Semi-Annual Progress Report for University Transportation Centers

Reporting Period [October 1, 2023 – March 31, 2024]

- **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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- **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)

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- **Signature of Submitting Official**

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 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 reporting period, our major goals were to:

- Collect and review research project proposals for the 2024 Calendar Year (CY2024):
  - Create a revised call for proposals, based on External Advisory Board guidance.
  - Distribute the call for proposals at consortium member institutions.
  - Receive proposals and review at the institution and Executive Committee levels.
  - Submit candidate proposals to the External Advisory Board for review and recommendations.
- Serve as host institution for the upcoming 2024 CUTC Summer Meeting:
  - Work with USDOT and CUTC leadership on structure and schedule for meeting.
  - Reserve venues, transportation, and catering services at the South Padre Island meeting site.
  - Arrange for tours with SpaceX and the Brownsville Port Authority for 85+ guests.
  - Create and roll out an online registration system and begin accepting registrations.
  - Arrange for keynote speakers and panelists for the planned workshops and sessions.
- Continue execution of seventeen (17) first-year research projects:
  - Recruit and maintain personnel for the projects and make progress on research work.
  - Further develop connections with industry partners for the projects.
  - Submission of publications and professional presentations based on research results.
- Educate students and develop technical workforce:
  - Offer transportation related courses.
  - Hire graduate and undergraduate students for UTCRS projects.
  - Plan 2024 summer research experiences, including collection and review of applications and selection of participants for the 10-week workforce development experience at MxV Rail.
- Engage the community in rail related activities:
  - Offer transportation related K-12 STEM activities including tours of UTCRS facilities.
  - Recruit, advertise, and plan for the 2024 UTCRS K-12 STEM 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**
Held regular meetings of the UTCRS Executive Committee	**Complete**	**100%**
Revised Call for Proposals for CY2024 Research Projects	**Complete**	**100%**
Released Call for Proposals and received twenty (20) CY2024 research proposals	**Complete**	**100%**
Reviewed CY2024 proposals at institution and executive committee levels	**Complete**	**100%**
Submitted CY2024 proposals to External Advisory Board for technical review.	**Under Review**	**100%**
Reserved venues and services for 2024 CUTC Summer Meeting hosted by UTCRS	**Complete**	**100%**
Created and rolled out registration site for 2024 CUTC Summer Meeting	**Complete**	**100%**
Attend and present at the January 2024 USDOT UTC meeting	**Complete**	**100%**
Research & Technology Transfer	**Status**	**% Complete**
Continue work on seventeen (17) UTCRS-funded research projects for 2023-2024. Further details in Section 1.2.2 Research Projects and Section 4 Outcomes.	**On Schedule**	**60%**
Thirteen (13) new conference and journal publications were accepted/published.	**Complete**	**100%**
Twenty-one (21) conference and journal publications previously reported as submitted are now accepted/published.	**Complete**	**100%**
Submitted two (2) new US patent applications	**Under Review**	**100%**
Took ten (10) students who received the Dwight David Eisenhower Transportation Fellowship to present at the January 2024 TRB meeting in Washington, DC	**Complete**	**100%**
Organized and sponsored a Student Poster Session at the 2024 ASME Joint Rail Conference to highlight the work performed by the students of the UTCRS.	**On Schedule**	**50%**
Inauguration of a second bearing tester laboratory, including construction of two new four bearing testers with associated upgrades to HVAC, power, instrumentation, and communications.	**Complete**	**100%**
Development of new rail anchor slip test system, including construction, instrumentation, and demonstration to industry personnel and Class I railroad.	**Complete**	**100%**
Ongoing endurance testing of reconditioned bearings (MxV Rail funded)	**Ongoing**	**60%**
Performed a review of onboard sensor technologies and communications requirements for onboard sensors. (RSAE Labs funded)	**Complete**	**100%**
Evaluation of onboard condition monitoring systems for commercial applications, including calibration, evaluation of component suitability, energy harvesting studies, and data analysis. (HUM Industrial Technologies funded).	**Ongoing**	**67%**
Continued existing agreements for cooperation with industry partners including MxV Rail, CSX Transportation, BNSF, Rio Valley Switching Company, HUM Industrial, Schaeffler, and RSAE Labs.	**Ongoing**	**75%**
Education & Workforce Development	**Status**	**% Complete**
Hired **75** graduate and undergraduate students on UTCRS research projects	**Complete**	**100%**
Commitments obtained from school districts for approximately 1000+ K-12 students and teachers to attend the 2024 UTCRS Railway Safety Summer Camps	**Complete**	**100%**
323 students in transportation related courses taught by UTCRS affiliated faculty.	**Ongoing**	**90%**
Three (3) additional MS thesis graduates and two (2) additional PhD graduates.	**Completed**	**100%**
Recruitment of students for the 2024 UTCRS Bridge to Engineering (B2E) Program	**Completed**	**100%**
Engagement & Outreach	**Status**	**% Complete**
Finalize registration for 2024 UTCRS Railway Safety STEM Summer Camps.	**On Schedule**	**80%**

