National University Rail Center of Excellence

University of Illinois Urbana-Champaign
University of Illinois Chicago
University of Delaware
Kansas State University
Michigan Technological University
Morgan State University
Rutgers University
University of Texas at Austin
Tuskegee University

Annual Report 2025–2026

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NURAIL CENTER OF EXCELLENCE

The National University Rail Center of Excellence (NURail CoE) is focused on rail transportation and supported by the U.S. Department of Transportation (US DOT) and Federal Railroad Administration (FRA). The NURail CoE is a nine-university consortium led by the Rail Transportation and Engineering Center (RailTEC) at the University of Illinois at Urbana-Champaign (UIUC) and hosted by the Grainger College of Engineering within the Department of Civil and Environmental Engineering at UIUC.

This publication is a report of the NURail Center of Excellence's transportation research, education and workforce development, and technology transfer activities for May 2, 2025 – May 1, 2026.

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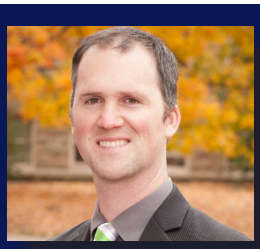

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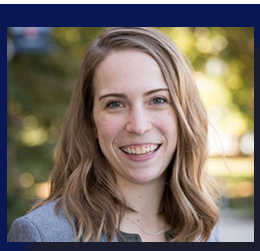

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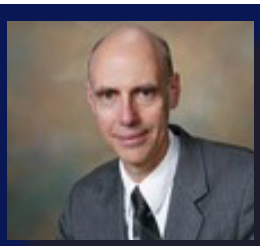

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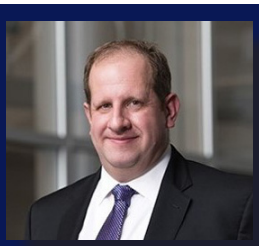

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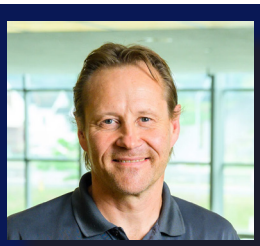

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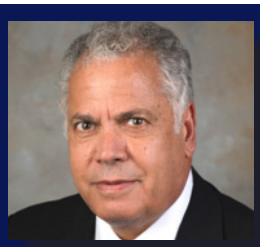

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Member Institutions

The University of Illinois Urbana-Champaign (UIUC) is a leader in railway engineering research and education in North America, with a rich history of significant contributions dating back more than a century. UIUC has expanded its Rail Transportation and Engineering Center (RailTEC) through rail research and educational programs during the past 28 years.

The University of Illinois Chicago (UIC) is a leader in transportation planning, rail and public transit, freight, and intermodal modeling and behavior. The Urban Transportation Center (UTC) is a research unit dedicated to innovative transportation research and education that provides technical assistance on urban transportation planning, policy, operations, finance and management.

The University of Delaware (UD) Railroad Engineering and Safety Program provides undergraduate and graduate courses, including a Graduate Certificate in Railroad Engineering, as well as a full range of railway-related research with a strong focus on track, vehicle-track interaction, and the application of data science (data analytics) to railway inspection and maintenance management.

Kansas State University (K-State) has deep rail industry ties with many engineering and business alumni previously or currently serving at the executive level for many Class I and short line railroads.

Michigan Technological University (MTU) established the Rail Transportation Program in 2007 and has developed into a one of the national leaders for railway education, research, and workforce development programs. In addition to railroad research projects led by faculty and staff across multiple disciplines, MTU has an extensive workforce development and education portfolio ranging from K-12 education to tech transfer for industry professionals.

Morgan State University (MSU) is an HBCU and Maryland's Preeminent Public Urban Research University. MSU frequently uses Baltimore as a living laboratory to address underserved and underinvested communities' needs. MSU's Transportation and Urban Infrastructure Development is part of the CRISI program titled, "Development and Implementation of HBCU-based Rail Engineering Program for Underrepresented Communities."

Rutgers University (RU) is the home of the Center for Advanced Infrastructure and Transportation and the Rutgers Rail and Transit Program, a leading academic hub for rail- and transit-related research, education, and workforce development. RU's projects and expertise include grade crossing safety, trespassing prevention, infrastructure data mining, intelligent rail systems, and hazardous material transportation safety and risk.

The University of Texas at Austin (UT) offers rail-focused courses and is conducting leading research on railway operations, network efficiency, alternative energy, and safety through the Texas Railway Analysis & Innovation Node (TRAIN). UT's rail research portfolio also includes developing advanced technologies for rail and track defect detection, and design of railroad bridge structures to resist increasing loads due to longer and heavier trains.

The Tuskegee University (TU) College of Engineering has been conducting rail engineering research and education for more than 20 years. TU is an HBCU with capabilities in mechanical, fracture and fatigue testing, microstructural analysis, welding failure analysis, and heat treatment.

University of Illinois Urbana-Champaign

ILLINOIS

Maintaining adequate track lateral resistance is essential for mitigating rail misalignment and buckling events, particularly under conditions of degraded ballast support. Traditional field-applied methods for measuring lateral resistance are effective but often intrusive, time-intensive, and not well suited for network-level screening. This research explores the feasibility of a non-destructive, scalable impulse-response testing approach to evaluate track lateral capacity through dynamic measurements.

Impulse-response tests were conducted on a full-scale concrete-tie ballasted track under three controlled ballast conditions: fully ballasted, end ballast removed on one side, and end ballast removed on both sides that represent different ballast degradation states. Lateral impacts were applied to rail and fastener components using an instrumented hammer, while accelerations were recorded at multiple locations to compute Frequency Response Functions (FRFs). Analysis focused on identifying repeatable response features sensitive to progressive ballast degradation.

Results demonstrate that low-frequency dynamic response (below approximately 60 Hz) provided clear, consistent distinction among ballast conditions, while higher-frequency resonances were dominated by rail and structural dynamics and showed limited sensitivity to ballast state. Using a simplified single-degree-of-freedom representation, equivalent dynamic stiffness and damping parameters were extracted from the low-frequency FRFs. Both parameters decreased systematically with ballast degradation, reflecting reduced lateral support and reduced energy dissipation capacity of the track system. Repeated tests conducted two weeks apart confirmed strong repeatability of the measurements, particularly when impacts were applied at rail fastener components.

This study demonstrates that impulse-response testing can provide mechanically meaningful indicators of track lateral stability without disturbing the track structure. The findings support further development of this method as a field-deployable screening tool to assess ballast condition and lateral resistance over longer track segments, complementing existing rail safety inspection practices.

