommended criteria for accepting bearings for reconditioning.

- The study of inactive bearings demonstrated instances in which long periods without rotation led to degradation of lubricant and seals. Damage to seals increases the risk of water ingress and severe damage to the raceway surface. This study, carried out at UTCRS-UTRGV in consultation with NTSB, and supported by bearings provided by CSX, was limited in size but has proven the existence of the effect and the need for a larger scale study. A larger study will likely lead to formal recommendations to have inactive railcars move periodically to mitigate lubricant degradation.

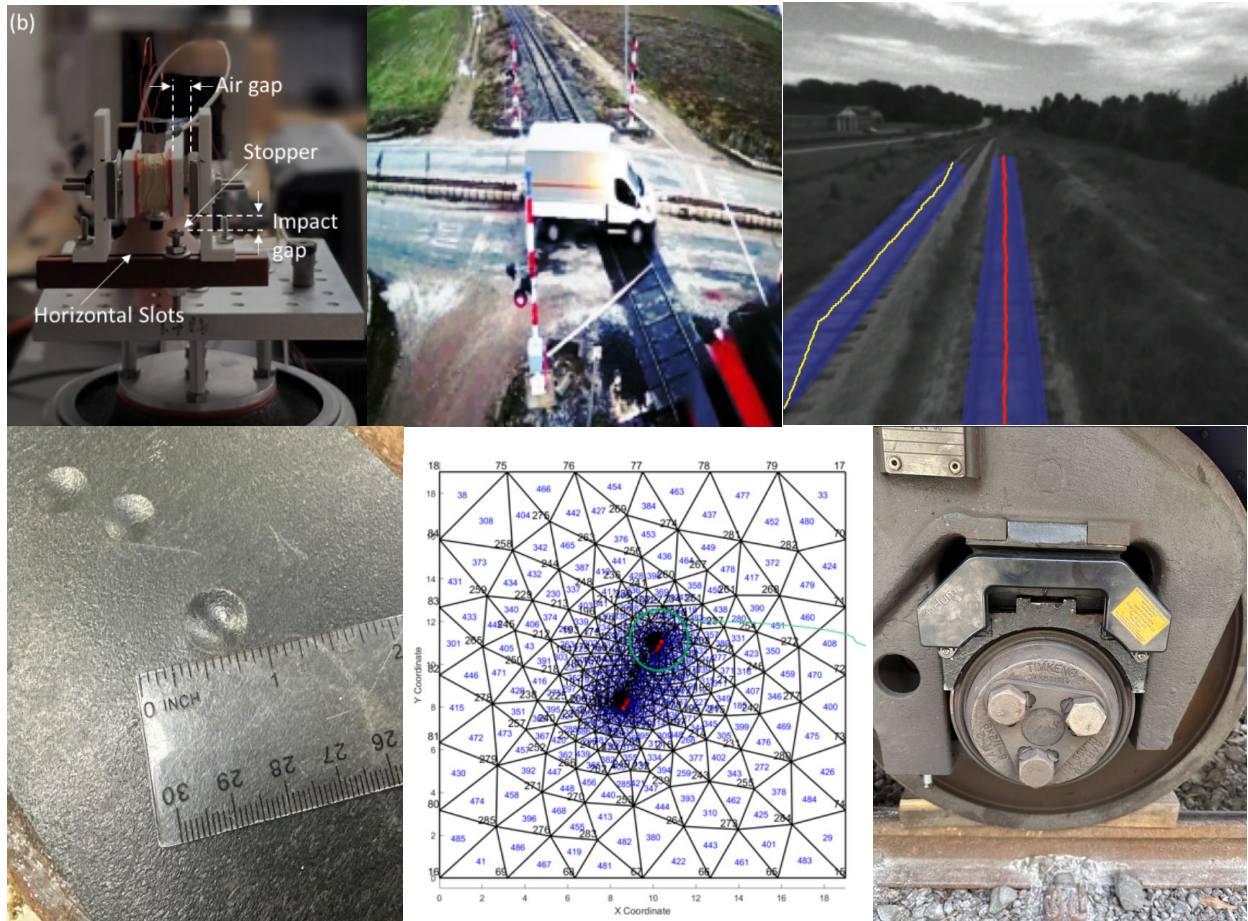


Figure 1: UTCRS Research Highlights. (First Row): Prototype of an electromechanical energy harvester to be mounted on tracks; AI capability to identify vehicles in grade crossings from distorted, low-resolution images; Automatic identification of track location during a drone flight. (Second Row): Indentation testing of composite plastic railroad ties; Finite element analysis of crack growth in a railhead; Field installation of a UTCRS-developed load sensor on Manildra railcars in Australia (October 2025).

