

Semi-Annual Progress Report for University Transportation Centers

Reporting Period [June 1, 2023 – September 30, 2023]

- **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**
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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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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 experienced in rail transportation systems leading to reduced fatalities and injuries. In addition, economic losses to stakeholders will be reduced by improving the safety and durability of U.S. rail transportation infrastructure. This will be accomplished through the development and application of new technologies and materials, rail component condition monitoring, remote sensing, asset management, performance management, construction methodologies, and addressing aging infrastructure. The center will produce transformational technology via the development of integrated platforms for detecting and assessing railway performance.

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, and state and federal agencies.

For this first reporting period, our major goals were to:

- Organize the External Advisory Board and Executive Committee
 - Establish the Board and Executive Committee
 - Deeply engage the Advisory Board in UTCRS planning
 - Review, revise, and approve 2023CY research projects
 - Get an early start on organizing the 2024CY review cycle
- Initiate research projects
 - Recruit personnel for the projects
 - Establish connections with industry partners for the projects
 - Start research work
- Educate students and develop technical workforce
 - Offer transportation related courses
 - Hire graduate and undergraduate students for UTCRS projects
 - Provide students with summer research experiences
- Engage the community in rail related activities
 - Conduct the 2023 UTCRS Railway Safety Summer Camps and K-12 Teacher Workshop
 - Recruit, advertise, and plan for the 2024 UTCRS Summer Camps

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
Established and met with UTCRS Advisory Board	Complete	100%
Established and held meetings of the UTCRS Executive Committee	Complete	100%

Selected, through our Advisory Board, seventeen 2023CY Research Projects	Complete	100%
Submitted Exhibit D and updated Research in Progress (RIP) for all projects	Complete	100%
Submitted UTCRS Data Management Plan	Complete	100%
Establish process for selecting 2024CY Research Projects and Call for Proposals	On Schedule	75%
Preparations to host the 2024 CUTC Summer Meeting in South Padre Island, TX	On Schedule	30%
Research	Status	% Complete
Began work on seventeen (17) research projects for 2023-2024	On Schedule	30%
Submitted 25 manuscripts and abstracts for publication	Under Review	40%
Published 2 conference and journal publications and 1 technical report	Complete	100%
Made agreements for cooperation with industry partners including MxV Rail, CSX Transportation, BNSF, Rio Valley Switching Company, HUM Industrial, Schaeffler, Timken, RSAE Labs.	Complete	100%
Education & Workforce Development	Status	% Complete
Hired 53 graduate and undergraduate students on UTCRS research projects	Complete	100%
Sent 8 undergraduate students for summer research experiences (REUs)	Complete	100%
Thirteen courses (7 graduate and 6 undergraduate) in transportation topics taught by UTCRS personnel.	Ongoing	50%
Recruited 7 STC students in the 2023 UTCRS Bridge to Engineering Program	Complete	100%
Mentored 4 High School Interns during an 8-week research intensive experience	Complete	100%
Engagement & Outreach	Status	% Complete
Conducted 2023 UTCRS K-12 Railway Safety Summer Camps (1120 K-12 students, 100 K-12 teachers)	Complete	100%
Began recruitment and posted advertisements for 2024 UTCRS Railway Safety Summer Camps	On Schedule	33%
UTCRS Website updates	Ongoing	75%

1.2.1 Advisory Board: The UTCRS has established an external advisory board that has been actively and deeply engaged in giving direction to our research and operations. The members and their brief biographies are given in Table 2. The Board met in person at the UTRGV Edinburg campus in Texas on June 29-30, 2023, for a two-day kick-off meeting that included an in-depth review of our first round of research proposals. They have since had multiple on-line follow-up meetings.

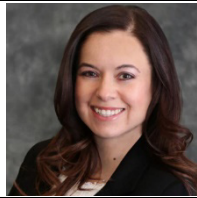


The Board is committed to ensuring that the UTCRS funds projects that are relevant and valuable for the rail industry, and the UTCRS leadership is committed to being responsive to their direction. The Board has already taken significant actions including:

- Review of 19 initial research proposals.
- Approval of four (4) of the initial proposals as submitted.
- Rejection of five (5) of the initial proposals as submitted.
- Recommended revisions to ten (10) of the initial proposals.
- Approval of thirteen (13) revised proposals, for a total of 17 funded projects for Year 1.

The Board has also been instrumental in recommending new research and in creating connections with industry technical staff. Board members took a leading role in suggesting or facilitating two of the research projects, one to measure slip forces in rail anchors and one to study the effects of long-term inactivity on bearing lifetime. Both projects have been approved and work on those projects has been ongoing. These

projects bring together effective collaborations between the UTCRS research team and Class I railroads (CSX and BNSF), NTSB, MxV Rail, and railroad industry partners like Timken and HUM Industrial.