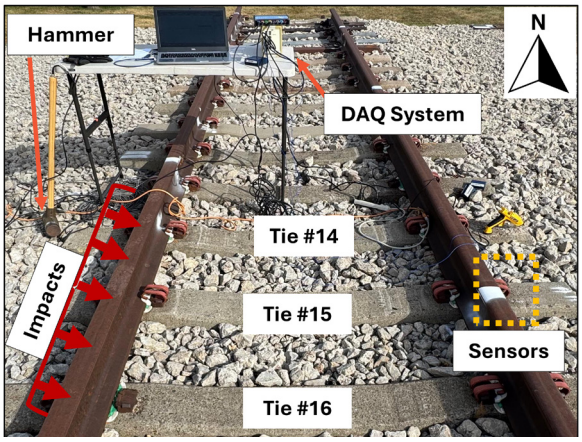


Illustration of Impulse Response test setup on test track

Xinhao Liu

Xinhao Liu is pursuing his Ph.D. in Civil & Environmental Engineering (CEE) at UIUC. He joined RailTEC as an undergraduate in 2019 and has been an active contributor ever since. He is an accomplished and dedicated scholar, having completed dual bachelor's degrees in CEE and Economics, dual master's degrees in CEE and Applied Statistics, and is now in his third year of doctoral studies.

Liu's research focuses on rail safety and operations, with particular emphasis on quantitative risk analysis and data-driven decision-making. His Ph.D. research centers on track-segment-level derailment risk modeling, with a particular focus on longer-train operations, integrating statistical modeling, programming, and emerging analytical tools to address real-world railroad safety challenges. He also serves as a Data Science Fellow with the Association of American Railroads' Policy and Economics team. In this role he develops automated data engineering pipelines to streamline analysis and results-generation processes that support the team by developing analytics solutions for engineering and modeling problems.

University of Illinois Chicago

UNIVERSITY OF ILLINOIS CHICAGO

Warehousing and Truck Traffic

Moving goods on trains instead of trucks provides positive externality by reducing congestion and greenhouse gas emissions. The freight rail industry can increase the economic competitiveness of regional and local economies. Access to the rail network is often a critical component of a logistics center that serves as an anchor for the local economy. This project examines impacts of railroad facilities and operations on the local economy using cross-sectional and longitudinal analysis of large data.

Study objective

This study aims to understand the impact of warehouses and truck traffic on neighborhoods in Illinois. Warehouses provide jobs, but they may not be for local residents, and may not be desirable from the economic perspective for specific population groups. The impact of warehouses on local traffic as well as the net benefit for the local community has not been fully understood.

Activities

There are four tasks for this study. For Task 1, we completed the review of literature on financial impacts of warehouses related to jobs and property tax, grants, and other local government revenue sources. We have also carried out a review of studies that quantified costs of truck traffic such as pavement and bridge maintenance, accidents, congestion, and air and noise pollution. For Task 2, we have obtained the IRB approval to interview people who are knowledgeable about impacts of warehouse developments. For Task 3, we have been developing a workflow for using AI to automatically count trucks by analyzing images captured by motion-activated trail cameras. This will allow us to efficiently collect data that will be used to estimate truck generation potential of warehouses. We have carried out on-field testing at multiple sites to validate the accuracy of the camera and AI data processing. For Task 4, we have completed the analysis of sample warehouses in northern Illinois and other parts of the state to demonstrate the economic impacts estimation framework. We have obtained and analyzed tax records for each of the warehouses. For comparison purposes (to estimate the opportunity cost) we have also analyzed data on selected land uses including agriculture, light industry, and data centers. In the next quarter, we will carry out interviews of local experts (Task 2). collect truck count data at various warehouses (Task 3), and document the findings from Tasks 1 and 4.

Aerial of UTC rail study

Brian Christian

Brian Christian is a Fulbright Scholar in the UIC Master of Urban Planning & Policy program, President of the Urban Planning & Policy Student Association (UPPSA), and a Research Specialist at the UTC.

Since Spring 2025, he has been working on the NURail CoE study, which analyzes the impacts of railyards on urban economic development across the United States. His work involves assembling and structuring large-scale geospatial datasets, as well as interpreting analyses related to rail infrastructure, freight networks, and economic indicators. Over the course of the project, he has worked extensively with national transportation datasets, including NTAD rail infrastructure layers, U.S. Census tract boundaries, and FAF5 freight network links. Using GIS, he has developed workflows for processing spatial data and railyard geometries to better represent railyard footprints and their relationships to surrounding census geographies. He is highly engaged in this research and values the opportunity to apply geospatial analysis, transportation data systems, and policy-oriented research methods to better understand the evolving role of rail infrastructure in shaping economic development in the United States.

University of Delaware

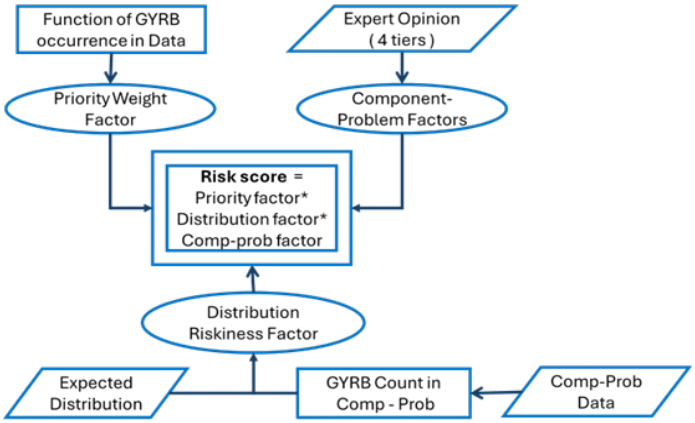


Figure 1. Risk score framework for defect to risk mapping

The University of Delaware is leading two complementary research projects advancing risk-based railroad track inspection strategies. Together, these efforts aim to improve safety and inspection efficiency by optimizing inspection intervals for manual walking inspections and track geometry car measurements based on observed risk and degradation behavior.

Data-Driven Risk-Based Modeling of Manual Walking Inspection Frequency

Manual walking inspections remain a critical component of railroad safety programs, yet inspection frequency is typically prescribed using fixed regulatory intervals and defect counts that do not reflect defect severity or historical behavior. This project develops a data-driven framework that transforms multi-year walking inspection records into interpretable, risk-based indicators to support inspection decisions.

The methodology integrates defect priority, engineering-informed damage potential for specific component–problem pairs, and historical abnormal severity trends to compute defect-level risk scores. These scores are aggregated over time to generate segment-level cumulative risk and rates of risk accumulation. Short-term and longer-term trends are evaluated to distinguish emerging versus sustained deterioration. The framework has been applied to an anonymized urban metro dataset and is currently being validated using a freight rail dataset.

Risk-Based Track Geometry Inspection Model

The second project optimizes track geometry inspection intervals using a risk-based framework grounded in perturbation initiation, growth, and detection reliability. Geometry measurements were analyzed to estimate degradation rates and project time-to-defect for individual locations. Track sections were divided into 10 segments, with time-to-defect values aggregated to develop segment-specific risk distributions.

