Semi-Annual Progress Report for University Transportation Centers
Reporting Period [October 1, 2024 – March 31, 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)

- **Federal Grant or Other Identifying Number Assigned by Agency:** 69A3552348340

- **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

- **Submission Date:** April 30, 2025

- **DUNS and EIN Numbers:** DUNS: 069444511 and EIN: 465292740

- **Recipient Organization:**
  The University of Texas Rio Grande Valley (UTRGV)
  1201 West University Drive, Edinburg, TX 78539-2999

- **Recipient Identifying Number or Account Number:** 5100001271 (Federal); 5400001410 and 31001701 (Non-Federal Cost Share)

- **Project/Grant Period:** June 1, 2023 – May 31, 2028

- **Reporting Period End Date:** March 31, 2025

- **Report Term or Frequency (annual, semi-annual, quarterly, other):** Semi-annual

- **Signature of Submitting Official**

Constantine d.

———————————————————————————————

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 fourth reporting period, our major goals were:

- Issue a call for proposals for the third year of research projects
- Continue work on twenty (20) second year projects
  - Present research results in journal and conference publications
  - Submit reports to industry partners and sponsors
- Educate students and develop technical workforce
  - Employ and supervise undergraduate and graduate students for 20 research projects
  - Take students to present at the Transportation Research Board meeting
  - Offer courses in transportation related subjects
  - Offer transportation seminars and workshops by industry and government experts
- Engage the community in rail related activities
  - Plan for 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 new partners including labor organizations and corporations
  - Complete 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 the following table:

Table 1 – Accomplishments During the Reporting Period		
Administrative	**Status**	**% Complete**
Hold regular meetings of the Executive Committee	**Complete**	**100%**
Issue Call for Proposals for 2025CY projects	**Complete**	**100%**
Receive proposals for 2025CY projects and submit to Advisory Board	**Complete**	**100%**
Post 2024CY final reports and submit to TRID database	**In progress**	**94%**
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**	**50%**
20 new conference and journal publications were accepted and/or published	**Complete**	**100%**

1 conference publication previously reported as accepted was published		**Complete**	**100%**
10 papers have been accepted for the 2025 International Heavy-Haul Association		**Complete**	**100%**
8 students presented at the January 2025 Transportation Research Board (TRB)		**Complete**	**100%**
Upgrades to new rail anchor slip test system	Test rig upgrades	**Complete**	**100%**
	Regular data production runs	**Ongoing**	**75%**
Development of new lateral loading capability for single bearing test rig		**Complete**	**100%**
Endurance testing of reconditioned bearings (MxV Rail funded)		**Ongoing**	**75%**
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**	**75%**
	Beta Version Online	**Completed**	**100%**
Continued existing agreements for cooperation with industry partners including MxV Rail, CSX Transportation, BNSF, ENSCO, TTC, and Hum		**Completed**	**100%**
New funded project with Oak Ridge National Labs, for testing and calibration of vibration and temperature sensors (See 1.2.2 below)		**Initiated**	**10%**
Pre-Award 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)		**Initiated**	**10%**
Education & Workforce Development		**Status**	**% Complete**
Supported **93** graduate/undergraduate students involved in UTCRS activities		**Complete**	**100%**
Center-affiliated faculty taught **14** undergraduate and **4** graduate courses in transportation-related subjects, during the reporting period		**Ongoing**	**70%**
Arranged 2025 summer transportation internships (MxV Rail) for **3** students		**Completed**	**100%**
Arranged 2025 summer transportation internships (ENSCO) for **2** students		**Completed**	**100%**
Arranged 2025 summer research experience for undergraduates (REU) for **2** students at our consortium partner Texas A&M Transportation Institute		**Completed**	**100%**
Arranged regular semester internships for **2** High School students at the UTCRS		**Completed**	**100%**
Community Engagement & Outreach		**Status**	**% Complete**
Preparations for the 2025 UTCRS STEM Summer Camps and Teacher Workshop		**Ongoing**	**50%**
Onsite visits to UTCRS facilities by personnel from FRA, BNSF, Hum, Brotherhood of Railroad Signalmen, ORNL, MxV Rail, ENSCO, Rio Valley Switching Company		**Completed**	**100%**
UTCRS Website updates		**Up to Date**	**100%**

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 now 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 is now expected to begin in June 2025, but technical and planning meetings, staffing, and equipment acquisition have already initiated.