Table 2 - UTCRS External Advisory Board

<p>1. Kari L. Gonzales (Chair) President and CEO, MxV Rail. She leads the world's premier rail research organization based in Pueblo, CO. She has over 20 years rail industry experience, including service in multiple senior positions, 25 technical publications, and leadership on key industry committees.</p>	
<p>2. Kim Bowling Director of Wayside Diagnostics, CSX Transportation. She has over 30 years of rail industry experience, including work in locomotive engineering, car engineering, and industrial engineering. She serves on key technical committees, including chair of the AAR Equipment Health Monitoring Committee and member of the Asset Health Task Force.</p>	
<p>3. Edward "Ed" F. Boyle, Jr. Vice President of Engineering, Norfolk Southern Group. He has 26 years of engineering and management experience with Norfolk Southern. He is the Chairman of the AAR Infrastructure Systems Research Committee, a member of the AAR Railway Technology Working Committee, and a member of the AREMA Board of Governors.</p>	
<p>4. Alan E. Calegari President and CEO, MERMEC Inc. He has served in numerous senior executive positions including Director and Site Manager with PanAm World Services; Director and General Manager with Johnson Controls FMS Inc.; President & CEO Union Switch & Signal (US&S) lately named Ansaldo STS; President Siemens Building Automation-Security; President and CEO, Expert System USA Inc.</p>	
<p>5. Gary Fry, Ph.D. Vice President, Fry Technical Services Inc. He has 30 years of experience in education, research, and consulting on the design and behavior of railway infrastructure and mechanical systems and the fatigue and fracture behavior of structural metals and weldments. His research results have been incorporated into international codes of practice used in the design of structural components and systems.</p>	
<p>6. Amy Hamilton Principal Engineer, Trinity Industries She has worked with Trinity Industries since 2010 in new car engineering, fleet engineering and reliability, and currently in technical and regulatory compliance. She participates in AAR Tank Car Committee and the RSI Committee on Tank Cars Technical Sub-committee.</p>	

1.2.2 Research Projects: As discussed above, seventeen research projects have been selected with the guidance and approval of the UTCRS Advisory Board. The project titles with links to project descriptions are given in Table 3. All have been entered into the RIP (Research in Progress) database, and Exhibit D project descriptions are posted on the UTCRS website (<https://www.utrgv.edu/railwaysafety/research/index.htm>).

The projects are classified into three broad areas (Infrastructure, Mechanical, and Operations). Six projects have industrial partners providing technical support, access to data, and in-kind contributions of equipment or samples. Several of the projects have early-career faculty as PIs or co-PIs (Dr. Jia Chen, Dr. Gasser Ali, Dr. Ping Xu, Dr. Siang Zhou, Dr. Mustapha Rahmaninezhad, and Dr. Mohsen Amjadian).

Table 3 – Research Projects	
Projects approved for 2023CY	
1.	(Infrastructure) Enhancing the TAMU Model for Predicting Buckling in Rails. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs tamu rail buckling prediction 2023.pdf
2.	(Infrastructure) Development of a Computational Model for Predicting Fracture in Rails Subject to Long-Term Cyclic Fatigue Loading. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs tamu rail fracture prediction 2023.pdf
3.	(Infrastructure) Autonomous Rail Surface Defect Detection. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs usc automatic surface defect detection 2023.pdf
4.	(Infrastructure) Intelligent Aerial Drones for Traversability Assessment of Railroad Tracks. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs usc intelligent aerial drones 2023.pdf
5.	(Infrastructure) Rapid Detection of Track Changes from Onboard Data Acquisition Records. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs usc rapid detection of track stiffness changes 2023.pdf
6.	(Infrastructure) Rail Anchor Slip Force Testing. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs utrgv rail anchor slip force testing 2023.pdf
7.	(Mechanical) Non-Contact Energy Harvesting for Rural Grade Crossings. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs unl non-contact energy harvesting 2023.pdf
8.	(Mechanical) Ultrasonic Inspection of Reconditioned Railroad Bearings. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs unl ultrasonic inspection of reconditioned bearings 2023.pdf
9.	(Mechanical) AI-Enabled Intelligent Vibration Sensor for Active Highway-Rail Grade Crossings. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs utrgv ai-enabled-vibration-sensor-for-hrgc 2023.pdf
10.	(Mechanical) Effect of Long-Term Inactivity on Railcar Bearings. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs utrgv effect of long term inactivity on railcar bearings 2023.pdf
11.	(Mechanical) Next Generation On-Board Sensor Technologies for Rolling Stock. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs utrgv next generation on-board sensors 2023.pdf
12.	(Operations) Development of a National Track Safety Database. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs tamu national track safety database 2023.pdf
13.	(Operations) Mining and Learning from Railway Safety Data with Graphs and Tensors. https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs ucr mining and learning from railway safety data 2023.pdf
14.	(Operations) Pedestrian and Bicyclist Safety at Highway-Rail Grade Crossings (HRGCs). https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs unl pedestrian and bicycle safety at hrgcs 2023.pdf
15.	(Operations) Satellite Radar Data Analysis for Change Detection of Rural and Urban Railways https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs usc satellite radar data analysis 2023.pdf
16.	(Operations) Track Intrusion Detection and Track Integrity Evaluation https://www.utrgv.edu/railwaysafety/ files/documents/research/exhibit-d utcrs usc track intrusion detection 2023.pdf

17. (Operations) Grade Crossing Monitoring Using Deep Learning
https://www.utrgv.edu/railwaysafety/files/documents/research/exhibit-d_utcrs_utrgv_grade_crossing_monitoring_using_deep_learning_2023.pdf

1.2.3 Selection Process for 2024CY Research Projects:

The UTCRS has prepared a draft selection process for the next round of research projects. This draft has been approved by the Executive Committee and is now under review by the Advisory Board. Proposals will be accepted from any faculty or principal investigator (PI) eligible staff member from the consortium research institutions.

The selection criteria will include: (1) Relevance to UTCRS' strategic research goals and research focus areas. (2) Responsiveness to the expressed research needs of the rail industry including railroads, rail equipment manufacturers, and regulatory agencies. (3) Technical soundness and achievability within the proposed timeframe and budget. (4) Demonstrated expertise of the principal investigator and researchers applicable to the proposed project. (5) Adequate plans for technology transfer. (6) Significant commitment to student involvement. (7) If applicable, performance on previous USDOT UTC research projects including submission of reports and deliverables on deadline, meeting budget, and substantial accomplishment of project goals.

The review process will include: (1) An initial peer review, organized at each institution, to create a short list for submission to the next level, (2) a review by the UTCRS Executive Committee, and (3) a review by the UTCRS Advisory Board. Each level may reject, approve, or request revisions on proposals received.