4.1.3 Rail Anchor Testing; Rail Modeling

Rail anchor slip force measurement is being conducted in collaboration with engineers from BNSF Railway (Class I Railroad) and MxV Rail. The slip testing complements theoretical and experimental work being performed at UTCRS. The overall benefit of this work is to prevent rail buckling and cracking.

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 and identifying potential hazards. Results from this reporting period include:

- Progress in extracting railcar velocity from vibration signatures, this is essential for low power sensors without GPS capability.
- Improved AI ability to recognize grade crossing hazards from distorted, rotated, and low-resolution images (see Figure 1, 1st row).

- Automatic generation of simulated video of hazard conditions. Large numbers of scenarios are needed to train AI models and only limited numbers of videos of actual hazards are available.

4.1.5 Improvements to Remote Sensing for Track Condition Monitoring

UTCRS-USC researchers have submitted provisional patents for new railcar and UAV mounted methods for detecting track imperfections and intrusions (see Figure 1, 1st row).

4.2 Education, Workforce Development, and Community Engagement

4.2.1 Transportation-Related College Courses Offered

For the April 2025 - September 2025 period, UTCRS-affiliated faculty reported teaching:

- University of Nebraska Lincoln (UNL): 3 undergraduate courses, 1 graduate course.
- Texas A&M University (TAMU): 1 undergraduate course, 2 graduate courses.
- University of South Carolina (USC): 2 undergraduate courses, 2 graduate courses.
- University of Texas Rio Grande Valley (UTRGV): 7 undergraduate courses, 3 graduate courses.

A total of **782** students (**139** Graduate and **643** Undergraduate) were enrolled in these courses.

4.2.2 Workshops and Seminars

UTCRS offers both on-campus and online workshops and seminars open to students and faculty. Since June 2023, UTCRS has offered many on-campus workshops given by industry experts, including personnel from CSX, Trinity Rail, BNSF, NTSB, Herzog, MxV Rail, and the Brotherhood of Railway Signalmen (BRS).

4.2.3 Student Employment as Researchers

Table 5 summarizes the number of students employed as researchers at UTCRS. This includes students in the Bridge to Engineering (B²E) Program. Additionally, in Summer 2025, the UTCRS provided three High School students the opportunity to engage in research internships working alongside UTRGV students and faculty. One of those students is now working with the center as part of the dual enrollment program.

Table 5 – Student Researchers Employed at UTCRS		
Student Researcher Classification	From All Sources	Federal Funds
Undergraduate Research Assistants	48	47
Masters’ Research Assistants	30	19
Doctoral Research Assistants	15	15
Totals	93	81

Most research projects had industry and federal partners, giving the students direct connections with working engineers and professionals, which has helped them develop technical expertise that are rarely found in new college graduates. This year, at least five students saw their design work go into commercial products, and seventeen students were co-authors with industry engineers on conference papers.

4.2.4 Internships and REUs

Each summer UTCRS facilitates the selection of UTRGV undergraduate student participants in a Research Experience for Undergraduates (REU). Depending on research project selections, 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. For Summer 2025, UTCRS also arranged internship placements at the two rail testing facilities, MxV Rail and ENSCO-TTC, both in Pueblo, Colorado. A total of **ten** students participated (3 at MxV Rail, 2 at ENSCO-TTC, 3 at UCR, and 2 at TAMU).

4.2.5 Bridge to Engineering (B²E) Program

Each summer, UTCRS hosts students making the transition from a two-year pre-engineering program at South Texas College (STC) to upper-level engineering at UTRGV. They receive research employment,

mentoring, and tuition support. In the current reporting period, STC recruited and employed **six** students for Summer 2025. Previous cycles were Summer 2023 with **seven** students and Summer 2024 with **eight** students. To date, all students have successfully transitioned into UTRGV engineering programs. Two members of the Summer 2023 cohort graduated in May 2025, and three more members are expected to graduate in December 2025, with two of them expected to continue their graduate studies with UTCRS.