1.2.2 New Collaboration with Oak Ridge National Laboratory

UTCRS recently (March 2025) entered into an agreement with Oak Ridge National Laboratory (ORNL) to evaluate ORNL-developed bearing vibration and temperature sensors using UTCRS facilities. The ORNL

system is specialized for railcars carrying nuclear waste. In the first phase, scheduled to begin May 2025, ORNL sensors will be compared with UTCRS sensors under a variety of speed, load, impact, and air flows in short duration runs. If the results are satisfactory, long term testing will follow.

1.2.3 Advisory Board

UTCRS has an established 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.

The current 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)

1.2.4 UTCRS Sponsored Research Projects

Twenty (20) research projects are currently in progress for 2024CY (June 2024-August 2025). The 2024CY project titles with links to project descriptions are given in Table 2. 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 –2024CY Research Projects in Progress, 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_coeffficients_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_rizos_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_vitzilaios_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

During this reporting period, a total of **93** students were employed from federal and matching funds. This includes students in the Bridge to Engineering (B²E) Program. Additionally, the UTCRS provided one High School student at UTRGV and one at UCR the opportunity to engage in a research internship opportunity working alongside university students and faculty.

Table 3 – Student Researchers Employed at UTCRS		
Student Researcher Classification	**From All Sources**	**Federal Funds**
Undergraduate Research Assistants	47	29

Master's Research Assistants	41	24
Doctoral Research Assistants	5	3
Totals	**93**	**56**

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 21 newly published or submitted publications, as shown 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 ten (10) abstracts accepted.

Seminars, Presentations, and Webinars: During the reporting period, students from UTRGV and UNL gave presentations at the Transportation Research Board (TRB) meeting, January 5-9, 2025. Dr. Constantine Tarawneh gave a UTCRS Webinar on freight rail onboard monitoring technologies on March 7, 2025, was one of the four panelists on the CUTC Workforce Development Webinar on March 25, 2025, and presented a poster on the inactive bearing study at the National Safety Summit hosted by Safety21 on March 27, 2025.

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

- Prof. Constantine Tarawneh (UTRGV) 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. 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 annual Dwight David Eisenhower Transportation Fellowship Program (DDETFP) Local Competition, (5) member of the CUTC Student Awards Selection Committee, (6) member of the organizing committee for the newly founded 2026 InnovaRail Conference, and (7) Guest Editor of a special issue for the Journal of Sustainability entitled "Sustainable Study of Railway Engineering and Rail Transportation."
- Prof S. Mustapha Rahmaninezhad (UTRGV) served as a member and committee communications coordinator for the TRB AKG50 Standing Committee on Transportation Earthworks.
- Prof. Dimitris Rizos (USC) served as: (1) Chair of the 2024 Joint Rail Conference, (2) member of TRB AR060, (2) member of AREMA Committee 24 Education and Training, (3) academic co-Chair of the Railway Engineering Education Symposium (REES) 2024 Executive Committee, (4) Academic Editor of the Journal of Advances in Civil Engineering, and (5) member of the organizing committee for the newly founded 2026 InnovaRail conference.
- Prof. Aemal Khattak (UNL) is an editorial board member, Transportation Research Board; and Area Editor with the Journal of Transportation Safety and Security.
- Prof. 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, Smart and Resilient Transportation, and is on the editorial boards of High-Speed Railway, Intelligent Transportation Infrastructure, and Transportation Geotechnics.
- Prof. Nikolaos Vitzilaios (USC) is program chair for the 2024 International Conference on Unmanned Aircraft Systems, is on the Board of Directors, South Carolina interagency Drone Users Consortium, and is Associate Editor, Journal of Intelligent & Robotic Systems.