After the Advisory Board review, the Director will make the final decision to fund Advisory Board approved projects only, consistent with the center budget. If there are remaining funds, the UTCRS may issue a second call for proposals.

1.2.4 Student Researchers: Table 4 shows the number of student researchers employed at the UTCRS during the reporting period. One of the columns includes the total number of students supported from all funding sources including federal and non-federal cost share, whereas the other column provides the number of students directly supported by federal funds.

Table 4 – Student Researchers Employed at UTCRS		
Student Researcher Classification	From All Sources	Federal Funds
Undergraduate Research Assistants	33	23
Masters' Research Assistants	10	6
Doctoral Research Assistants	10	9
Totals	53	38

Students funded by the UTCRS are also actively involved in education and outreach efforts through on-campus and off-campus community events where they present about the different transportation careers and opportunities available to students and talk about railway safety issues and ongoing research projects being conducted at the UTCRS. These students facilitate, on a regular basis, presentations, tours, and symposiums, and attend various community events and K-12 science fairs representing the UTCRS.

1.2.5 Bridge to Engineering Program: South Texas College (STC) is currently preparing recruiting and selection efforts for students to participate in the Summer 2024 UTCRS Bridge to Engineering Program. A recruitment committee has been established consisting of STC Associate Director Martin Knecht in addition to two STC engineering faculty members. The committee is developing an online application, a selection process, and strategies for student recruitment during the Spring 2024 semester. A draft of the online

application has been currently developed using Google forms and the committee is in the process of developing a selection rubric. These tools will be deployed during the Spring 2024 semester.

For the Summer 2023 UTCRS Bridge to Engineering Program, a formal recruiting and selection process was not yet in place since the grant was not funded until the end of the Spring 2023 semester. Despite this, 7 STC students were selected and participated. The students were recruited through engineering class visits, email announcements, and faculty referrals. Six of the seven STC students completed their associate degrees from STC over the summer and are now full-time students at UTRGV and involved in the UTCRS as undergraduate research assistants. The seventh student is expected to complete their associate degree at the end of this fall semester, and they intend to enroll at UTRGV full-time upon completion of their degree.

1.3 How have the results been disseminated?

1.3.1 Professional Community: For the professional community, the primary dissemination is through publications. Since June 2023, we have submitted 28 manuscripts, reports, and abstracts to journals and conferences; a complete listing is given in Table 6 in Section 3.1. However, UTCRS personnel have also been actively engaged in technical committees, panels, and industry organizations. These memberships provide opportunities to discuss UTCRS work and increase the center's exposure. Some highlights include:

- Dr. Constantine Tarawneh testified before the National Transportation Safety Board (NTSB) at the East Palestine hearings, specifically representing UTCRS as an expert on bearing-related train derailments and wayside detection systems (<https://www.nts.gov/news/events/Pages/East-Palestine-Hearing-Event.aspx>).
- Dr. Constantine Tarawneh is the University Outreach Chair for the 2024 Joint Rail Conference and also Chair of the Rail Safety and Security Track Session.
- Dr. Constantine Tarawneh serves as: (1) a member of the TRB Railroad Operating Technologies Committee (AR030), (2) a member of the Council of University Transportation Centers (CUTC) Executive Committee, (3) one of the four Directors of the Research and Education Division (RED) within the American Road and Transportation Builders Association (ARTBA), (4) campus manager for the Dwight David Eisenhower Transportation Fellowship Program (DDETFP) Local Competition held at UTRGV annually, and (5) member of the CUTC Student Awards Selection Committee.
- Dr. Constantine Tarawneh is a Guest Editor of a special issue for the Journal of Sustainability entitled "Sustainable Study of Railway Engineering and Rail Transportation." https://www.mdpi.com/journal/sustainability/special_issues/3UDYW6JUXR
- Dr. Dimitris Rizos is Chair of the 2024 Joint Rail Conference.
- Dr. Yu Qian is on Technical Committee (TC) 202, International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) and is part of the AAR Substructure Technical Advisory Group (TAG). He is Communication Coordinator for TRB committee AR060.
- Dr. Nikolaos Vitzilaios is Program Chair for the 2024 International Conference on Unmanned Aircraft Systems.
- Dr. Vagelis Papalexakis is co-Chair for the 2024 SIAM International Conference on Data Mining (SDM) 2024, and co-Chair for 2024 IEEE Data Science and Advanced Analytics (DSAA).

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

- Dr. Tarawneh gave expert interviews with numerous local, regional, national, and international media outlets on the East Palestine incident, again specifically representing UTCRS. Some of these outlets included [CNN](#), [Washington Post](#), [Bloomberg News](#), [trains.com](#), [Pittsburg Post-Gazette](#), [FREIGHTWAVES](#), [JURIST](#), [MEAWW.COM](#), [Ideastream Public Media](#), [Akron Beacon Journal](#), as well

as news segments with [Scripps News Morning Rush](#), and [Bloomberg Markets: The Close](#) (watch starting time frame 31:30 into the show).

- The Federal Railroad Administration (FRA) issued a [Safety Advisory 2023-01; Evaluation of Policies and Procedures Related to the Use and Maintenance of Hot Bearing Wayside Detectors](#). This advisory featured one of the journal articles published by the UTCRS research team led by Dr. Constantine Tarawneh.
- The lead institution, UTRGV, published a story regarding the new acquired USDOT UTC grant along with a summary of some of the stories that have been nationally circulating regarding the February 3, 2023, East Palestine, OH derailment and the expert opinion of Dr. Constantine Tarawneh regarding wayside detection systems and bearing-related train derailments. See story here: <https://www.utrgv.edu/newsroom/2023/03/09/utrgv-utcrs-awarded-grant-to-promote-railway-transportation-safety.htm>
- The UTCRS Facebook page (<https://www.facebook.com/utcrailwaysafety/>) has photos and news, particularly about K-12 events such as UTCRS Summer Camps and teacher workshops, awards received by UTCRS research 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.
- Our largest campus event is the UTCRS Railway Summer Camps, which engaged 1120 K-12 students (515 Elementary, 425 Middle School, and 180 High School) and 100 teachers. However, we also routinely give tours for incoming freshmen engineering students (“Boot Camp”) and general visitors from the community.
- Finally, our Program Coordinator, Ms. Manuela Cantu, has made direct contact with dozens of public-school administrators and teachers to notify them of upcoming events and opportunities.