Inspection intervals were determined based on segment-level risk criteria, resulting in varied recommended intervals across the track. The overall interval was selected based on the highest-risk segment. This framework demonstrates strong potential to improve safety and optimize inspection resource allocation.

Johnson Chukwu

Johnson Chukwu is a graduate student in the Department of Civil, Construction and Environmental Engineering at the University of Delaware. He will graduate with a master's degree in Spring of 2026, and plans to pursue a Ph.D. His research interests include track geometry inspection, track maintenance and railway safety. Johnson aims to contribute to the development and maintenance of safer and cost-effective railway infrastructure and assets. Johnson is presently the President of the American Railway Engineering and Maintenance-of-Way Association (AREMA) Student Chapter at the University of Delaware. He recently presented at the Big Data in Railroad Maintenance Planning Conference, hosted by UD.

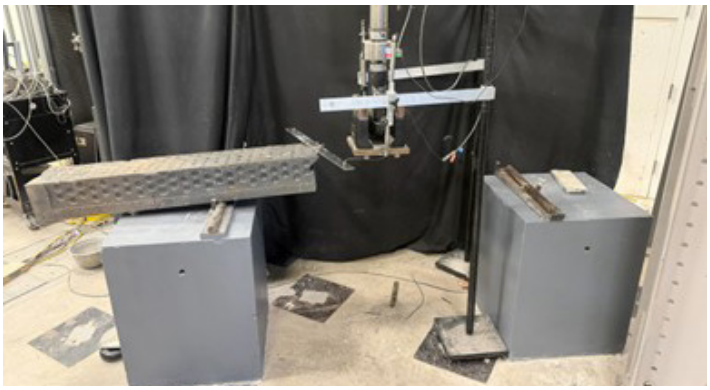
Kansas State University

Wood Tie Deflected Failure Point

AREMA Chapter 40 design standards for concrete crossties require flexural capacity design and testing, but wood and polymer composite crosstie design standards do not require flexural evaluation. Ostensibly the different tie technologies perform the same design function: maintaining rail gauge and transferring train load to the ballast and subgrade. Designed to keep concrete ties uncracked in track, the codified flexural requirements have resulted concrete ties that are both flexural strong as well as stiff.

Furthermore, high prestressing forces, intended to prevent or limit cracking, has led to vulnerability in end-splitting due to radial bursting stress at the tie end. Previous research at K-State has improved tie design practice to limit tie splitting, however the fundamental difference between concrete and other crosstie types remains encoded. Acknowledging excellent performance of wood and composite ties in-track and the anecdotal excellent performance of certain concrete tie designs, we seek to understand which aspects of concrete tie design contribute to in-track performance and in contrast which aspects may be unnecessary.

The present research seeks to compare the flexural behavior of different crosstie technologies with a goal of understanding the similarities and differences in flexural behavior. Commercially produced wood, composite, and concrete crossties are tested in center negative and rail-seat positive flexure as described in AREMA Chapter 40 and the relative flexural performances are compared. Unsurprisingly, wood and composite ties have lower bending stiffness and somewhat lower strength while demonstrating greater deflection capability. The observations obtained in this testing help to quantify the relative structural contribution of the differing tie technologies and may indicate that required flexural capacity for concrete ties should be assessed on the basis of deflection rather than load. Accordingly, we suggest further research into concrete tie design paradigms that prioritize deflection performance which we believe will lead to robust performance and long service life.



Polymer Tie Failure Point

Kyler Starbuck

Kyler Starbuck is a master of science student in the Department of Civil Engineering at Kansas State University with an emphasis on structural engineering. A Fredonia, Kansas native, having grown up on a cattle ranch, Starbuck is a highly capable experimentalist with excellent mechanical aptitude.

Starbuck is conducting the aforementioned flexural capacity research involving testing of ties and comparison of sectional deformation characteristics. To date, Starbuck has tested wooden and composite ties in center-negative flexure with future work to include rail-seat positive flexural tests. After graduating from K-State Starbuck intends to pursue professional practice in structural design.

Michigan Technological University

Keynote speaker Craig Morehouse, Vice President of Transportation for BNSF Railway

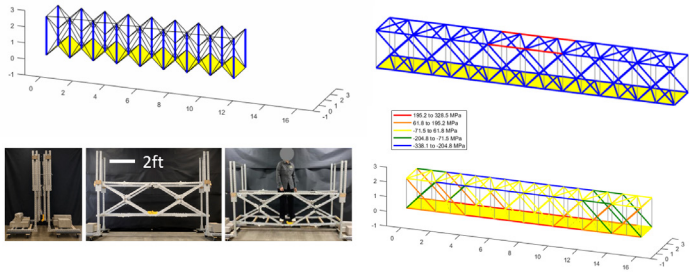
On September 8, 2025, Michigan Technological University hosted Railroad Night, bringing together approximately 60 students, faculty, alumni, and industry representatives for an evening focused on engagement and professional development within the rail industry. The keynote address was delivered by Craig Morehouse, Vice President of Transportation for BNSF Railway and a 2005 MTU alumnus. Morehouse shared reflections on his professional journey and offered insights into emerging trends shaping the future of rail transportation. The evening also recognized Adam Sohasky (MTU 2009) with an honorary membership in the Railroad Engineering and Activities Club (REAC) in appreciation of his continued support and contributions to MTU's rail program.

Micromechanics of Fresh and Fouled Railway Ballast

Initiated in August 2025, this project examines grain-scale behavior of fresh and fouled ballast to better understand lateral track strength and improve Discrete Element Method (DEM) simulations. Using a custom inter-particle loading apparatus, initial testing of Ontario Trap Rock demonstrated reliable measurement of normal and tangential responses, with friction values ranging from 0.45 to 0.65. Crushing tests revealed increasing grain strength and a progressive shift toward spheroidal shapes. Future work will incorporate field-fouled ballast and expanded testing capability, supporting improved ballast condition assessment and maintenance decision-making.

Modular Kirigami Truss for Temporary Railroad Bridge Systems

Beginning in August 2025, this project explores deployable bridge systems for rapid railroad bridge replacement following extreme events. A simulation platform was developed to evaluate deployment motion and load capacity across multiple bridge concepts. Results indicate that integrating scissor mechanisms with origami-inspired designs yields a modular system capable of supporting railroad loads. A reduced-scale prototype has been constructed, with future efforts focused on high-fidelity modeling and actuation integration.



A reduced-scale 8-ft long prototype with 2 units was fabricated using metallic members as a proof-of-concept demonstration.