- Prof. Yuche Chen (USC), Member of Editorial Board for Transportation Research Part D, he serves as research coordinator for Transportation Research Board Committee on Transportation Environment and Ecology AEP 70.
- Prof. Vagelis Papalexakis (UCR) 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).
- Prof. 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. During this reporting period, the following stories have been shared with the community:
- A story about the [$9.7 million Rail Safety Research Initiative](#) led by the Brotherhood of Railroad Signalmen (BRS) in partnership with the UTCRS, Hum, and ENSCO, and funded by the Federal Railroad Administration (FRA) through their CRISI Program was published in November 4, 2024, and shared with different local news outlets and social media.
- A story about the [signing ceremony](#) between the BRS, UTCRS, Hum, and ENSCO, officially kicking off the partnership between the four entities to work on rail safety and workforce development initiatives under the newly funded FRA CRISI grant was published on January 17, 2025.
- A story announcing the [2025 UTCRS STEM Summer Camps](#) was released on April 25, 2025.
- Two stories were published through local and national outlets featuring UTCRS High School Intern, Gary Montelongo, who won a prestigious national award for his work on railway safety. More details are provided in Sections 4 and 5 of this report. [Featured Article 1](#); [Featured Article 2](#).
- 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, faculty, and staff, and professional development 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 (April 1, 2025 – September 30, 2025) include:
- **Administrative**
  - Meet all USDOT and UTC reporting requirements
  - Receive decisions on 2025CY project proposals from the External Advisory Board
  - Initiate funding and hiring for 2025CY projects that receive approval
  - Attend 2025 CUTC summer meeting
  - Upgrade interface to public database of bearing test data based on feedback from beta version already rolled out
  - Continue cooperation with other universities who have transportation centers and research and FRA to organize an annual rail conference (InnovaRail) that brings together academia, federal and state agencies, rail industry, and workforce organizations
- **Research**
  - Complete work on approved 2024CY research projects
  - 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

- 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 rail industry partners of the UTCRS (e.g., REU Program and Internships)
  - Offer transportation-related courses for the Fall 2025 and Spring 2026 semesters
  - Employ and mentor students in the 2025 Bridge to Engineering (B2E) program
- **Engagement and Outreach**
  - Conduct 2025 UTCRS STEM Summer Camps
  - Conduct 2025 UTCRS STEM Teacher Workshop
  - Conduct 2025 UTCRS Research Experience for Teachers (RET) Program
  - 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 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
- 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 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, 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, CO, 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 and host UTCRS student researchers at their Pueblo, CO, facility.
Hum Industrial Technology, Inc. St. Louis, MO	**Industry Sponsor** Hum 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 as well as a 15-foot segment of fully assembled rail track (in-kind cost share).
The Timken Company North Canton, OH	**Industry Collaborator** Timken is a partner in the inactive rail bearing study. They 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 a signed collaboration agreement with Ironhorse to access RVSC facilities for testing of 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.
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.

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 a FRA CRISI funded project to develop and integrate our technologies into the existing railway signals framework.
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
South Texas Preparatory Academy Edinburg, TX	**Community Collaborator** STPA participates in the annual UTCRS STEM Summer 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
Donna ISD Donna, TX	**Community Collaborator** Donna 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. 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 60 journal and conference publications since the start of funding in June 2023.