In the next reporting cycle, we plan to add a newsletter to our dissemination plan. During the first year, we also hope to initiate a publicly accessible data portal, as promised in our Data Management Plan.

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

Our objectives for the next reporting period include:

- **Administrative**
 - Finalize the 2024CY Call for Proposals.
 - Receive and review 2024CY research proposals.
 - Attend and present at the January 2024 TRB UTC meeting.
 - Meet all USDOT and UTC reporting requirements.
 - Co-Sponsor the 2024 ASME Joint Rail Conference.
 - Complete preparations to host the 2024 Summer CUTC Meeting at South Padre Island, TX.
- **Research**
 - Continue work on approved 2023CY research projects.
 - Further increase engagement with industrial partners.
 - Submit manuscripts for journal and conference publications.
 - Organize and sponsor a Student Poster Session at the 2024 ASME Joint Rail Conference to highlight the work performed by the undergraduate and graduate students of the UTCRS.
- **Education and Workforce Development**
 - Continue employing, training, and developing undergraduate and graduate student researchers and engaging them in workshops, seminars, webinars, and conferences.
 - Give students opportunities to take on more responsibilities by directly interacting with the various industry partners of the UTCRS and engaging them in research activities performed as part of the joint projects which involve on-site work at partner facilities.

- Offer transportation related courses for the Spring 2024 semester.
- **Engagement and Outreach**
 - Begin enrolling students and school districts for 2024 UTCRS STEM Summer Camps.
 - Disseminate center products through our website, presentations, publications, and industry meetings.
 - Issue a UTCRS newsletter.

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

- Hold regular (at least monthly) meetings of the Executive Committee.
- Hold regular (at least twice per year) meetings with our External Advisory Board.
- Hold bi-weekly meetings of faculty with research students to provide guidance.
- Have students present at bi-weekly meetings to build confidence and professionalism.
- Make sure faculty and students are aware of conference deadlines and other opportunities to publish their work.
- 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

What organizations have been involved as partners?

Table 5 – Participants and Collaborating Institutions	
Organization and Location	Contribution
University of Texas Rio Grande Valley (UTRGV) Edinburg, TX	Consortium Institution and Project Lead Financial and in-kind support for five research projects, totaling \$238,890 committed for the current project cycle. Facilities supporting UTCRS include two bearing test labs with five bearing testers, a bearing inspection lab, and an office/electronics lab for students. UTCRS has access to UTRGV's comprehensive material test facilities and a CNC-equipped machine shop. UTRGV hosts the UTCRS STEM summer camps.
University of South Carolina (UofSC) Columbia, SC	Consortium Institution Financial and in-kind support for five research projects, totaling \$149,648 committed for the current project cycle. Research facilities available for UTCRS activities include a two-story, 7,400 ft ² high bay configured to conduct testing on full-scale structures or components of the railroad infrastructure. The research team has access to a fully equipped Materials Laboratory and Geotechnical Laboratory.
University of Nebraska – Lincoln (UNL) Lincoln, NE	Consortium Institution Financial and in-kind support for three research projects, totaling \$144,474 committed for the current project cycle. Facilities available for UTCRS activities include the Nebraska Transportation Center (NTC) Intelligent Transportation Systems (ITS) Lab, approximately 2000 ft ² . The ITS lab is integrated with a

	number of UNL test beds as well as with current city and state traffic monitoring systems.
Texas A&M University (TAMU) College Station, TX	Consortium Institution Financial and in-kind support for three research projects, totaling \$258,913 committed for the current project cycle. Facilities available for UTCRS activities include the Center for Infrastructure Renewal (TAMU-CIR) with extensive capabilities described at https://cir.tamu.edu/facilities/ .
University of California Riverside (UCR) Riverside, CA	Consortium Institution Financial and in-kind support for one research project, totaling \$50,000 committed for the current project cycle. Computing facilities made available for UTCRS work include a Lambda Vector Server with three NVIDIA RTX A6000 GPUs.
South Texas College (STC) McAllen, TX	Consortium Institution STC operates the UTCRS Bridge to Engineering program. STC faculty and staff recruit students for the program, run the selection program, and provide orientation for students in the program.
MxV Rail Pueblo, CO	Industry Collaborator MxV Rail is currently providing technical support and consultation for several 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 on-board sensor development at UTRGV. In the future, it is planned that MxV Rail will make two railcars available for UTCRS instrumentation, provide comparisons with wayside detector data, and host UTCRS student researchers at their Pueblo facility.
HUM Industrial Technology St. Louis, MO	Industry Sponsor HUM Industrial financially sponsors on-board 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 samples of 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.
The Timken Company North Canton, OH	Industry Collaborator Timken is a partner in the inactive rail bearing study and will identify and provide samples as well as ensure that testing protocols adhere to bearing manufacturer standards and Association of American Railroad (AAR) guidelines.
Rio Valley Switching Company McAllen, TX	Industry Collaborator Rio Valley will provide access to their grade crossings in support of the AI-enabled vibration sensor project.
Schaeffler Group Fort Mill, SC	Industry Sponsor Schaeffler financially sponsors AAR certification tests conducted at UTCRS on our bearing test rigs.