Gifty Odai

Gifty Odai joined MTU in Fall 2024 as a master's student in civil engineering, but over time developed a strong interest in geotechnical engineering and switched her focus. She is pursuing a Ph.D. in Civil Engineering with a research focus on the "Micromechanical behavior of railway ballast". She was recently awarded 2nd place at the MTU Graduate Research Colloquium for her presentation on "Micromechanics of Mining Derived Materials". Her long-term goal is to contribute to the development of resilient and sustainable infrastructure systems by integrating micromechanical insights into engineering design and practice, particularly within the railway sector.

Morgan State University

Derrick Mirindi, Doctoral Student, at the 2025 NURail CoE Annual Meeting, presenting a hedonic pricing study of freight rail corridors.

The research team at Morgan State University further explored the impacts of rail infrastructure on residential parcels across rural, suburban, and urban landscapes. The group is coordinating with other members of the NURail consortium to better quantify intercity rail ridership patterns. To this end, Morgan State will compile and analyze on-board survey data that has been collected at a variety of properties across the nation. This effort focuses on understanding the trip purpose motivators that drive ridership to better inform the design and marketing of rail passenger services. The Morgan State team has a deep background in rider survey analysis and was instrumental in the creation of the transit survey archive of the Transportation Secure Data Center at the DOE's National Renewable Energy Laboratory (NREL). To date, the Morgan team has been identifying the surveys conducted and the limited research performed on these data.

New Faculty: Yuliang Zhou

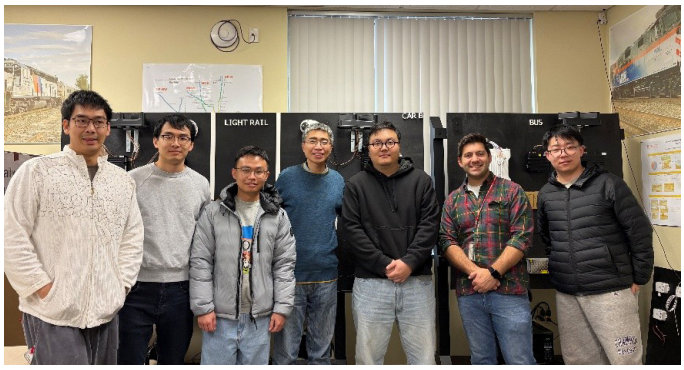
Dr. Zhou is an Assistant Professor in the Department of Transportation & Urban Infrastructure Studies. He earned his Ph.D. (2025) in Civil Engineering (Rail Transportation Engineering) from The Pennsylvania State University - University Park and previously completed a B.S. (2016) and a Ph.D. (2021) in Transportation Engineering at Tongji University, China. Dr. Zhou's research focuses on assessing the condition of rail infrastructure and monitoring its health using advanced sensing technologies, including fiber optic sensing, MEMS sensors, UAV-based imaging, and multi-sensor networks. He has contributed to research projects supported by the Federal Railroad Administration (FRA), U.S. Department of Transportation (USDOT), and the Association of American Railroads (AAR).

Student Spotlight: Nicole Anderson

Nicole Anderson, Ph.D., is a transportation safety researcher focused on improving the safety and efficiency of hazardous materials transportation, particularly in emerging energy logistics such as liquefied natural gas (LNG), hydrogen, ammonia, and lithium batteries. Her research develops risk-informed, data-driven decision-support tools to enhance public safety and transportation system resilience.

Her work centers on advancing a decision-support framework for LNG rail transport that integrates quantitative risk assessment, event tree analysis, and route optimization using the Risk Profiler Automation Tool (RPAT). This framework evaluates trade-offs between transportation cost and public safety by incorporating derailment probabilities, infrastructure characteristics, and population exposure into routing decisions. Her research demonstrates how risk-informed routing strategies can reduce the potential consequences of hazardous materials incidents while supporting more efficient and resilient energy logistics planning.

Rutgers University



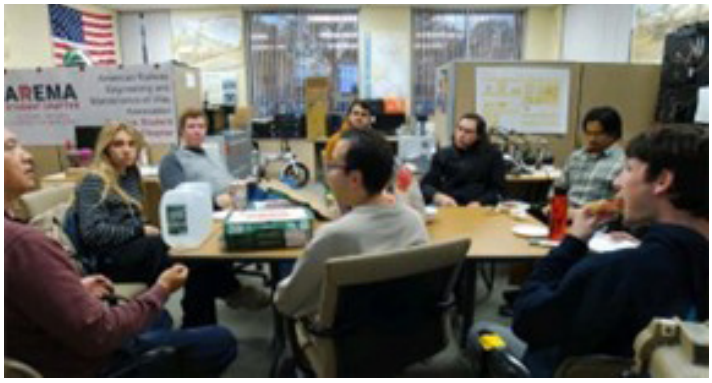
The Rutgers Rail and Transit Program Team

The Rutgers Rail and Transit Program is conducting research on AI-assisted track degradation modeling, with a particular focus on track geometry deterioration, supported by the NURAIL program. Led by Dr. Xiang Liu at the Rutgers Center for Advanced Infrastructure and Transportation (CAIT), the program is dedicated to advancing smart infrastructure and AI-driven railway safety.

As a key partner in NURAIL, Rutgers is leading efforts in Data Integration and Informatics for Track Asset Management. In collaboration with industry partners, the team is developing an informatics-enabled intelligent platform that integrates traditionally siloed datasets into a centralized data warehouse. This platform employs advanced spatio-temporal analytics to align and overlay track chart data with condition monitoring and operational records.

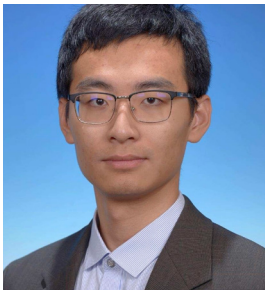
Through the application of statistical methods and machine learning techniques, the research enables the identification of track degradation patterns and the prediction of geometry changes over time. This approach supports a shift from reactive maintenance toward proactive, data-driven inspection and asset management strategies.

The platform's modular and scalable architecture ensures adaptability across diverse railroad systems. This work represents a significant advancement in infrastructure informatics by breaking down data silos and enabling more informed decision-making, ultimately enhancing the safety, resilience, and operational reliability of the national rail network.



The Rutgers Rail Lab collaborates with Rutgers AREMA Student Chapter for its 2026 Kick-off Meeting

Mulin Wan



Mulin Wan is a second-year Ph.D. student whose research focuses on AI-assisted track degradation modeling. His work applies advanced computational methods to enhance railway safety and efficiency. In particular, Mulin develops Transformer-based models to predict track gauge deterioration, enabling proactive maintenance in the rail industry.

A key component of his research is the Track Information Management System (TIMS), through which he has developed methods to synchronize multi-year spatio-temporal datasets from railroad partners, integrating heterogeneous data into a unified framework.