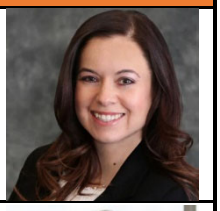
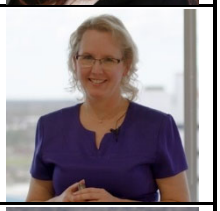
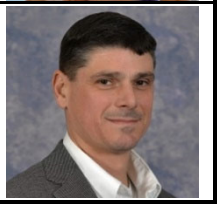
Arrange activities, personnel, and materials for summer camps	**On Schedule**	**85%**
Onsite visits to UTCRS facilities by MxV Rail, CSX Transportation, BNSF, HUM Industrial, Schaeffler, CTRL Systems, and the Brotherhood of Railroad Signalmen.	**Completed**	**100%**
UTCRS Website updates	**Ongoing**	**80%**

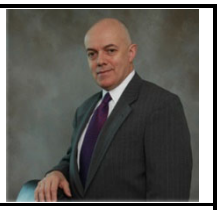
1.2.1 Advisory Board: During the first reporting period, UTCRS established an external advisory board that has been actively and deeply engaged in giving direction to our research and operations. The members and their brief biographies are given in Table 2. A new member representing NTSB was added in 2024.

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. During the first reporting period the Board took significant actions including: (a) Review of 19 initial research proposals, (b) Approval of four (4) of the initial proposals as submitted, (c) Rejection of five (5) of the initial proposals as submitted, (d) Recommended revisions to ten (10) of the initial proposals, and (e) Approval of thirteen (13) revised proposals, for a total of 17 funded projects for Year 1.

During the second reporting period, the Board is currently reviewing 20 proposals submitted from five consortium institutions. We expect the results of their review by May 10, 2024. During this period, the Board members have continued to engage with the UTCRS director and research faculty in suggesting opportunities for collaboration, suggesting research projects (several of which have resulted in proposals for second year projects), and consulting about industry needs and capabilities. 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 current 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 made significant progress and are successfully gathering data. 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 Technology, Inc.

Table 2 - UTCRS External Advisory Board

1. **Kari L. Gonzales** **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.	
2. **Kim Bowling (Chair)** **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.	
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.	

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.	
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.	
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.	
7.	**Joey Rhine (New Member added in 2024)** **Mechanical Subject Matter Expert, National Transportation Safety Board** After 9 years in the US Navy, he worked for Union Pacific until 2007 as a Manager of Locomotive Maintenance. In 2007 he started his career with the Federal Railroad Administration as a safety inspector in Southern California where he enforced 49 CFR regulations and investigated railroad accidents. Since 2014 he has been with the NTSB as a mechanical subject matter expert and as Investigator in charge of multiple rail incidents.	

1.2.2 Ongoing Research Projects: As discussed above, seventeen research projects have been selected with the guidance and approval of the UTCRS External 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 – CY2023 Research Projects funded by UTCRS
1. **(Infrastructure) Enhancing the TAMU Model for Predicting Buckling in Rails.**
2. **(Infrastructure) Development of a Computational Model for Predicting Fracture in Rails Subject to Long-Term Cyclic Fatigue Loading.**
3. **(Infrastructure) Autonomous Rail Surface Defect Detection.**
4. **(Infrastructure) Intelligent Aerial Drones for Traversability Assessment of Railroad Tracks.**
5. **(Infrastructure) Rapid Detection of Track Changes from Onboard Data Acquisition Records.**
6. **(Infrastructure) Rail Anchor Slip Force Testing.**
7. **(Mechanical) Non-Contact Energy Harvesting for Rural Grade Crossings.**
8. **(Mechanical) Ultrasonic Inspection of Reconditioned Railroad Bearings.**
9. **(Mechanical) AI-Enabled Intelligent Vibration Sensor for Active Highway-Rail Grade Crossings.**
10. **(Mechanical) Effect of Long-Term Inactivity on Railcar Bearings.**

11. **(Mechanical)** Next Generation On-Board Sensor Technologies for Rolling Stock.
12. **(Operations)** Development of a National Track Safety Database.
13. **(Operations)** Mining and Learning from Railway Safety Data with Graphs and Tensors.
14. **(Operations)** Pedestrian and Bicyclist Safety at Highway-Rail Grade Crossings (HRGCs).
15. **(Operations)** Satellite Radar Data Analysis for Change Detection of Rural and Urban Railways.
16. **(Operations)** Track Intrusion Detection and Track Integrity Evaluation.
17. **(Operations)** Grade Crossing Monitoring Using Deep Learning.