RSAE Labs Panama City, FL	Industry Sponsor RSAE Labs has contracted the UTCRS to perform a study of available rolling stock condition monitoring systems currently in use and how they can integrate to the company's Mist system of communication.
Geospace Technologies Houston, TX	Industry Collaborator Geospace Technologies is using the UTCRS acquired library of vibration signatures collected for healthy and defective bearings to develop their onboard sensor technologies. In accordance with our UTCRS Data Management Plan, we are providing rail industries with access to bearing data accumulated over two decades of testing.
National Transportation Safety Board (NTSB) Washington, DC	Government Agency Collaborator The NTSB is interested in bearing laboratory testing performed on reconditioned bearings and have expressed interest in learning about the performance of bearings that experience long periods of inactivity as these have been linked to a number of catastrophic derailments including the East Palestine, OH derailment. They are collaborating on the UTCRS funded project that is examining the effect of long periods of inactivity on railroad bearing performance.
Vanguard Academy Edinburg, TX	Community Collaborator Vanguard Academy has been participating in the annual UTCRS STEM Summer Camps for over 7 years now. The UTCRS also organizes regular facility tours for K-12 students at Vanguard Academy led by the UTCRS student researchers and we organize and run a 3-day solar car competition for middle school students every Fall and Spring semester sponsored by Vanguard Academy.
Region One Education Service Center Edinburg, TX	Community Collaborator The Region One Education Service Center is part of a state-wide system of 20 regional education service centers created in 1965 by the 59th Texas Legislature to assist school districts across the state. Located in South Texas on the United States/Mexico border, Region One ESC serves 38 school districts and 10 charter school systems in the eight county areas of Brooks County, Cameron County, Hidalgo County, Jim Hogg County, Starr County, Webb County, Willacy County, and Zapata County. The UTCRS assists Region One by organizing laboratory tours and student presentations to attract K-12 students to STEM disciplines with a focus on transportation engineering. The UTCRS also organizes and runs monthly one-day engineering camps for high school and middle school students.
IDEA Public Schools Weslaco, TX	Community Collaborator IDEA Public Schools participate in the annual UTCRS STEM Camps.
La Joya Independent School District (ISD) La Joya, TX	Community Collaborator La Joya ISD participates in the annual UTCRS STEM Summer Camps.
Weslaco Independent School District (ISD) Weslaco, TX	Community Collaborator Weslaco ISD participates in the annual UTCRS STEM Camps.
Pharr-San Juan-Alamo ISD Pharr, San Juan, Alamo, TX	Community Collaborator PSJA ISD participates in the annual UTCRS STEM Summer Camps.
Monte Alto ISD Monte Alto, TX	Community Collaborator Monte Alto ISD participates in the annual UTCRS STEM Camps.
Valley View ISD Pharr, TX	Community Collaborator Valley View ISD participates in the annual UTCRS STEM Camps.
Edcouch-Elsa ISD Edcouch, Elsa, TX	Community Collaborator Edcouch-Elsa ISD participates in the annual UTCRS STEM Camps.

Sharyland ISD Mission, TX	Community Collaborator Sharyland ISD participates in the annual UTCRS STEM Camps.
La Feria ISD La Feria, TX	Community Collaborator La Feria ISD participates in the annual UTCRS STEM Summer Camps.
Los Fresnos CISD Los Fresnos, TX	Community Collaborator Los Fresnos CISD participates in the annual UTCRS STEM Camps.
Mercedes ISD Mercedes, TX	Community Collaborator Mercedes ISD participates in the annual UTCRS STEM Camps.
Progreso ISD Progreso, TX	Community Collaborator Progreso ISD participates in the annual UTCRS STEM Camps.
Donna ISD Donna, TX	Community Collaborator Donna ISD participates in the annual UTCRS STEM Summer Camps.

3. OUTPUTS

3.1 Publications, conference papers, and presentations

A list of journal and conference submissions and publications is given in Table 6. Since this is the first reporting period, the list is weighted toward submissions; we anticipate that the majority of submissions will move to published/presented status in the next few reporting cycles. As can be seen, the UTCRS principal investigators and their research students have made a specific effort to target the 2024 ASME Joint Rail Conference (JRC), since it is the primary conference venue for disseminating recent progress in rail research. One of our associate directors, Dr. Dimitris Rizos at the University of South Carolina, is the 2024 Conference Chair and the UTCRS Director, Dr. Constantine Tarawneh, is the University Outreach Chair. Moreover, the UTCRS is a sponsor of the 2024 ASME JRC and organizers of a student poster session.

Table 6 – Journal and Conference Publications		
Citation	Type	Status
1. “On the Use of InSAR Techniques to Detect Precursors of Shallow Geohazards in Railway Right of Way,” AREMA 2023 Annual Conference, Indianapolis, IN	Conference	Published
2. “Rail surface spot irregularities in VTI simulations of train-track-bridge interaction,” Journal of Vibration and Control	Journal	Submitted
3. “On the use of B-Spline Signature Responses to detect structural change,” Structural Health Monitoring	Journal	Submitted
4. “Enhancing Railway Safety Through Satellite-Based Monitoring for Rockfall Potential,” 2024 ASME Joint Rail Conference	Conference	Submitted
5. “Investigating the Use of B-Spline Signature Responses to Detect Internal Rail Defects,” 2024 ASME Joint Rail Conference	Conference	Submitted
6. “A Hybrid Rail Surface Spot Irregularities (RSSI) Detection Algorithm Based on Onboard Measurements,” 2024 ASME Joint Rail Conference	Conference	Submitted
7. “UAV Imagery-Based Rail Surface Defects Detection Using EGNET and Incremental Learning,” 2024 ASME Joint Rail Conference	Conference	Submitted
8. “Railroad Crossing Intrusion Detection Based on UAV-Image and Open-World Object Detection,” 2024 ASME Joint Rail Conference	Conference	Submitted
9. “Performance of a Mobile, Non-Contacting, Reference-Free Prototype System for RNT and Rail Stress Measurements,” 2024 ASME Joint Rail Conference	Conference	Submitted
10. “Spectral Clustering in Railway Crossing Accidents Analysis,” 2024 ASME Joint Rail Conference	Conference	Submitted
11. “Kernel Ridge Regression in Predicting Railway Crossing Accidents,” 2024 ASME Joint Rail Conference	Conference	Submitted