In his current work, Mulin employs a two-stage synchronization approach combining RFID-assisted anchoring with cross-correlation to align wide-gauge measurement data. He then applies self-attention–based Transformer architectures to model spatio-temporal dependencies and forecast track gauge deterioration with up to a six-month lead time.

This framework transforms engineering and inspection records into a predictive, data-driven maintenance system that supports decision-making and improves long-term rail infrastructure reliability.

University of Texas at Austin

To help raise the profile of railway research and education within the Department of Civil, Architectural and Environmental Engineering (CAEE) at the University of Texas at Austin, during the 2025-26 academic year, the TRAIN lab used NURail CoE funds to support eight undergraduate student researchers. Mentored by Assistant Professor Tyler Dick, the undergraduate students have helped move CoE research forward by collecting and examining data, running simulations and conducting Geographic Information Systems analysis.

Professor Salvatore Salamone is progressing a project that aims to develop a non-contact, data-driven framework for automated rail defect detection using laser Doppler vibrometer (LDV) measurements. Over the past year, the project team has established a complete signal processing and analysis pipeline, including impulsive noise filtering, time–frequency feature extraction, and an LSTM-based autoencoder for unsupervised anomaly detection. The framework has been implemented and evaluated using field data collected from rails containing welded joints and transverse defects under realistic operating conditions. The results so far show that the approach can detect subtle changes in vibration responses caused by defects, and that these changes can be consistently linked to known damaged locations through reconstruction error trends. Current efforts are focused on improving model generalization across different track conditions and operating scenarios, enhancing the framework's capability to differentiate among defect types, and advancing toward real-time deployment for in-service railway monitoring.

Assistant Professor Yunlan (Emma) Zhang has been continuing her work to investigate the potential of architected instability-based metamaterials (AIMs) to strengthen the track structure. This year her research team completed the analytical model for the proposed architected instability-based metamaterial system and validated its predictions through laboratory experiments. Building on this validated framework, they established the relationships between key geometric parameters and mechanical performance, providing a strong foundation for subsequent design optimization and application development. Current efforts are focused on extending the model to enable temperature-controlled shape reconfiguration, with the goal of achieving adaptive and reversible responses under changing thermal conditions.

TRAIN lab graduate and undergraduate students tour the Austin CapMetro rail operations center and maintenance facility.

Juliana Johnson

Juliana Johnson is an M.S. student with the UT Austin TRAIN lab that is currently investigating the reliability of shared corridors under modern railway operating practices. Juliana obtained her undergraduate degree in Civil Engineering with a transportation focus at Iowa State University, and has gained passenger rail planning experience through internships with several design consulting firms. Since joining the TRAIN lab, Juliana has been using Rail Traffic Controller simulation software to study the performance implications of operating passenger trains on corridors with freight trains that exceed the length of passing sidings. Her study is focused on understanding and quantifying the delay mechanisms arising from interactions between these train types. The findings of her research will help inform prudent investments in track infrastructure to support dependable passenger and freight service.

Tuskegee University

Grinding of railhead of thermite welded samples.

Tuskegee University (TU) is a national, independent, and state-related institution of higher learning, located in the state of Alabama. Research in the Mechanical Engineering Department encompasses a wide spectrum of advanced topics such as fracture and failure analysis, corrosion, additive manufacturing, degradation of materials under extreme conditions, and the processing and characterization of ultra-high-temperature ceramic matrix composites (CMCs), flow diagnostics, microfluidic actuator design, fatigue crack propagation in bainitic, pearlitic, and manganese steels, rail steel repair, and the development of energy-efficient nanostructured cementitious compounds.

One key area of investigation is rail repair, specifically the evaluation of thermite welding, which is the most widely used technique for in-track welding and replacement of damaged rail segments. This process produces a Welded Zone (WZ) and a Heat Affected Zone (HAZ) with inhomogeneous microstructures and hardness, resulting in lower mechanical, fracture and fatigue properties of the thermite weld compared with the parent rail. The proposed research focuses on investigating the fatigue crack growth properties of the weld zone and the HAZ of thermite welds and compare these properties with the parent rail as well as those obtained using a GMAW repair technique developed by Tuskegee University. Conventional and inverse slow bend test on the modified GMAW repairs and thermite weld repairs will be performed according to AREMA standard test methods.

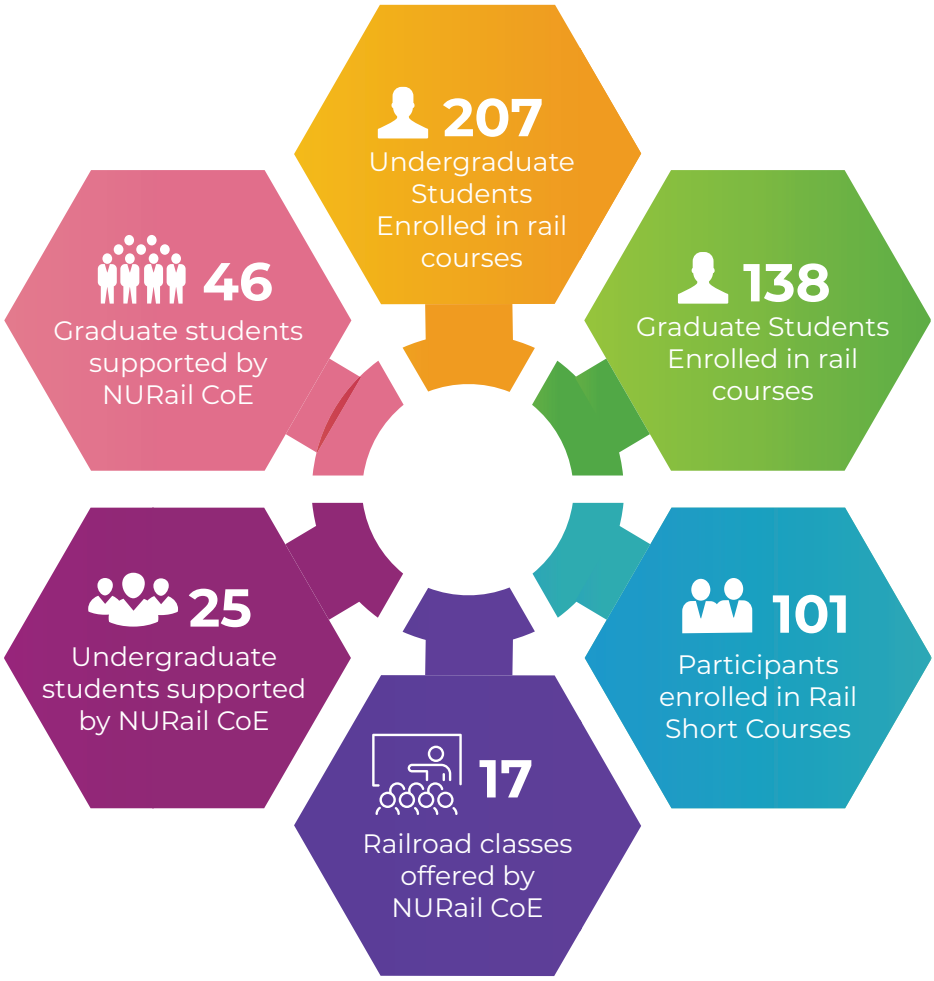
Milling of a rail section insert before GMAW welding.

