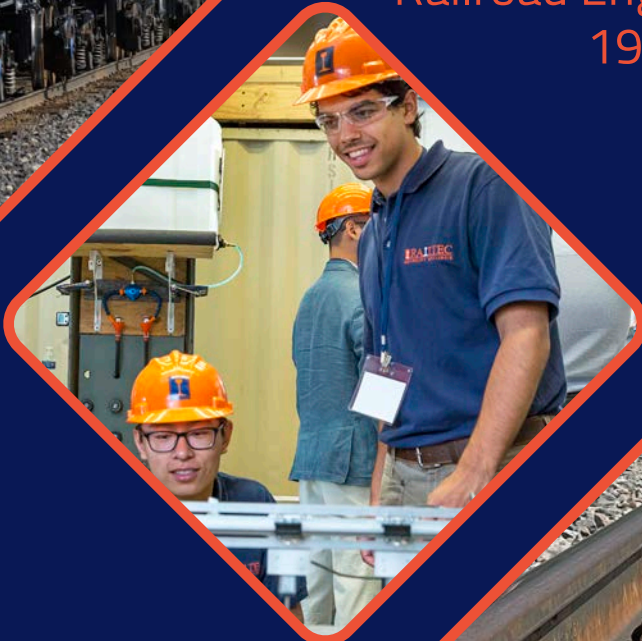




Celebrating the Resurgence  
of the University of Illinois  
Railroad Engineering Program  
1998-2023







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# LEGACY OF EXCELLENCE



For over 140 years the University of Illinois Urbana-Champaign has been a leader in railroad transportation engineering research and education. Significant contributions by Illinois faculty date to the latter 19th century. In 1885 Arthur Newell Talbot was hired to teach a variety of topics including railroad engineering. In the early 20th century, he led an AREA-ASCE Special Committee on Stresses in Railroad Track in a multi-decade effort that developed fundamental understanding of the principles of track design and behavior. Edward C. Schmidt worked in the laboratory and with railroads conducting extensive experimental testing of train resistance and locomotive power, later extended by John Tuthill. These results contributed to development the Davis Equation and its derivatives that continue to be used today to estimate train resistance power requirements.

Other notable 20th century rail faculty include Herbert F. Moore who solved the problem of shatter cracks in rail, Harry R. Wetenkamp whose research led to a new design of railroad wheel to prevent them from breaking, Everette E. King author of the textbook on Railway Signaling, D. Phillip Locklin author of several books on rail transport including 7 editions of Economics of Transportation, John F. Due, also noted for his contributions to railway transportation economics, and Clement C. Williams who was

the Civil Engineering Department head in the 1920s and wrote the book, Design of Railway Location.

Most notable for his impact in the 2nd half of the 20th century was William W. Hay who was Professor of Railroad Engineering for over 30 years. Through his teaching and research, he had a major influence on modern railroad engineering practices. His influence continues to be felt through his many students who rose to prominent positions in the rail industry. Hay's long and distinguished career at Illinois culminated in the 2nd edition of his book, Railroad Engineering, which remains the definitive North American text on subject.

A new era in the Illinois railway engineering program began in 1983 when Illinois was awarded one of three Association of American Railroads Affiliated Laboratories under the direction of Ernest Barenberg. He worked closely with AAR, the railroads, and dozens of Illinois faculty helping apply their specialized expertise developing solutions to a variety of important problems.

# RAILTEC RESURGENCE

Following Professor Barenberg's retirement, Illinois evaluated the future of its rail research and educational activities. Nearly all other universities in North America had dropped the remaining vestiges of their rail programs and there were real questions about why Illinois should retain theirs. However, senior Illinois faculty and administration understood that rail was a critical element of the nation's transportation system and that its importance was destined to grow. Meanwhile, AAR believed that Illinois was the strongest of its three Affiliated Labs and wanted its rail program to continue. A discussion ensued involving senior management at AAR, UIUC administrators in the College of Engineering and Department of Civil and Environmental Engineering, and Christopher Barkan, a member of the research staff at AAR. A decision was reached to reinvest in the Illinois rail program and hire Barkan to lead and reinvigorate it.

Beyond research AAR also wanted a new academic curriculum in railroad engineering to attract and educate a new generation of railway engineering professionals. Neither of the other Affiliated Labs had done this and the industry needed to recruit new engineering talent to replace an aging workforce.