12. R. Salinas, D. Hinojosa, C. Tarawneh, H. Foltz, "LoRa Wireless Temperature and Vibration Sensor," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
13. C. Tarawneh, A. Martinez, M. Adame, S. Garcia, J. Pams, C. Pena, "Healthy and Defective Railroad Tapered Roller Bearing Temperature Metrics," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
14. D. Capitanachi, G. De Leon, C. Rodriguez, C. Tarawneh, H. Foltz, "Powering Onboard Bearing Health Monitoring Sensor with Thermoelectric Generators Under Non-Uniform Temperatures," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
15. A.D.S. Trinidad, S. Gutierrez, C. Pena, D. Aguila, C. Tarawneh, "Investigating the Effects of Lateral Loading on the Performance of Railroad Tapered Roller Bearings," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
16. K. Quaye, P. Xu, D. Dera, H. Foltz, C. Tarawneh, A. Diaz, "Feature Extraction from Vibration Signatures Acquired from Railroad Bearing Onboard Condition Monitoring Sensor Modules," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
17. "Computational Model for Predicting Liff-off Induced Buckling in Rail Structures," ASCE Journal of Applied Mechanics	Journal	Submitted
18. G. Whetstone, T. Liu, P. Fudlailah, C. V. Drodody, D. H. Allen, "Experimental Evaluation of Crack Evolution in Rails Using a Phased Array," Journal of Nondestructive Evaluation, 42 (97), 06 November 2023.	Journal	Published
19. C. Tarawneh, B. Wilson, B. Porter, L. Cantu, "Historical Implications of Wayside Detector Systems and their Ability to Detect Hot Bearing Derailments," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
20. H. Gorabi, S.M. Rahmaninezhad, A. Sanchez, C. Tarawneh, S. Zhou, A. Fuentes, S. Wilk, "Experimental Study on Longitudinal Track Resistance of Anchored Rail," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
21. J. Rodriguez, S. Zhou, C. Tarawneh, T. Salazar-Flores, H. Gorabi, S.M. Rahmaninezhad, "Development of Rail Anchor Testing Through Literature Review of CWR Buckling Resistance Evaluation," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
22. J. Pams, C. Tarawneh, J. Montoya, B. Wilson, L. Cantu, H. Alkhaldi, "Railroad Track and Wheel Defect Detection with Onboard Condition Monitoring System," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
23. D. Espinoza, G. Ali, C. Tarawneh, "AI-Based Hazard Detection for Railway Crossings," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted
24. A.J. Khattak, M.N. Aman, M.U. Farooq, "Pedestrian and Bicyclist Exposure Prediction Models for Highway-Rail Grade Crossings," 2024 ASME Joint Rail Conference	Conference	Submitted
25. "High-Strength, Reduced-Modulus, High-Performance Concrete for Prestressed Concrete Crosstie Applications," FRA Research Results	Technical Report	Completed
26. T. Adelung, S. Martinez, A.J. Fuller, L.F. Ammerlaan, J.A. Turner, "Ultrasonic Nondestructive Quantification of Case Depth in Railroad Bearings: Statistical Analysis and Machine Learning Prediction," 2024 ASME Joint Rail Conference	Conference	Submitted
27. J.A. Turner, A.J. Fuller, B.J. Gray, M. McConnell, N.J. Matz, T.M. Liebe, "Rolling Contact Fatigue Performance of Railroad Bearing Rollers Manufactured using Laser Powder Bed Fusion," 2024 ASME Joint Rail Conference	Conference	Submitted
28. J. Pams, C. Tarawneh, D. Rocha, B. Wilson, L. Cantu, H. Alkhaldi, "Optimized Vibration-Based Health Metrics for Freight Rail Bearings," 2024 ASME Joint Rail Conference	Conference	Abstract Accepted

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

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. The goal is to have a complete repository of photo galleries, videos, news articles, and professional scholarly work and publications that carefully document the UTCRS operations and activities over the past five years. It already contains visitor information, a listing and description of all current and past research projects, links to reports on completed projects, registration information for center activities such as summer camps, and listings of key personnel and our Advisory Board. The publication section is currently being updated, and the Call for Proposals for 2024CY will be updated pending approval by our Advisory Board. We hope to add a portal for access to research data during the upcoming year.

UTCRS also 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:

- New non-destructive testing (NDT) techniques for rails.
- New calibration strategies for on-board load sensors.
- New systems for early detection of track degradation.
- New AI techniques for detecting intrusions on tracks.
- New models for rail buckling.
- New energy harvesting techniques to power wireless sensors for rail systems.

3.4 Inventions, patent applications, and/or licenses

No new patents or licenses to report this period.

3.5 Other products

Other products during the June-October 2023 reporting period include:

- 2 MS theses
- 1 Doctoral dissertation
- 1 Technical Report to FRA
- K-12 grade-appropriate STEM curriculum for Elementary, Middle School, and High School produced by UTCRS faculty in collaboration with K-12 teachers participating in the Research Experience for Teachers (RET) Program funded by the UTCRS UTC grant.