Table 5 – Journal and Conference Publications (Reporting Period Only)			
Citation	**Type**	**Status at Last Report**	**Status in Current Report**
1. V. Musu, D.H. Allen and G. Fry (2025), "Computational Model for Predicting Lift-Off Induced Buckling in Rail Structures," submitted to ASCE J. Engineering Mech	Journal	N/A	Submitted

2. Y. Tang and Y. Qian (2025), "Real-Time Railroad Crossing Surveillance with YOLO-RCNN and Edge Computing," Engineering Applications of Artificial Intelligence	Journal	N/A	Submitted
3. R. Naseri, B. Gedney, H. Asgari, and DC Rizos (2024), "Rail Squat Detection Using Hybrid Processing of Axle Box Acceleration Measurements," Results in Engineering	Journal	N/A	Submitted
4. D.C. Rizos, S. Byraju, MA Sutton, and N. Li (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	N/A	Submitted
5. MM Shakiul Haque and A. J. Khattak (2024) "Modeling and operational performance evaluation of driveway assistance devices for lane closures on two-lane highway work zones." ASCE Journal of Transportation Engineering, Part A: Systems, Vol. 151(3); https://doi.org/10.1061/JTEPBS.TEENG-8763	Journal	N/A	Published
6. D. Ahn and E. E. Papalexakis (2024), "Global and Local Structure Learning for Sparse Tensor Completion," 2024 IEEE International Conference on Big Data, Washington, DC	Conference	N/A	Published
7. H. Mortazavi, S.R. Kommidi, Y.-R. Kim and D. H. Allen (2025), "Development of Materials Parameters for Prediction of Rail Fracture Determination of Rail Fracture," accepted to 13th International Heavy Haul Association Conference, Colorado Springs, CO, Nov. 2025 (IHHA + WCRR)	Conference	N/A	Accepted
8. B. Altay, D.H. Allen and Y.-R. Kim (2025), "A Model for Predicting the Effects of Grain Structure on Fracture in Rails," accepted to 13th International Heavy Haul Association Conference, Colorado Springs, CO, Nov. 2025 (IHHA + WCRR)	Conference	N/A	Accepted
9. E. E. Papalexakis, R. Jiang, M. Gutierrez, D. Ahn, P. Xu, C. Tarawneh, and J. Chen, "Tensor Mining of Public Railroad Accident Reports," 13th International Heavy Haul Association (IHHA) Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
10. Y. Luo, H. Patel, Y. Fu, D. Ahn, J. Chen, Y. Dong, and 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	N/A	Accepted
11. D. Ahn, J. Jang, and E. E. Papalexakis, "Improving Group Fairness in Tensor Completion via Imbalance Mitigating Entity Augmentation," Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD), Sydney, Australia, June 2025	Conference	N/A	Accepted
12. C. Tarawneh, A. Martinez, A. Blanton, M. Adame, and H. Foltz "Effect of Long-Term Inactivity on Railcar Bearings: Preliminary Results," 13th International Heavy Haul Association Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
13. P. Mensah, J. A. Turner, C. Nelson, M. Amjadian, and C. Tarawneh, "Non-Contact Energy Harvester for Rural Grade Crossings," 13th International Heavy Haul Association Conference (IHHA), Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted

14. T. Sucin and N. Vitzilaios (2025), "Robust Track Following for UAV based Inspection," IHHA-WCRR 2025 Joint Conference, Colorado Springs, CO, USA, November 17-21, 2025	Conference	N/A	Accepted
15. K. Lewandowski, T. Sucin and N. Vitzilaios (2025), "UAV-Based Railway Track Following," International Conference on Unmanned Aircraft Systems, Charlotte, NC, USA	Conference	N/A	Accepted
16. G. G. Ali, G. Gutierrez, and C. Tarawneh, "Graph-Based Testbed for Vulnerability Analysis of the US Rail Infrastructure Network," 13th International Heavy Haul Association (IHHA) Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
17. G. G. Ali, G. Gutierrez, and C. Tarawneh, "Exploring Rail Incident Factors using Machine Learning," 13th International Heavy Haul Association (IHHA) Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
18. J. Turner, C. Tarawneh, S. Martinez, and E. Miranda, "Defect Prediction of Bearings Using Ultrasonic and Eddy Current Inspections," 13th International Heavy Haul Association (IHHA) Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
19. S. Saberi, D.H. Allen and Y.-R. Kim, "Modeling Crack Growth Due to Cyclic Loading in Rails Using a Cohesive Zone Model Embedded within a Finite Element Code," 13th International Heavy Haul Association (IHHA) Conference, Colorado Springs, CO, Nov. 2025	Conference	N/A	Accepted
20. H. S. Shahgir, C. Lim, J. Chen, E. E. Papalexakis, and Y. Dong, "ExpertGenQA: Open-ended QA generation in Specialized Domains," 2025 Association for Computational Linguistics	Conference	N/A	Submitted
21. 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. 21 Oct. 2024. https://doi.org/10.1145/3627673.3679833	Conference	Accepted	Published