1.2.3 Selection Process for 2024CY Research Projects: The UTCRS is using a revised selection process for the next round of research projects. The revised process has been reviewed by both the Executive Committee and the Advisory Board. Proposals will be accepted from any principal investigator (PI) eligible faculty/staff member from the consortium research institutions.

The selection criteria now include: (1) Relevance to UTCRS' strategic research goals, (2) Responsiveness to the expressed research needs of the rail industry, (3) Technical soundness and achievability within the proposed timeframe and budget, (4) Demonstrated and applicable expertise of the project personnel, (5) Plans for technology transfer, (6) Commitment to student involvement, and (7) Performance on previous USDOT projects including submission of reports and deliverables on deadline.

The review process now includes: (1) An initial peer review and short list, organized at each institution, (2) review by the UTCRS Executive Committee, and (3) review by the UTCRS Advisory Board. Each level may reject, approve, or request revisions on proposals received. For the upcoming CY2024 funding cycle, twenty (20) proposals have been received. We have currently completed Steps 1 and 2 of the review process, and Step 3 is scheduled to be completed on May 10, 2024.

1.2.4 Student Researchers: Table 4 shows the number of student researchers employed at the UTCRS during the reporting period. One column includes the total number of students supported from all funding sources including federal and non-federal cost share, the other 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	46	31
Masters' Research Assistants	18	13
Doctoral Research Assistants	11	11
Totals	75	55

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 (B2E) Program: South Texas College (STC) manages recruiting and selection efforts for the UTCRS Bridge to Engineering Program. The highly successful and ongoing impacts of the 2023 cohort are discussed in Section 4.3. In the previous report, it was noted that a recruitment committee was established to select the 2024 STC cohort along with an online application, selection process, and strategies

for student recruitment. During the current period, the committee recruited 12 applicants from which 8 have been selected by the UTCRS Executive Committee to start on June 1, 2024.

1.3 How have the results been disseminated?

1.3.1 Professional Community: For the professional community, the primary dissemination is through publications. Since the start of funding in June 2023, we have submitted a total of 40 publications in professional venues. Out of these, 15 are new for this reporting period and 21 of them advanced during this reporting period from submitted or abstract-only status to final accepted status. A complete listing is given in Table 6. 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 representing UTCRS as an expert on bearing-related train derailments and wayside detection systems (https://www.ntsb.gov/news/events/Pages/East-Palestine-Hearing-Event.aspx).
- Dr. Tarawneh is the University Outreach Chair for the 2024 ASME Joint Rail Conference and also the Chair of the Rail Safety and Security Track Session within this international conference.
- Dr. 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 (1) Chair of the 2024 ASME Joint Rail Conference, (2) a TRB AR050 member, (3) member of AREMA Committee 24 Education and Training, (4) Academic Co-Chair of the REES 2024 Executive Committee, and (5) Academic Editor of the Journal of Advances in Civil Engineering.
- Dr. Yu Qian is on Technical Committee (TC) 202, International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) and is part of the AAR Substructure Technical Advisory Group (TAG). He is Communication Coordinator for TRB committee AR060; Organizing Committee Chair for 2024 Geo Shanghai International Conference, member of the Technical Committee of the 7th International Conference on Transportation Infrastructure and Materials, and is Associate Editor for Smart and Resilient Transportation, as well as a member of several editorial boards.
- Dr. Nikolaos Vitzilaios is Program Chair for the 2024 International Conference on Unmanned Aircraft Systems, and is on the Board of Directors, South Carolina Interagency Drone Users Consortium.
- Dr. Vagelis Papalexakis is co-Chair for the 2024 SIAM International Conference on Data Mining (SDM) 2024, and co-Chair for 2024 IEEE Data Science and Advanced Analytics (DSAA). He is co-editor-in-chief or associate editor for multiple journals.

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 UTCRS Director, Dr. Tarawneh.
- Dr. Tarawneh's work on reconditioned bearings was featured in a Railway Age article.
- 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 Safety STEM 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.