Smith Samah

Smith Samah is a mechanical engineer currently pursuing a Ph.D. in materials science and engineering at Tuskegee University under the guidance of Dr. H. Aglan. Smith's research focuses on the fracture and fatigue damage tolerance relationships of GMAW welded rails, as well as failure analysis of slow bend tests performed on both thermite and slot welded rail joints.

His work seeks to characterize how different welding techniques influence crack initiation, propagation, and ultimate failure under varying loading conditions. By integrating mechanical testing with detailed failure analysis, Smith aims to identify critical performance differences between welding methods. The goal of his research is to support the development of slot welding as a field-ready technique for rail repair and construction, ultimately improving rail integrity, safety, and long-term performance in the rail industry.

Education & Workforce Development



- 21 Students attended the NURail CoE Annual Meeting; 81 students attended other rail and transportation events
- 47 Graduates entering rail and transit workforce
- 52 AREMA Student Chapter Members
- 53 students specializing in rail transportation engineering
- 350 students enrolled in rail courses
- 838 K–12 students reached at nine rail-focused K–12 outreach activities

NURail CoE Courses

University of Illinois Urbana-Champaign	University of Delaware	Michigan Technological University	Rutgers University	University of Texas at Austin
CEE 408 Railroad Transportation Engineering	CIEG 318 Introduction to Railroads	CEE 4404/CEE 5414: Railroad Engineering	RR Transportation System (180:551)	CE 397 Railway Terminal Design and Operations
CEE 409 Railroad Track Engineering	CIEG 417/617 Railroad Safety & Derailment Engineering	CEE 4407/CEE 5417: Transportation Design	Rail Data Analytics (180:557)	CE 377K/397 Railway Project Design & Construction
CEE 412 High-Speed Rail Engineering	CIEG 418/618 Railroad Engineering	CEE 3490: Introduction to Sustainable Rail Transport	Rail Track Engineering & Safety (180:555)	
CEE 411 Railroad Project Design and Construction	CIEG 414/614 Railroad Geotechnical Engineering	MAE 4990: Senior Design Project (Railway Topics)		

Railroad Environmental Conference

RREC features presentations by railroaders, consulting engineers, academics and others involved in all aspects of railroad environmental topics. 2025 was hosted by University of Illinois Urbana-Champaign and had 402 attendees.

Sustainability & Resiliency Day

The Sustainability & Resiliency (S&R) Day was hosted by the American Railway Engineering and Maintenance-of-Way Association (AREMA) and RailTEC at the University of Illinois Urbana-Champaign. 2025 had 111 attendees.

Delaware Big Data Conference

Railways use advanced technology to gather extensive data on track, equipment, and operations. This "Big Data" requires new analysis techniques to convert it into useful information for planning maintenance and operations. This conference was hosted at University of Delaware and had 220 attendees.

Midwest Rail Conference

The Midwest Rail Conference host by Michigan Technological University had 150 total registrations and brought together industry leaders to discuss key issues shaping the region's extensive rail network. Covering freight and passenger rail across states like Wisconsin, Indiana, Illinois, Michigan, and Ohio, the conference explored topics such as rail investment, decarbonization, urban rail development, and the future of high-speed passenger service.

Railroad Night

On September 8th, 2025, Michigan Tech hosted an engaging Rail Night, bringing together 60 students, faculty and industry representatives. The evening started with an interactive industry panel discussion that was both informative and enjoyable, sparking meaningful conversations about the rail industry.

Conferences **5**

940+ Attendees

NURail CoE hosted five conferences, Railroad Environmental Conference (402 attendees), Sustainability & Resiliency Day (111 attendees), Michigan Rail Conference (150 attendees), Railroad Night (60 attendees), and Delaware's Big Data Conference (220 attendees) for a total of 943 attendees.

Seminars **9**

1400+ Attendees

NURail CoE hosted nine seminars at University of Illinois Urbana-Champaign, University of Illinois Chicago, and Kansas State for a total of 1411 participants. This included both in-person and online participants.

Year 2 Project Table

Project ID	Principal Investigator	University	Project Title	Completion Status
KSU-I1	Robert Peterman	Kansas State University	Development of a Hybrid Concrete Tie for Increased Rotational Capacity and Resilience	
MTU-I1	Quang Tran & Paul Sanders	Michigan Technological University	Enhancing Accuracy of Ultrasound Imaging in Detecting Surface Cracks in Metal Using Microbubbles	
MTU-I2	Yousef Darestani	Michigan Technological University	Life-Cycle Cost Assessment of Coastal Rail Infrastructure	
MTU-I3	Sai Sandeep Chitta	Michigan Technological University	Micromechanics of Fresh and Fouled Railway Ballast	
MTU-I4	Yi Zhu	Michigan Technological University	Modular Kirigami Truss for Temporary Railroad Bridge Systems	
MTU-I5	Colin Brooks	Michigan Technological University	Integrating Long-Distance Drone Operations into Rail Inspections	
MTU-S1	Elizabeth S. Veinott	Michigan Technological University	Improving Rail Safety: Effect of highway rail-grade crossing type (short storage) and cognitive load on driver decisions	
RU-SC1	Xiang Liu	Rutgers University	Data Integration and Informatics for Track Asset Management	
TU-S1	Heshmat Aglan	Tuskegee University	Fracture and Fatigue Damage Tolerance of Arc Welded Railhead and Thermite Weld Repairs	
UD-S1	Allan Zarembski	University of Delaware	Risk Based Track Surfacing Model	
UD-S2	Joseph Palese	University of Delaware	Risk Based Walking Inspection Frequency Model	
UIC-SC2	Jane Lin	University of Illinois Chicago	AI-Enabled Autonomous Drayage–Rail Coordination for Efficient Intermodal Logistics	
UIC-SC3	Kouros Mohammadian	University of Illinois Chicago	A Data-Driven Framework for Prioritizing and Optimizing Rail Service Investments Using IPDI	
UIC-SC4	Kouros Mohammadian	University of Illinois Chicago	Rail as a Supply-Chain Stabilizer: Mapping Shock Propagation and Redundancy Gaps in U.S. Freight Rail	
UIC-SC5	P.S. Sriraj	University of Illinois Chicago	Analysis of Variations in Service Quality and its Determinants across Commuter Rail Markets	
UIC-SC6	P.S. Sriraj	University of Illinois Chicago	Financial Resilience for Rail in the Age of AI: Reducing Electricity Costs and Enhancing Corridor Revenue	