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: (1) improved interface for the bearing temperature and vibration model, (2) updated list of publications, (3) updated list of projects, (4) updated personnel section, (5) updated photo galleries, and (6) updated links to news media items about UTCRS.

3.2.2 Online Database for Bearing Test Data

During this reporting period, UTCRS brought online (http://utcrsdatabase.ad.utrgv.edu/) an initial version publicly accessible portal for bearing test data. This searchable database allows access to both raw data and statistical summary data. The following progress was made: (a) public interface placed online, (b) ongoing migration of UTCRS archival data from over 10 years of tests. In addition, automated real time upload of data from tests in progress is under construction, along with improvements to metadata files.

3.2.4 Facebook Page

UTCRS maintains a Facebook page (https://www.facebook.com/utcrailwaysafety/) intended for outreach events and to engage the community, specifically K-12 teachers, students and their parents/guardians.

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, and
- Improvements to modeling for rail buckling and cracking.

UTCRS consortium members are developing novel instruments and expanding testing capabilities. Some examples include:
- UTRGV has upgraded its test rig for measuring rail anchor slip force to allow temperature variation, and to improve the range and accuracy of force and displacement measurements.
- UTRGV is adding the ability to apply controlled lateral forces in its single bearing test rig.

3.4 Inventions, patent applications, and/or licenses

During the current reporting period, USC filed two provisional patent applications:
- "In-Motion System for Track Stiffness Change Detection," Provisional Patent Application: USC ID No. 1765
- "Autonomous Railroad Intrusion Detection System with UAV imagery," Provisional Patent Application: USC ID No. 1760

In the previous report, it was noted that two patent applications were filed by USC: 63/603,182 "Portable Railroad Grade Crossing Monitoring System," and 63/565,581 "Rail Surface Defect Detection from Onboard Vibration Sensors." The technology for 63/603,182 is now being offered for licensing at (http://techfinder.sc.edu/technology/55198).

UTRGV has an ongoing licensing agreement with Hum Industrial for UTCRS-UTRGV patented sensor technologies. TAMU has an ongoing agreement with MxV Rail to transfer rail bucking models and data.

3.5 Other products

During this reporting period (Winter 2024 graduations only), UTCRS supported students produced
- 3 Master's Theses
- 1 Doctoral Dissertation

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 2023CY projects, available at both the center website (www.utrgv.edu/utcrs) and the Transport Research International Documentation (TRID) database.

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 miniature solar panels to provide battery recharging for bearing adaptor-mounted wireless sensors, including the effects of shading, fouling, and abrasion of the bezel surface.
- Improvements to how speed and load are taken into account when reporting the health of bearings and wheels.
- Final calibration runs prior to field deployment of load sensors embedded in bearing adapter pads and development of a new load sensor design for adapters used in overseas markets.
- First lab demonstration of a reduced size (44 x 20mm) and cost bearing vibration sensor; firmware compatible with existing sensors.