4. OUTCOMES

Given that this is the first reporting period in the life cycle of the grant, the outcomes are somewhat limited since the main efforts concentrated on getting the UTCRS projects approved by the Executive Team and the External Advisory Board. Some of the notable outcomes during this period are as follows:

Research: The UTCRS research team hit the ground running building on momentum from the ongoing collaboration with the industry partner HUM Industrial Technology, Inc., where the UTCRS-UTRGV team has been assisting with the implementation and deployment of the wireless on-board condition monitoring system in pilot tests in freight revenue service across North America. The prototype sensors were assembled, tested, and validated at the UTRGV-UTCRS facilities by student researchers under the

supervision of faculty and HUM engineers. Picture 1 depicts HUM CEO and CTO overseeing the assembly and preparation of the first batch of HUM Boomerangs that were deployed in a pilot test over the summer of 2023. Picture 2 was taken during the deployment of the sensors in a pilot test. The acquired data from this pilot test resulted in the identification and removal of two wheel axle assemblies with condemnable damage on the wheel tread. The data has also identified several segments of bad track. Research is ongoing and two conference publications have been submitted with the initial results of this work.



Education, Workforce Development, and Community Engagement:

The UTCRS organized and ran six different education and workforce development programs during the summer of 2023. These six programs involved 10 UTRGV faculty, 23 undergraduate and graduate students, 7 STC students participating in the Bridge to Engineering Program, 4 High School Interns, 12 K-12 STEM teachers participating in the RET Program, 8 REUs, and 1120 K-12 students in the summer camps.



Picture 3 depicts the faculty, staff, students, teachers, and high school interns that participated in the various education and workforce development programs in Summer 2023. The outcomes of these programs are as follows:

Student Training: The UTCRS engaged in research and trained 23 undergraduate and graduate students who not only participated in the scholarly activities of the new projects funded by the UTCRS but also assisted in the 2023 UTCRS STEM Summer camps as mentors for the K-12 students hosted at UTRGV.

Research Experience for Undergraduates (REU) Program: The UTCRS facilitated the selection of 8 UTRGV undergraduate student participants (all Hispanic U.S. Citizens) where each consortium partner (UNL, UofSC, TAMU, and UCR) hosted two students and engaged them in a 10-week research intensive experience working on UTCRS synergistic projects between UTRGV and the consortium partners. All 8 students have since returned to UTRGV and have been retained and are working on UTCRS funded projects in collaboration with the faculty at the consortium partners. All 8 students have expressed their intent to join the graduate programs at their respective departments and continue working at the UTCRS.

Research Experience for Teachers (RET) Program: The UTCRS hosted 12 K-12 STEM teachers participating in this 5-week research and training program. The teachers developed grade-appropriate curricula for elementary, middle school, and high school grades with the assistance of UTRGV-UTCRS faculty and students. The developed curricula involve hands-on activities focusing on STEM concepts aligned with the learning objectives at their grade levels. The activities and teaching modules feature engineering applications relevant to transportation with an emphasis on railway safety. The developed curricula will be posted on the UTCRS website once it has been formatted for dissemination.

Bridge to Engineering (B²E) Program: The UTCRS hosted 7 students, 6 of whom have completed their associate degrees at the UTCRS community college partner, South Texas College (STC), where they were engaged in research and education activities of the center. Moreover, to facilitate their transition to a 4-year degree at UTRGV, the UTCRS faculty mentored and advised these students during the summer and helped them enroll in two courses, paid for by the UTCRS, that count towards their respective degrees. This inaugural program for the UTCRS was a huge success as all students are now enrolled in engineering programs at UTRGV pursuing their bachelor's degrees in mechanical, civil, and electrical engineering. These students are also retained by the UTCRS as they are now undergraduate research assistants involved in the various UTCRS funded research projects. This program accomplished its goals thus far.

High School Interns: The UTCRS hosted 4 high school interns for an 8-week period during the summer. These students were engaged in the various research and education activities of the UTCRS and were mentored by undergraduate and graduate students who shared their experience with these interns in an effort to excite them to pursue careers in engineering and the transportation field.





K-12 STEM Summer Camps and Teacher Workshop: The UTCRS hosted 1120 K-12 students and 100 teachers during the month of June 2023 at the UTRGV campus. The teachers who participated in the summer camps were all trained beforehand during a teacher workshop organized and run by UTRGV-UTCRS faculty and staff on May 20, 2023. The purpose of this workshop is to expose the teachers to the developed curricula and hands-on activities so they can assist the RET teachers and UTRGV faculty and students during the camps. The teachers were provided with certificates of completion and as part of their training, these teachers have access to the UTCRS robotic kits, iPads, and all other material needed to implement the specific curriculum in their classes. These summer camps and teacher workshops have been increasing awareness in 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. Pictures 4 and 5 depict students engaged in the STEM summer camp activities. Picture 6 shows a group of high school female students (all Hispanic U.S. Citizens), who have expressed their interest in STEM careers, participating in the UTCRS facilities tour which is part of the summer camp activities. The picture also depicts two of our External Advisory Board Members, Ms. Amy Hamilton from Trinity Industries and Ms. Kim Bowling from CSX Transportation, who were also part of the tours during their on-site board member meeting. The Advisory Board witnessed in-person our STEM summer camps and our final competition. Ms. Kim Bowling was our keynote speaker during our 2023 UTCRS Summer Camps closing ceremony. These camps have contributed to a significant increase in female participation in STEM activities at UTRGV, which is evident by the increase in the number of our female undergraduate and graduate students involved in the various UTCRS research, education, and workforce development activities.

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 effect will be a reduction in injuries, fewer service stoppages, and more cost-effective maintenance.