Year 2 Project Table

Project ID	Principal Investigator	University	Project Title	Completion Status
UIUC-I1	Riley Edwards	University of Illinois Urbana-Champaign	Buckle Risk Modeling Leveraging Track Geometry and Condition Data	
UIUC-I2	Ramez Hajj	University of Illinois Urbana-Champaign	Combined Grade Crossing Track/Highway Multiphysics Model	
UIUC-I3	John Popovics	University of Illinois Urbana-Champaign	Quantifying Lateral Track Capacity Using Non-destructive Nonlinear Vibration Response	
UIUC-I4	Erol Tutumluer	University of Illinois Urbana-Champaign	Field Ballast Condition Evaluation Using Machine Vision and Artificial Intelligence	
UIUC-I5	Riley Edwards	University of Illinois Urbana-Champaign	Comparative Evaluation of Capital and Spot Tamping Effectiveness through Track Geometry Deterioration Rates	
UIUC-I6	Marcus Dersch	University of Illinois Urbana-Champaign	Rail Anchor Slip Strength: Effect of Anchor Wear, Rail Wear, Load Rate, and Reaction Position	
UIUC-I7	Marcus Dersch	University of Illinois Urbana-Champaign	UAV-Based Measurements with Optimization-Based Geometric Correction	
UIUC-I8	Marcus Dersch	University of Illinois Urbana-Champaign	Advancement of 3D Dynamic Finite Element Model Framework	
UIUC-S1	Chris Barkan	University of Illinois Urbana-Champaign	Efficacy of 4-Quad Grade Crossing Gates Compared to Other Warning Systems	
UIUC-S2	Chris Barkan	University of Illinois Urbana-Champaign	Advanced Simulation Modeling of Tank Car Safety Performance in Derailments	
UIUC-SC1	Kirill Levchenko	University of Illinois Urbana-Champaign	Positive Train Control with Asymmetric Authentication and Key Management	
UT-I1	Yunlan (Emma) Zhang	University of Texas at Austin	Strengthening the Railway Track Lateral Resistance by Reinforcing Ballast with Architected Instability-based Metamaterials (AIMs)	
UT-S1	Salvatore Salamone	University of Texas at Austin	Rail Defect Detection System Based on Non-contact Vibration Measurements	
UT-SC1	C. Tyler Dick	University of Texas at Austin	Optimizing Efficiency and Cost of Innovative Strategies for Freight Rail Motive Power Energy Supply	
UT-SC2	C. Tyler Dick	University of Texas at Austin	Comparing Freight Rail Propulsion Strategies for Efficient and Economical US Mainline Operations	

Supported Students

University of Illinois Urbana-Champaign

Derek Campbell is an M.S. student in Civil Engineering conducting research on the effect of four-quad versus two-quad crossing gates on preventing collisions between trains and motor vehicles highway-rail grade crossings.

Sunav Dahal is a Ph.D. student in Civil Engineering working on lateral track stability using impulse response measurements.

Kelin Ding is a Ph.D. student in Civil Engineering, her research focus is on railway ballast fouling conditions and particle shape characteristics using computer vision and deep learning techniques.

Sam Eberle was an M.S. student in Civil Engineering advancing methodologies to estimate the track's propensity to buckle linearly on a tie-by-tie basis along an entire rail corridor via the execution of torsional resistance laboratory experiments.

Coleman Froehlke was an M.S. student in Civil Engineering quantifying the effect of anchor and rail wear on drive-on rail anchor slip strength such that rail stress management practices could be improved.

Jose Gustavo Ramos is a Ph.D. student in Civil Engineering developing a scalable and safe approach for quantifying rail creep-related movement and assessing longitudinal restraint effectiveness under operational conditions.

Paige Hardt was an M.S. student in Civil Engineering quantifying the effectiveness of maintenance via advancing methods to identify track maintenance through rail geometry data.

Drew Hohe is an M.S. student in Civil Engineering using an advanced simulation model to evaluate the dynamic forces in train derailments and the types of damage experienced by tank cars involved in these derailments.

Kaifeng Hu is a Ph.D. student in Civil Engineering leveraging track geometry and infrastructure condition data to advance methodologies to estimate the track's propensity to buckle linearly on a tie-by-tie basis along an entire rail corridor and is executing torsional resistance laboratory experiments.

Kamyar Kosarneshan is a Ph.D. student in Civil Engineering quantifying the effect of non-uniform longitudinal resistance and longitudinal rail creep on rail stress management and track buckle risk through the advancement of a dynamic finite element model.

Srivalli Lanka is an M.S. student in Information Sciences conducting statistical analysis quantifying the relationship between selected railroad infrastructure characteristics and derailment rate on railroad mainlines for use in transportation risk assessment.

Babak Asadi is a Ph.D. student in Civil Engineering, with a research focus in AI.

Richard Liu is an M.S. in Computer Science with a research focus on EOT-HOT communication security.

Xinhao Liu is a Ph.D. student in Civil Engineering conducting statistical analyses of the relationship between train length and use of distributed power, to quantify the effect on derailment rate, derailment severity, and transportation risk.

Cayden Schroeder is an M.S. student in Civil Engineering quantifying the effectiveness of maintenance via advancing methods to identify track maintenance through rail geometry data.

Nakul Vasani is an M.S. student in Information Sciences advancing methodologies to estimate the track's propensity to buckle linearly on a tie-by-tie basis along an entire rail corridor via assessing train dynamics along a route and incorporating the wheel-rail forces.

University of Illinois Chicago

Vivian Aguilar is a student in the College of Urban Planning and Public Affairs is researching data pertaining to grade crossings and safety issues associated with blocked crossings.

Arman Aminipanah is a Ph.D. student in the College of Business working on Virtual Power Purchase.

Brian Christian is a MUPP student at the College of Urban Planning and Public Affairs working on data collection and data development for rail yards nationwide and conducting spatial analysis to merge rail yard data with land use data.

Abbie Hamilton is a MUPP student at the College of Urban Planning and Public Affairs researching data governance practices of commuter rail service providers regarding management of rail assets.

Nirupama Jayaraman is a Ph.D. Student in the College of Liberal Arts and Sciences, and is working on assimilating literature on the impact of blocked crossings and related data on crossings.

Paula Palliwoda is a MUPP student in the College of Urban Planning and Public Affairs, and is working on assimilating literature on the impact of blocked crossings and related data on crossings.

Zachary Perkins is a MUPP student at the College of Urban Planning and Public Affairs conducting reviews of published recent rider experience survey data and analysis of select commuter rail systems.

Archit Rathod is an M.S. student at the College of Engineering, Department of Computer Science, he is providing technical support for data processing and data cleaning and imputation for railyards nationwide.