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 modular system that can be used to evaluate new sensing techniques. Elements of this system are on schedule for testing on a local short line (RVSC) in Summer 2025 and installation at the MxV FAST® Loop facility in August 2025.
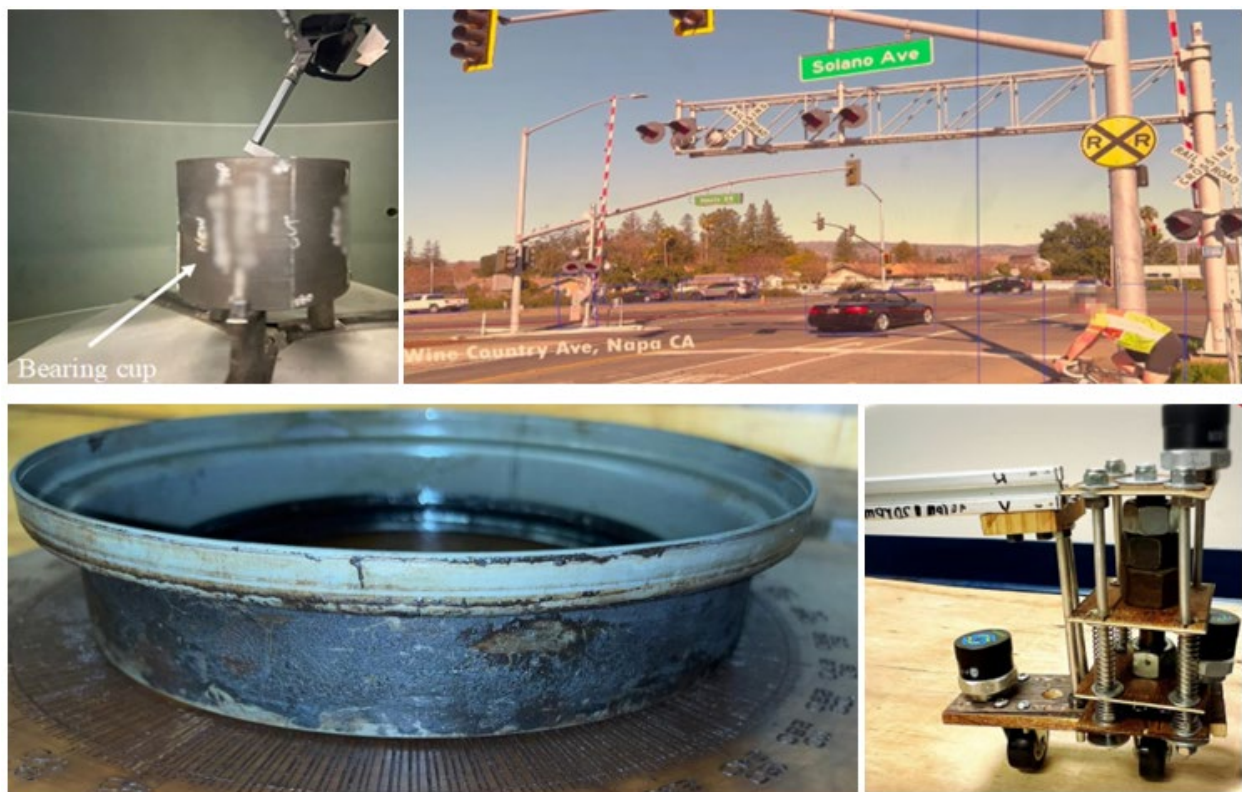

Figure 1: UTCRS Research Highlights. (First Row): Ultrasonic inspection of a bearing cup; automatic detection of a cyclist entering a grade crossing. (Second row): Leaking seal found during inactive bearing test; scale model of a prototype rail stiffness monitor.

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. Moreover, more recent testing has focused on introducing new non-destructive techniques, such as Eddie Current Testing, to scan bearing repaired surfaces to ensure that there are no surface or near-surface flaws that can initiate and propagate spalling.