4.2.7 STEM Summer Camps and Teacher Workshops

In June 2025, UTCRS conducted our annual STEM Summer Camps. These are our largest community engagement activity. Students from across the Rio Grande Valley participate in specially designed week-long STEM camps related to transportation engineering with focus on engineering design, programming, robotics, automation, and sensor technologies. The camps foster teamwork and confidence building in all activities. Attendees for 2025 included:

- **694** K-12 students total
- **316** elementary students
- **288** middle school students
- **90** high school students

Students from **17** different school districts and **140** different schools attended. K-12 teachers also attend both as chaperones and through UTCRS workshops on transportation-related curriculum. In Summer 2025, a total of **50** teachers participated.



Figure 2: UTCRS-UTRGV 2025 STEM Summer activities. (Left) A high-school team working on a rail grade crossing challenge (almost 700 students attended the June STEM Summer Camps). (Right) Participants in the Teacher's Workshop on May 31, 2025.

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 practices. Most of our projects are ongoing, but a number of advances can be identified:

- Reconditioned bearing reliability: UTCRS results presented to the AAR, Class I railroads, and reconditioning facilities are leading 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, and rapid progression of defects. This

work has been disseminated and should lead to new best practices on periodic checking and movement of railcars that are not currently in service.

- Preventing overloaded railcars: UTCRS has developed onboard load sensors that can weigh railcars in real time and warn of overload conditions that could damage suspensions and degrade track. This technology has been transferred to industry, and the first sensors entered pilot commercial use in October 2025.
- Longer sensor life: UTCRS has developed new harvesting and recharging strategies for wireless onboard sensors that exceed the breakeven point, and thus allow sensors that are not limited by battery life. The designs have been transferred to industry and implementation is expected within the next year.
- Increased workforce pool: More than **80** 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; track inspections and rail neutral temperature; track condition monitoring and rail geometry; rail fracture and buckling; rail grade crossing monitoring; and data analysis through artificial intelligence and machine learning tools. These trainings are both through employment and through formal workshops offered both by UTCRS personnel and by industry collaborators visiting the center.

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?

New practices: The UTCRS is 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 project 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, guest lectures, and workshops.

Start-up company: 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, and Hum's product engineer is a UTCRS alumnus.

The collaboration with Hum has transitioned to the current UTCRS UTC grant, with deployments on railcars operated by several Class I and short line railroads, and partnership in our new FRA CRISI grant. UTCRS serves as Hum's research division and is engaged in sensor optimization and enhancement, development of energy harvesting systems to prolong service life, data analysis, addition of new sensing capabilities, and design and fabrication of the next generation of sensors.

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

During the April 1, 2025, to September 30, 2025, reporting period, UTCRS personnel submitted for publication and/or published 35 papers on a wide range of technical topics. Some examples are:

- New computational models for fracture and buckling of railroad tracks.
- New autonomous systems to inspect rail geometry and detect changes.
- Key results on the performance of reconditioned bearings.
- Key results on lubricant degradation in inactive railcar bearings.

Table 4 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 directly employed hundreds of undergraduate and graduate students in its research activities. Students develop valuable skill sets through hands-on projects relevant to the railroad industry, making these students workforce ready upon graduation. Thousands of other university students have been engaged through courses taught by UTCRS faculty, workshops and professional development, and community outreach activities.

In the longer-term, the UTCRS K-12 outreach efforts are building interest in transportation careers among youth who will enter the workforce over the next 5-15 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 career opportunities. During Summer 2025 alone, in the current reporting period, we reached over 694 K-12 students and approximately 50 K-12 educators.

6. CHANGES/PROBLEMS

6.1 Changes in approach and reasons for change

Proposal Review Process: We have been continuously revising the selection process for research proposals. For 2024CY proposals, we moved up the submission deadline to allow additional time for External Advisory Board (EAB) review. For 2025CY proposals, we added an additional step of submitting proposals for USDOT review after EAB approval. In our upcoming call for 2026CY proposals, the criteria and guidance will be changed to better reflect and highlight the USDOT priority for work that produces tangible products, transferable technology, and actionable results.

Redirected or Extended Research Projects: One of the 2024CY projects, “FAST® Loop Comparison of Onboard Condition Monitoring Versus Wayside Detection,” has been redirected. The revised plan is to demonstrate on a local short line in November 2025 and report in December 2025. Four other projects have requested no cost extensions to December 31, 2025.

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

In the previous report, it was stated that one 2023CY project final report, related to energy harvesting, was embargoed to allow time for a patent application. This application is still in progress, but the researcher reports that the patent will be submitted by December 31, 2025, and we can then proceed to upload the final report to the UTCRS website and submit to TRID.