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**
  - Meet all USDOT and UTC reporting requirements.
  - Complete External Advisory Board review of CY2024 research proposals.
  - Finalize CY2024 research proposals, notify researchers, prepare Exhibit D, and enter projects in Research in Progress (RIPs).
  - Co-Sponsor the 2024 ASME Joint Rail Conference (to complete May 15, 2024)
  - Host the 2024 CUTC Summer Meeting at South Padre Island, TX (to complete June 2024)
  - Complete upgrades and improve public access to our data repository to fully implement our approved Data Management Plan.
- **Research**
  - Finish work on approved CY2023 research projects and enter them into TRID database.
  - Continue to engage with industrial partners and seek opportunities for technology transfer.
  - Submit manuscripts for journal and conference publications.
  - Take advantage of newly expanded capacity in UTCRS testing facilities to serve more rail industry partners and increase pace of research.
- **Education and Workforce Development**
  - Conduct the 2024 UTCRS Railway Safety Summer Camps for K-12 students and teachers. We have a goal of 1000+ attendees this year.
  - Continue employing, training, and developing undergraduate and graduate student researchers and engaging them in workshops, seminars, webinars, and conferences.
  - Continue offering students opportunities to take on professional responsibilities by directly interacting with 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 Summer and Fall 2024 semesters.

- Recruit and provide a summer research experience for up to 8 transfer students from South Texas College (STC) through the Bridge to Engineering (B2E) program.
- **Engagement and Outreach**
  - Finalize enrolling students and school districts for 2024 UTCRS STEM Summer Camps.
  - Disseminate center products through 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 UTCRS Executive Committee.
- Hold regular (at least twice per year) meetings with our External Advisory Board.
- Hold bi-weekly meetings of faculty with research students to provide guidance.
- Have students present at bi-weekly meetings to build confidence and professionalism.
- Make faculty/students 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 annual UTCRS Railway Safety STEM summer camps.
University of South Carolina (USC) 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 few UNL test beds and with current city and state traffic monitoring systems.
Texas A&M University	**Consortium Institution**

(TAMU) College Station, TX	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 is 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, the reconditioned bearings study, and next generation on-board sensor development at UTRGV. MxV Rail will make two railcars available for UTCRS instrumentation to provide comparisons with wayside systems, and will host UTCRS student researchers at their Pueblo, CO 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 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 force measurement project. They provide technical support and consultation and 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 and AAR standards and 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 Association of American Railroads (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 associated with 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 5-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. The UTCRS assists Region One by organizing laboratory tours and student presentations and offering monthly one-day engineering camps for high school and middle school students to attract K-12 students to STEM disciplines with a focus on transportation engineering.
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 Camps.
Weslaco 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 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 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.
South Texas ISD Preparatory Academy Edinburg, TX	**Community Collaborator** South Texas 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 is given in Table 6. For completeness, this is a cumulative list that shows the progress of publications through the stages of submission, revision, acceptance, and publication. 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 (https://www.utrgv.edu/railwaysafety/workforce/jrc-2024-poster-session/index.htm)

Key to Table 6

Blue: New Publication since last report	Beige: Updated Status since last report	White: No Change since last report	Gray: Withdrawn or Changed Type

Table 6 – Journal and Conference Publications

Citation	Type	Status at Last Report	Status in Current Report
1. Byrraju, S., Rizos, D. C., Sutton, M. A., Li, N., & Hughes, K. (2023). On the Use of InSAR Techniques to Detect Precursors of Shallow Geohazards in Railway Right of Way. AREMA Annual Meeting.	Conference	Published	Published
2. Naseri, R., Mohammadzadeh, S., & Rizos, D. C. (2024). Rail surface spot irregularity effects in VTI simulations of train-track-bridge interaction. Journal of Vibration and Controls, OnLineFirst.	Journal	Submitted	Published
3. Gedney, B. L., Naseri, R., AlKharousi, S., & Rizos, D. C. (2024). B-Spline Signature Responses in structural change detection: method development. Structural Health Monitoring, Under revision.	Journal	Submitted	Under revision
4. Byrraju, S., Rizos, D. C., Sutton, M., & Li, N. Enhancing Railway Safety Through Satellite-Based Monitoring for Rockfall Potential. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted
5. Gedney, B. L., Naseri, R., & Rizos, D. C. Investigating the Use of B-Spline Signature Responses to Detect Internal Rail Defects. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted
6. Naseri, R., Gedney, B. L., Asgari, H., & Rizos, D. C. A Hybrid Rail Surface Spot Irregularities (RSSI) Detection Algorithm Based on Onboard Measurements. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted
7. Guo, H., Qian, Y., Rizos, D., & Vitzilaios, N. UAV Imagery-Based Rail Surface Detects Detection Using Egnet and Incremental Learning. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted
8. Ozegbe, K., & Rizos, D. C. (2024). B-Spline impulse response functions (BIRF) for transient SSI analysis of pile foundations: Developments and implementation. Structural Dynamics and Earthquake Engineering, Under revision.	Journal	N/A	Under revision
9. Tang, Y., Qian, Y., Rizos, D. C., & Vitzilaios, N. Railroad Crossing Intrusion Detection Based on UAV-Image and Open-World Object Detection. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted

10. Rizos, D. C., Stinson, B., Penna, C., Gedney, B., & Naseri, R. Performance of a Mobile, Non-Contacting, Reference-Free Prototype System for RNT and Rail Stress Measurements. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Accepted
11. Lewandowski, K. & Vitzilaios, N. UAV-Based Railroad Line Detection. 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	N/A	Accepted
12. Qian, Y. (2024). Intelligent railroad inspection and monitoring. Frontiers in Built Environment, SI: Rising Stars in Geotechnical Engineering, vol. 2024. doi: 10.3389/fbuil.2024.1389092	Journal	N/A	Published
13. Tang, Y.G., & Qian, Y. (2024). High-Speed Railway Track Components Inspection Framework Based on YOLOv8 with High-Performance Model Deployment. High-speed Railway. doi: https://doi.org/10.1016/j.hspr.2024.02.001	Journal	N/A	Published
14. Tang, Y.G., Wang, Y., & Qian, Y. (2024). Edge-computing Oriented Real-Time Missing Track Components Detection. Transportation Research Record: Journal of the Transportation Research Board, Transportation Research Board of the National Academies. doi: https://doi.org/10.1177/03611981241230546	Journal + Presentation	N/A	Published
15. Guo, F. G., Liu, J., Qian, Y.*, & Xie, Q. (2024). Rail Surface Defect Detection Using A Transformer-Based Network. Journal of Industrial Information Integration. (Published Online 2024). doi: https://doi.org/10.1016/j.jii.2024.100584	Journal	N/A	Published
16. Guo, F. G., Qian, Y.*, & Yu, H. (2023). Automatic Rail Surface Defect Inspection Using the Pixel-wise Semantic Segmentation Mode. IEEE Sensor Journal. (Published Online 2023). doi: https://doi.org/10.1109/JSEN.2023.3280117	Journal	N/A	Published
17. E. Villalobos, H. Lugo, B. Cheng, M. Gutierrez, C. Tarawneh, P. Xu, J. Chen, and E. E. Papalexakis, "Spectral Clustering in Railway Crossing Accidents Analysis," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Paper Accepted
18. E. Villalobos, C. Tarawneh, J. Chen, E. E. Papalexakis, and P. Xu, "Kernel Ridge Regression in Predicting Railway Crossing Accidents," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Submitted	Paper Accepted
19. R. Salinas, D. Hinojosa, C. Tarawneh, H. Foltz, "LoRa Wireless Temperature and Vibration Sensor," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Abstract Accepted	Changed to Student Poster
20. 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, Columbia, SC.	Conference	Abstract Accepted	Paper Accepted
21. 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	Paper Accepted
22. 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	Paper Accepted
23. 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, Columbia, SC.	Conference	Abstract Accepted	Paper Accepted
24. "Computational Model for Predicting Lift-Off Induced Buckling in Rail Structures", by V. Musu, D.H. Allen and G.T. Fry, submitted to Computers & Structures.	Journal	Submitted	Submitted to New Journal