- Hum sponsored tests on how indexing of bearing cups affects the RMS vibration produced by outer raceway defects, showing significant reductions when defects are not in the loaded region.
- In the previous cycle, UTCRS reported completion of the first round of UTCRS sponsored test of inactive bearings suggested by NTSB and conducted in collaboration with CSX Transportation. The results have been widely disseminated in reports and will be presented in two papers at the 2025 IHHA conference. Currently, the laboratory testing is awaiting acquisition of more inactive bearings taken from railcars, which will be supplied by CSX Transportation (Class I Railroad).

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. The slip testing complements other theoretical and experimental work being performed at UTCRS consortium universities that seek to model rail buckling. New results for this reporting cycle include measurement of slip force under variations in temperature. An agreement has been reached with BNSF to construct a new 15-foot rail track test bed donated by them as cost share for the ongoing project.

4.1.4 Applications of Artificial Intelligence (AI) in Rail Safety
Artificial intelligence, specifically deep learning through convolutional neural network architectures has potential for monitoring and identifying potential hazards. For this cycle, new publications describe improvements to AI methods for analyzing accident reports, and a graph-based testbed for vulnerability analysis of rail infrastructure.

4.1.5 Improvements to Remote Sensing for Track Condition Monitoring
As noted above, UTCRS-USC researchers have submitted provisional patents for new railcar mounted methods for detecting track imperfections, and UAV mounted systems that can detect right-of-way intrusions.

4.2 Education, Workforce Development, and Community Engagement

UTCRS continued 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

Many of our programs occur during the summer and are not in this reporting period. However, planning, registration, and participant selection are underway for Summer 2025 including:
- Research Experiences for Undergraduates (REU)
- Industry internships at ENSCO and MxV Rail
- Bridge to Engineering (B^{2}E) Program for students from South Texas College (STC)
- STEM summer camps for K-12 students
- STEM Workshops for K-12 teachers
- UTCRS High School Summer Internships

4.2.1 Transportation-Related College Courses Offered
For the October 2024 – March 2025 period, UTCRS-affiliated faculty reported teaching:
- University of Nebraska Lincoln: 1 graduate course.
- University of South Carolina: 5 undergraduate courses, 3 graduate courses.
- University of Texas Rio Grande Valley: 9 undergraduate courses, 1 graduate course.

4.2.2 Workshops and Seminars
UTCRS offers both on-campus and online workshops and seminars open to students and faculty. For this reporting cycle these include:

- Webinar: "Mitigating Train Derailments Through Proactive Condition Monitoring of Rolling Stock," presented on March 7, 2025.
- Webinar: "CUTC Workforce Development: Best Practices from University Transportation Centers," presented on March 25, 2025.

Since June 2023, UTCRS has offered many on-campus workshops given by industry experts, including personnel from CSX, Trinity Rail, BNSF, NTSB, Hum, and the Brotherhood of Railroad Signalmen (BRS).

4.2.3 Student Employment as Researchers

During the current reporting period alone, UTCRS engaged **93** 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 and technical experiences that are rarely found in new college graduates. During the current reporting cycle alone, students at UTCRS have taken primary responsibility for professional-level tasks for industrial sponsors including:

- 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.
- Designing and calibrating onboard railcar load sensors.

Some further facts about UTCRS student researchers:

- Since June 2023, there have been more than 95 instances (20 in the current cycle) in which UTCRS student researchers have authored or co-authored journal or conference publications.
- All UTCRS-UTRGV researchers supported by federal funds are US citizens or permanent residents.

Figure 2: UTCRS-UTRGV team of student presenters, faculty, and staff at the January 2025 Transportation Research Board (TRB) annual meeting. In all, 18 personnel from UTCRS collaborating institutions attended TRB.