Ethan Reid is a MUPP student at the College of Urban Planning and Public Affairs reviewing and documenting different methods of determining quality service for commuter services.

Lucas Sreniawski is a MUPP student at the College of Urban Planning and Public Affairs, his work focuses on compiling historical land use data near rail yards to develop a longitudinal land use data to identify changes over time.

Ross Uhler is a MUPP student at the College of Urban Planning and Public Affairs is researching sources and degrees of uncertainty pertaining to rail system assets that could impact the quality and reliability of decision support analysis.

Michigan Technological University

Zhongqi Fan is a Ph.D. student in Structural Engineering researching modular kirigami truss for temporary railroad bridge systems.

Siva Ikkurthi is a Ph.D. student in Civil Engineering researching Advanced micromechanics research on mining-derived granular materials.

Nya McDougald is a Ph.D. student in Psychology researching Human Factors Driving Experiments.

Gifty Odai is a Ph.D. student in Civil Engineering researching advanced micromechanics research on mining-derived granular materials.

Hinga Roseline Raliba is a Ph.D. student in Civil Engineering researching enhancing accuracy of ultrasound imaging in detecting surface cracks in metal using microbubbles.

Morgan State University

Derrick Mirindi is a Ph.D. student in Architecture, Urbanism, and Built Environment analyzing sound and vibration profiles of rail infrastructure.

University of Delaware

Johnson Chukwu is a Ph.D. student in CE analyzing risk based scheduling of track geometry car scheduling.

Manisha Kandel is a Masters student in CE analyzing walking inspection intervals considering a risk basis.

Kansas State

Veeshal Modi is a Mechanical Engineering, Ph.D. researching Rail Neutral Stress Detection.

Kyler Starbuck is an M.S. student in Civil Engineering researching Crosstie Flexural Behavior for Various Tie Types.

Rutgers University

Weitian Li is a Ph.D. student researching infrastructure degradation modeling.

Mulin Wan is a Ph.D. student researching infrastructure degradation modeling.

University of Texas at Austin

Matthew Friar is an M.S. student in Civil Engineering investigating trends in the location and characteristics of train handling derailments over time.

Juliana Johnson is an M.S. student in Civil Engineering investigating the performance of shared corridors under evolving railway operating practices.

Jinghang Weng is a Ph.D. student in Civil Engineering working on nondestructive evaluation of railway infrastructure, with a focus on detecting rail defects using vibration measurements and data-driven methods.

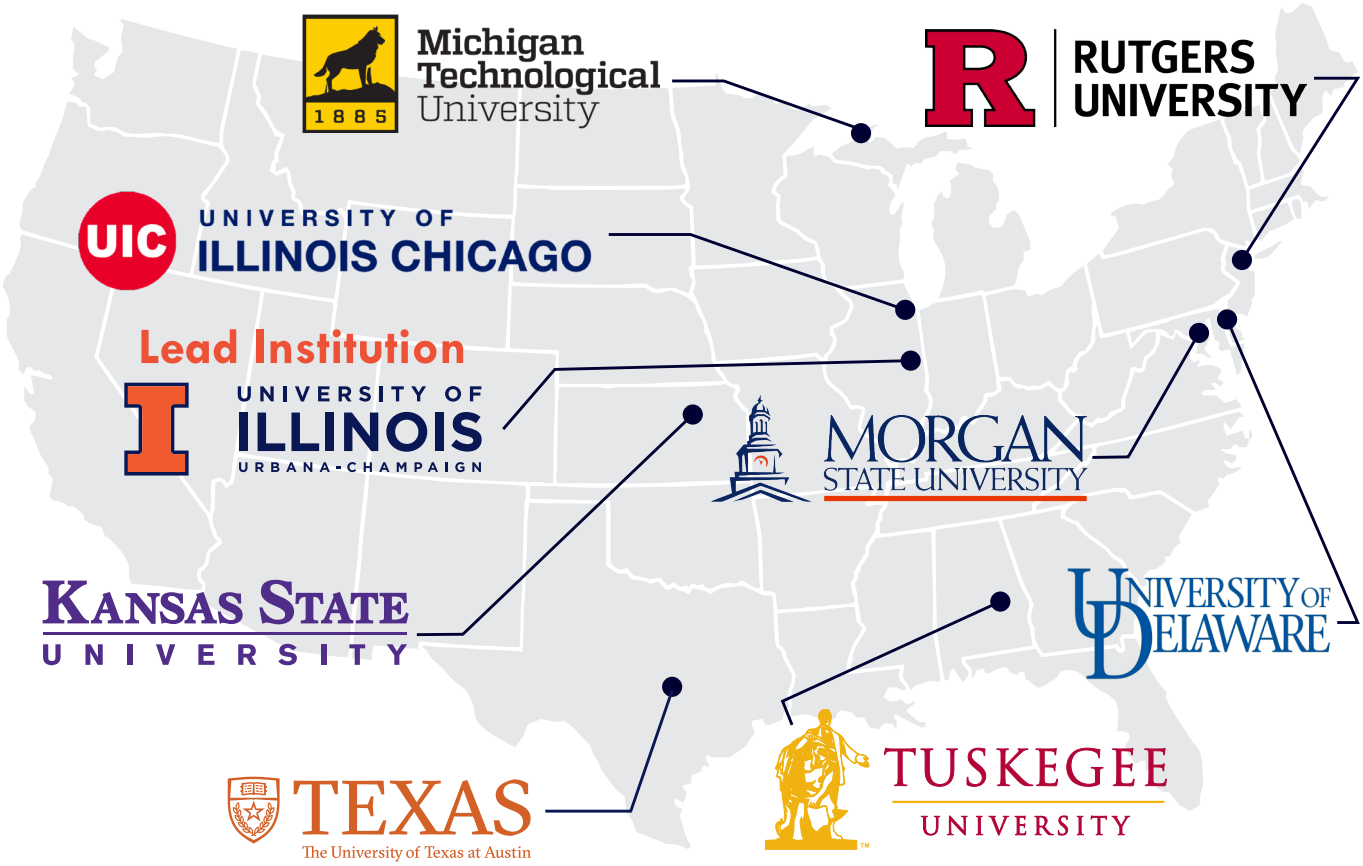
Heyang Zhang is a Ph.D. student in Civil Engineering investigating the performance of short-haul rail corridors.

Sibo Zhang is a Ph.D. student in Civil Engineering developing Architected Instability-based Metamaterials (AIMs) to reinforce ballast.

Tuskegee University

Al-Rajean Allie is an M.S. Student in Mechanical Engineering studying fracture and fatigue properties of thermite welded rails.

Smith Samah is a Ph.D. student in Materials Science and Engineering studying fracture and fatigue damage tolerance of Gas Metal Arc Welding (GMAW) welded rails, and slow bend failure of GMAW and Thermite welded rails.



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