25. M. Amjadian, Md. M. Rahman, C. Tarawneh, V. Villarreal, D. Rocha, "AI-Enabled Vibration Sensing System for Early Detection of Trains at Active Highway-Rail Grade Crossings," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	N/A	Accepted
26. G. Whetstone, T. Liu, P. Fudlailah, C. V. Droddy, D. H. Allen, "Experimental Evaluation of Crack Evolution in Rails Using a Phased Array," Journal of Nondestructive Evaluation, 42 (97), 2023.	Journal	Published	Published
27. Liu, T., and D.H. Allen, "Modeling Buckling in Rails with Nonlinear Track Resistance," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference Presentation	N/A	Accepted
28. Whetstone, G., T. Liu, P. Fudlailah, D.H. Allen and C.V. Droddy, "A Method for Quantifying Experimentally Observed Crack Growth in Rails," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference Presentation	N/A	Accepted
29. S. Saberi, S. Komidi, Y.R. Kim and D.H. Allen, "A Model for Predicting Crack Growth in Rails Using a Cohesive Zone Model," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference Presentation	N/A	Accepted
30. 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, Columbia, SC.	Conference	Abstract Accepted	Paper Accepted
31. 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	Changed to Student Poster
32. 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, Columbia, SC.	Conference	Abstract Accepted	Paper Accepted
33. D. Espinoza, G. Ali, C. Tarawneh, "AI-Based Hazard Detection for Railway Crossings," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Abstract Accepted	Paper Accepted
34. 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	Paper Accepted
35. 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, Columbia, SC.	Conference Presentation	Submitted	Accepted
36. "High-Strength, Reduced-Modulus, High-Performance Concrete for Prestressed Concrete Crosstie Applications," FRA Research Results	Technical Report	Completed	Completed
37. Khattak, A. J., Farooq, M. U., & Farhan, A. (2023). Motor Vehicle Drivers' Knowledge of Safely Traversing Highway-Rail Grade Crossings. Transportation Research Record, 03611981231208902.	Journal	N/A	Published
38. Farooq, M.U., and Khattak, A.J., 2023. Investigating Highway-Rail Grade Crossing Inventory Data Quality's Role in Crash Model Estimation and Crash Prediction. Applied Sciences. https://doi.org/10.3390/app132011537	Journal	N/A	Published
39. Zhao, L., Farooq, M.U., and Khattak, A.J. Improving Highway-Rail Grade Crossing Crash Prediction Models by Addressing Crossing Inventory Data Accuracy. Presented at the Transportation Research Board (TRB) 103rd Annual Meeting, January 7-11, 2024, Washington DC, 2023. TRBAM-24-04159.	Conference Presentation Published Abstract	N/A	Presented Published
40. Farooq, M.U., and Khattak, A.J. Exploring Statistical and Machine Learning-Based Missing Data Imputation Methods to Improve Crash Frequency Prediction Models for Highway-Rail Grade Crossings. Presented at the International Road Federation (IRF) Global R2T Conference & Exhibition, November 14-16, Phoenix, Arizona, 2023.	Conference Presentation	N/A	Presented

41. 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, Columbia, SC.	Conference	Submitted	Accepted
42. 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, Columbia, SC.	Conference	Submitted	Accepted
43. J. Pams, C. Tarawneh, D. Rocha, B. Wilson, L. Cantu, A. Diaz, "Optimized Vibration-Based Health Metrics for Freight Rail Bearings," 2024 ASME Joint Rail Conference, Columbia, SC.	Conference	Abstract Accepted	Paper 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 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 the 2024 CUTC Summer Meeting, and listings of key personnel and our External Advisory Board.

During this reporting period, the publication section was updated, the Call for Proposals for CY2024 was posted, and links to registration for the 2024 CUTC Summer Meeting were added. We are continuing work on a portal for posting research data, including real-time monitoring of our tester labs and automated collection and archiving of data. During the second reporting period, we completed preparatory steps including upgrades to network communications in the lab rooms, installation of real time cameras for each tester, upgraded computers for compatibility with IT security requirements for online systems, and acquisition and set up of a dedicated server. We anticipate completing this project by the end of 2024, with the ability to remotely monitor any of our bearing testers.

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

New Safety Technologies: 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 and rail crack growth.
- New energy harvesting techniques to power wireless sensors for rail systems.

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

- TAMU is developing two new experimental testbeds, one for evaluating nonlinear lateral track resistance, and one for uniaxial cyclic loading of rails with internal defects.

- UTRGV has completed construction of a specialized test rig to measure rail anchor slip force.
- UTRGV has completed construction of two additional four bearing testers, with associated improvements to HVAC support to maintain AAR test conditions.
- UTRGV has upgraded one of the bearing test rigs to incorporate accurate lateral force testing.
- UTRGV has outfitted its test facilities with real-time remote monitoring and automatic data archiving.