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. During the current report cycle, UTCRS has been arranging placements and opportunities for Summer 2025. MxV Rail and ENSCO, both in Pueblo, Colorado, have agreed to take interns for projects directly related to railroad safety and operations. In addition, REU positions will be available, as mentioned above, at each of the consortium partners. Past REU cycles have been highly successful, with multiple students electing to pursue graduate studies at their host institution.

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

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 five students for this program who will begin employment in Summer 2025. Previous cycles (Summer 2023, seven students, and Summer 2024, eight students) were highly successful with all students transitioning successfully. Some members of the Summer 2023 cohort are graduating in May 2025.

4.2.6 High School Interns

Each summer, UTCRS hosts High School Interns, who are assigned to existing teams of college-level student researchers. During the current reporting cycle, one high school intern elected to continue work with the center during the regular semesters, and another one, Gary Montelongo, was a finalist for the Society of Science Thermo Fisher Scientific Junior Innovators Challenge for his work on train suspension systems (see stories featured in section *1.3.2*).

4.2.7 STEM Summer Camps

During the current reporting cycle, UTCRS planned and advertised for the 2025 STEM Summer Camps to be held in June 2025. These camps are conducted annually and are our largest community engagement activity. The most recent camps in June 2024 hosted 1183 K-12 students in total (717 elementary, 344 middle school, and 122 high school)

The students, all from school districts in the Rio Grande Valley, participate in specially designed 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, and focus on teaching the engineering design cycle through interactive hands-on activities with applications in transportation engineering and railway safety.

Figure 4: Photos of elementary (left) and high school (right) students from the 2024 UTCRS STEM Summer Camps.

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

UTCRS also conducted planning and recruitment for the upcoming Summer 2025 STEM Teacher Workshop and Research Experiences for Teachers (RET). The teachers participated in the summer camps and are trained beforehand 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.

In the most recent cycle, Summer 2024, UTCRS hosted 65 K-12 STEM teachers in the two programs combined. Teachers developed grade-appropriate curricula for elementary, middle school, and high school grades with the assistance of UTCRS-UTRGV faculty and students. The developed curricula have been posted on the UTCRS website and have been formatted for dissemination.

4.2.9 Awards and Recognitions

Manuela Cantu, UTCRS-UTRGV Program Coordinator, won the CUTC Award for Administrative Leadership awarded at the January 2025 CUTC meeting. Jeffery Pams, UTCRS graduate research assistant, won the UTCRS Outstanding Student of the Year Award at the same meeting. Three undergraduate students (Gael De Leon, Andres Salinas, and Roberto Avila) who are employed by UTCRS to do circuit design won *first place* in circuit design at the IEEE Region V Meeting.

Figure 5: (Left) Manuela Cantu, CUTC Award for Administrative Leadership; (Right) Jeffery Pams, UTCRS Outstanding Student of the Year Award recipient.

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 railroad 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 working on two projects that are of great interest to the NTSB as they relate to the findings of the 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, Brenco, 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, and Hum's product engineer is a UTCRS alumnus. This collaboration demonstrates that UTCRS research and workforce development efforts have led to the start-up formation, and placement of UTCRS graduates in the rail industry.

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. UTCRS 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. This work is expected to revolutionize the way the rail industry monitors their rolling stock by augmenting current wayside detection systems with onboard technologies that enhance safety and reliability. Most importantly, the new onboard technologies enable 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 October 1, 2024, to March 31, 2025, reporting period, UTCRS personnel submitted or published papers for publication on a wide range of technical topics. Some examples are:

- New AI techniques to mine rail transportation data.
- New fracture models for railroad tracks.
- New ways to automate detection of hazards in the railroad right-of-way.

- New methods for detecting rail geometry defects.
- New studies on lubricant degradation in inactive railcar bearings.
- New non-destructive techniques for inspecting reconditioned bearings.

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.

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 PI has submitted a final project report but has asked for a temporary embargo on publication to file a patent application related to his UTCRS funded project exploring energy harvesting technologies.