Our first cycle of research projects has just started, and it is expected that the most significant impacts will come when the projects are more mature. However, at this early stage, a number of tangible, completed advances can be identified:

- Reconditioned bearing safety: An ongoing industry sponsored UTCRS project is conducting lifetime tests on reconditioned bearings. This work has already confirmed that reconditioned bearings with no apparent defects on the cone or cup surface can have subsurface defects leading directly to early failure. The results show the need for new non-destructive inspection protocols.
- Longer sensor life: An industry sponsored UTCRS project in the first reporting period identified several causes of battery drain in a commercial on-board sensor. The details are proprietary; however, this work led directly to design changes that multiply the battery life and support more frequent reporting.
- Increased workforce pool: More than two dozen students have received direct, hands-on training in rail specific skills like bearing assembly, disassembly, and inspection; testing of components to AAR specifications; mounting bearings on axles; mining databases of on-board sensor data to identify potential failures; developing Artificial Intelligence (AI) and Machine Learning (ML) algorithms for predictive maintenance.

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

The UTCRS is currently working on two projects that are of great interest to the NTSB as they relate to the ongoing investigation concerning the East Palestine, OH train derailment. The cause of that derailment is believed to be a reconditioned railroad bearing that experienced two long stretches of inactivity, one for 208 days, and another for 565 days. Hence, one of the UTCRS projects is investigating the effect of long periods of inactivity on railroad bearings in service, and the other is investigating the efficacy and performance of reconditioned bearings. The results of both projects are expected to contribute invaluable to the investigation report that will be prepared by the NTSB. These projects bring together a government agency (NTSB) with rail industry partners (MxV Rail and Timken), Class I Railroad (CSX Transportation), and the UTCRS. The results of these studies are expected to impact processes and procedures used to recondition railroad bearings, and operation protocols regarding acceptable periods of bearing inactivity in freight rail revenue service. The UTCRS is the only center performing these studies and the results will be disseminated through conference and journal publications and presentations, technical reports, seminars and webinars, and professional workshops.

Moreover, the 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., and these technologies form the basis of this company. One of the UTCRS students who completed his master's degree was hired by HUM as a Product Engineer, and he is stationed at the UTCRS to oversee the testing, validation, implementation, and deployment of the UTCRS-HUM developed on-board wireless rolling stock condition monitoring system. This collaboration demonstrates how work performed at the UTCRS has led to the formation of HUM, and how workforce development efforts have been successful in placing UTCRS graduates in the rail industry, thus providing both technical and human capital.

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

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

During the current reporting period, UTCRS personnel submitted papers for publication on a wide range of technical topics. Some examples are:

- A study with new insights on combining thermoelectric generators in rail applications.
- A proposal for synchronized data collection in on-board sensors.
- Thermal studies on damaged roller bearings.
- Improvements in recognizing intrusions on the railroad right-of-way.
- Improved models for rail buckling.
- Applications of AI to UAV images of railroad tracks to identify changes.
- Predicting rockfall potential from satellite images.
- Characterizing the performance of rail anchors.
- Characterizing the performance of in-service bearings with long periods of inactivity.

5.4 What is the impact on transportation workforce development?

Since its inception, the UTCRS has engaged over 800 undergraduate and graduate students in its various research, education, technology transfer, professional development, and community outreach activities. These students are mentored by a team of highly qualified and dedicated faculty who are committed to providing a well-rounded education and research experience in the transportation engineering field. Students develop valuable skill-sets through hands-on projects relevant to the railroad industry, preparing technical reports and briefs on work accomplished, co-authorship of journal and conference papers, presentation at local and national symposiums and conferences, and writing and defending theses and dissertations, making these students workforce ready upon graduation.

In addition to developing well-rounded transportation engineering workforce skills in research students, the UTCRS educates and provides development opportunities for a largely Hispanic student population that is statistically underrepresented in the professional transportation field. Over a third of the UTCRS students have been female, which is approximately double the national average in transportation related occupations.

During the current reporting cycle, two UTRGV students working with the UTCRS graduated with MS degrees and have since joined the University of Nebraska-Lincoln (UNL), a consortium partner, to pursue their doctoral degrees. These two students are currently working on UTCRS funded projects at UNL, which demonstrates the strong and efficient pipeline that has been established by the UTCRS consortium, offering historically underrepresented students in STEM with the opportunity to pursue their doctoral degrees in transportation-related research. Moreover, one student completed their doctoral degree, and 61 students renewed their employment with the center. Since June 2023, UTCRS students have taken primary responsibility for professional-level tasks for our industrial sponsors including:

- Setting up and conducting bearing durability and accelerated life tests for industry to AAR standards and including an AAR audit.
- Evaluating energy harvesting systems for commercial field deployment.
- Developing and maintaining control and data acquisition systems for bearing testers.
- Bearing teardowns and inspections including preparation of technical reports that summarize the results of the teardowns and inspections.
- Monitoring of incoming data streams from on-board sensors and reporting results and summaries to industry partners and Class I railroads.

UTCRS is producing graduates who can, and have been, immediately productive in the rail industry. 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. Since its inception, the UTCRS has engaged and trained more than 850 teachers, program coordinators, counselors, and administrators on how to implement the UTCRS Curricula in diverse educational settings. During Summer 2023 alone, in the first reporting period, we reached 1120 K-12 students and 100 K-12 educators, which include 12 teachers who participated in the UTCRS Research Experience for Teachers (RET) Program.

6. CHANGES/PROBLEMS

6.1 Changes in approach and reasons for change

Based on input from our Advisory Board, the list of funded projects for 2023CY differs from the projects initially suggested in the Prospectus originally submitted to USDOT. The new and revised projects are more directly relevant to industry needs and have a significantly increased level of industry collaboration. The new list of projects was selected to align with the originally proposed first year budget; therefore, there was no impact on expenditures.

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

The UTCRS submitted a Data Management Plan (DMP), which was revised based on recommendations of the OST-R Grant Manager, and then approved by OST-R. All project PIs have been informed of the DMP requirements. The lead institution, UTRGV, has taken responsibility for making sure the requirements are fulfilled, and will host all databases and reports.