3.4 Inventions, patent applications, and/or licenses

Two patent applications were filed by USC:

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

3.5 Other products

Table 8 – Theses and Dissertations (Cumulative)	
Student	**Thesis or Dissertation**
Lewandowski, K., University of South Carolina	MS Thesis: "UAV-Based Tracking and Following of Railroad Lines."
Stinson, Brittany, University of South Carolina	MS Thesis: "Field Implementation of A Stereo Vision System For RNT and Stress Measurements in CWR."
Ozegbe, Kingsley, University of South Carolina	PhD Dissertation: "B-Spline Impulse Response Functions For Transient SSI Analysis of Pile Foundations."
Whetstone, Gavin, Texas A&M University	MS Thesis: "Development of an NDE Technique for Measuring Crack Growth in Railheads."
Musu, Valentina, Texas A&M University	PhD Dissertation: "Modeling Buckling in Rails."
Martinez, Sergio, University of Texas Rio Grande Valley	MS Thesis: "Vibration-Based Machine Learning Models for Condition Monitoring of Railroad Rolling Stock." **CUTC Award**
Mensah, Prince, University of Texas Rio Grande Valley	MS Thesis: "Design and Implementation of a Load Sensor in a Bearing Adapter Assembly for Freight Railcar Applications."

4. OUTCOMES

Some of the notable outcomes during this period are as follows:

4.1 Research

On-Board Sensors: The UTCRS-UTRGV team continued their ongoing collaboration with the industry partner HUM Industrial Technology, Inc., where the 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. New accomplishments for the October 2023 – April 2024 reporting period include:

- Completion of a study of energy harvesting and energy storage to power onboard sensors, resulting in short-run production of test units ready for field trials. Initial field trials revealed the need for mechanical modifications to ensure compatibility with a range of railcar siderails.
- Completion of a study of power consumption in onboard sensors, resulting in modifications to firmware and hardware in a commercial product that are successful in extending battery life.
- Ongoing data analysis of incoming data from HUM sensors in commercial pilot deployments, resulting in refinements to the bearing health index (BHI).
- Evaluation of alternate sensor components that have reduced cost and power consumption. This project is expected to identify avenues for extended battery life and lower cost of operation.
- Demonstrated ability to identify very early stage bearing degradation (<0.5 in^2 spall) in the field, with subsequent endurance testing in the lab demonstrating growth of the spall to condemnable levels over the course of 40,000 miles.

- Demonstrated ability of onboard sensing to identify wheel and track defects in the field.

The UTCRS is also conducting its own research into next generation on-board sensors (Project 11 in Table 3). A wired prototype suitable for demonstration of simultaneous sampling of accelerometers in either the laboratory or a test track (e.g. MxV FAST Track) has been completed and tested in the lab. In addition, UTCRS AI researchers developed an algorithm, to be presented at the 2024 JRC, which can accurately determine railcar speed from vibration signatures. This is important because it does not require external communications or GPS at the wheel level, either of which severely impact battery life.

Bearing Testing: The UTCRS continues to produce results with significant industry impact in our ongoing bearing testing programs. Some of the experiments are funded directly with USDOT funds, and others funded by industry partners. New results over the October 2023 – April 2024 reporting period include:

- Initial results from an MxV sponsored test of reconditioned bearings demonstrated significant differences from new bearings, including cases of early failure, particularly in the case of water-etched bearings. This work was presented at the AAR Research Review in April 2024.
- Initial results from the UTCRS sponsored test of inactive bearings (Project 10 in Table 3), suggested by NTSB and conducted in collaboration with CSX Transportation, revealed issues with lubricant separation and failure of seals. Further work is needed prior to final conclusions but industry partners have already been informed of the issues identified.

Figure 1: Onboard Sensing (Left to Right): Detected wheel defect, detected rail defect, detected bearing defect, bearing adapter with load sensing and energy harvesting based on UTCRS licensed technology.

Rail Anchor Slip Testing: This work (Project 6 in Table 3) is being conducted in collaboration with staff from BNSF and MxV Rail. Accomplishments during this reporting period include:

- Completion of the first version of the test rig, with onsite presence of MxV and BNSF personnel during the initial validation in March 2024. This development required significant amounts of mechanical and electronic design. The validation runs indicated the need to construct a rig with greatly increased capacity for physical displacement of the rail.
- Completion of a second version of the test rig, with increased cylinder volume and actuator force, in April 2024. This required substantial work and effort from 4 students and three faculty members.

4.2 Education, Workforce Development, and Community Engagement

Joint Rail Conference: One of the UTCRS Associate Directors, Dr. Dimitris Rizos, is serving as Chair for the 2024 ASME Joint Rail Conference, to be held in May 2024 in Columbia, SC. This is the premier conference for railroad research, and UTCRS has made several contributions including:

- Creation and sponsorship of a new Student Poster Competition. The first competition has 21 submissions from UTCRS students, including papers that are collaborations across institutions and papers that resulted from summer REU experiences sponsored by UTCRS.
- UTCRS faculty serving on organizing and technical committees and session chairs for the conference.
- Submission of 32 conference papers based on UTCRS projects from all consortium universities.

College Courses Offered: UTCRS affiliated faculty taught transportation courses with the following reported enrollment:

- University of Texas Rio Grande Valley: 78 undergraduate students.
- University of Nebraska Lincoln: 27 undergraduate and 11 graduate students.
- Texas A&M University: 51 undergraduate and 6 graduate students.
- University of South Carolina: 150 students at all levels.

Bridge to Engineering (B2E) Program: In the previous reporting period, UTCRS hosted 7 students, 6 of whom had 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. They also received advising, and assistance in registering for two summer courses counting toward their degrees. In the current reporting period, UTCRS can report that the program has been very successful in achieving its goals. All seven of the students are currently enrolled in UTRGV engineering programs, all remain employed as student researchers with UTCRS, and all are authors on papers accepted to the 2024 Joint Rail Conference. For Summer 2024, three will be interns at MxV Rail, one will take an internship with British Petroleum, and three will perform research at UTCRS working on USDOT funded projects.

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 is still in progress, 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:

- Reliability of reconditioned bearings: UTCRS preliminary results, presented at the AAR in April 2024, have already confirmed that:
  - reconditioned bearings with no visually apparent defects on the cone or cup surface can have subsurface defects leading directly to early failure,
  - new non-destructive inspection protocols are needed, and
  - some types of damaged bearing may not be suitable for reconditioning.
- Reliability of inactive bearings: While testing is in progress, the early results have already found:
  - instances of contaminated or clearly separated lubricant, and
  - early failures of seal rings.
- Longer sensor life: An industry sponsored UTCRS project in the first and second reporting periods had two separate findings that led directly to improved sensor life:
  - identification of multiple causes of battery drain in a commercial on-board sensor, resulting in design changes that multiply the battery life and support more frequent reporting, and
  - development of a thermoelectric energy harvesting system to the point of field-testing readiness.
- Increased workforce pool: Over 50 students have received hands-on training in rail specific skills like bearing test set up and bearing assembly, disassembly, and inspection; testing of components to AAR specifications; 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 recondition bearing studies above 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. Ongoing results of both projects have already been communicated to industry partners and at industry-attended meetings and symposia and are expected to contribute invaluably 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.

The collaboration with HUM, the start-up company that has licensed the UTCRS developed sensor technologies, has transitioned to the current UTCRS UTC grant, and joint work has been ongoing to deploy sensors in a few 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. During the current reporting period, the collaboration has led to extensions of sensor operating life, advances on novel load sensors, and a new energy harvesting system. This work is expected to revolutionize the way the rail industry monitors the condition of their rolling stock and will aid in the transition from reactive wayside detection systems to proactive on-board technologies, which 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?

UTCRS personnel submitted or published papers on a wide range of technical topics. Some examples are:

- New insights on combining thermoelectric generators in rail applications.
- Improvements in recognizing intrusions on the railroad right-of-way.
- Improved models for rail buckling and new models for crack growth in rails.
- Applications of AI to UAV images of railroad tracks to identify changes.
- Applications of AI to enable bearing vibration sensors to determine railcar speed independently.
- Predicting rockfall potential from satellite images.
- Characterizing the performance of rail anchors.
- Characterizing the performance of in-service bearings with long periods of inactivity.
- Automatic methods to identify cracks in rail surfaces.
- Advances in ultrasonic inspection of bearings.

5.4 What is the impact on transportation workforce development?

Since its inception, the UTCRS has engaged over 1000 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. Moreover, 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.

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.
- Evaluating new accelerometers that could reduce cost and extend reporting life of onboard sensors.
- In house construction and instrumentation of a rail anchor test rig.

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 hosted more than 8500 K-12 students and engaged and trained more than 900 teachers, program coordinators, counselors, and administrators on how to implement the UTCRS STEM Curricula in diverse educational settings. UTCRS faculty and staff provide training and guidance throughout the year.

6. CHANGES/PROBLEMS

6.1 Changes in approach and reasons for change

We revised the schedule and process for soliciting, reviewing, and vetting research proposals, and have implemented the new process for the CY2024 cycle of proposals. The reasons were to (a) encourage closer alignment of proposals with industry needs, (b) allow more time for revisions based on Advisory Board feedback, and (c) give researchers earlier notice of acceptance to facilitate planning and recruitment.

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

Nothing to report.