Professor Barkan pursued three principal objectives: broadening the rail research program that Barenberg established by engaging new faculty expertise and increasing the amount and sources of funding for rail research, expanding the rail curriculum to attract top-quality students and educate them so they could enter rail sector positions with a robust understanding of rail engineering fundamentals, and strengthening Illinois' service to the rail industry, government, academia, and the public.

The accomplishments of the last quarter century would not have occurred without the outstanding team of faculty, postdoctoral fellows, research and administrative staff, and hundreds of dedicated and talented graduate and undergraduate students. They have produced hundreds of publications from projects supported by a diverse group of sponsors including: AAR, FRA, NSF, RSI, TRB, railroads, rail supply companies, rail customers, and others. RailTEC research results have been presented at numerous national and international conferences, workshops, and meetings, including AREMA, AAR, TRB, WCRR, IHH, and many others.

Illinois has enjoyed a strong record of achievement in railroad engineering, beginning in the 19th century, continuing throughout the 20th, and has renewed its commitment to leadership in the 21st.

# RAILTEC FACULTY



Christopher Barkan, Ph.D.  
Professor  
George Krambles Director – RailTEC



J. Riley Edwards, Ph.D., P.E.  
Assistant Professor



Conrad Ruppert, Jr., P.E.  
Adjunct Instructor



James Shi  
Adjunct Instructor



C. Tyler Dick, Ph.D., P.E.  
Research Associate Professor



TC Kao, Ph.D., P.E.  
Visiting Professor



Rapik Saat, Ph.D.  
Research Assistant Professor



Donald Uzarski, Ph.D., P.E.  
Adjunct Professor



# RESEARCH ENGINEERS & POSTDOCTORAL FELLOWS



Marcus Dersch, Ph.D., P.E.  
Principal Research Engineer



Arthur de Oliveira Lima, MS  
Research Engineer



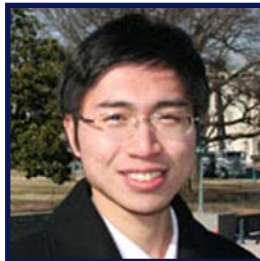
Matt Csenge, MS  
Research Engineer



Ryan Kernes, MS  
Research Engineer



Chen-Yu Lin, Ph.D.  
Postdoctoral Fellow



Xiang Liu, Ph.D.  
Postdoctoral Fellow



Yu Qian, Ph.D.  
Research Engineer



Brent Williams  
Research Engineer

# RAILTEC STAFF



Emma Ehrenhart  
Senior Manager



L.B. Fry  
Research Program Coordinator



Tim Gress  
Associate Director



Kimberley Schlichting  
Assistant to the Director



Vicki Dixon  
Assistant to the Director



Angela Stanford  
Research Program Coordinator



# RAILTEC PUBLICATIONS



Scan to view RailTEC publications.

RailTEC is a global leader in applied and theoretical research advancing the field in a broad range of important and timely railroad and rail transit engineering and transportation topics. Advanced research investigations are underway in railway safety, systems, and infrastructure, addressing dozens of topics that are essential to maintaining the safety, efficiency, reliability, sustainability and resiliency of railroad freight and passenger transportation. Much of this research is translational in nature and having a substantial impact on practice.

# RAILTEC TIMELINE

1983

AAR selected Illinois as one of its three original Affiliated Laboratories with Ernest Barenberg as Director.



1998

Renewed commitment to rail program with creation of new, full-time faculty position in rail engineering and development of railroad academic curriculum. Christopher P.L. Barkan was hired for this role.



1999

First Railroad Environmental Conference (RREC) held in 1999 with 150 attendees. RREC continues to be the principal annual gathering of the railroad environmental community with over 400 attendees.



2001

C. Tyler Dick received the first M.S. degree in 2001 then joined RailTEC as Senior Research Engineer in 2012 to lead, support and conduct rail research and educational programs.



2003

CN Railway established an ongoing fellowship that supports graduate students' research and education in rail engineering.



2004

George Avery Grimes received the first Ph.D. under the newly rejuvenated rail engineering program.



2005

Norfolk Southern funded the establishment of the William W. Hay Seminars in 2005. The Hay Seminar Series continues to host a diverse group of speakers today.



2008

University of Illinois AREMA Student Chapter founded to foster students in their development as future leaders in railroad engineering.



The first Railway Engineering Education Symposium (REES) organized and hosted.



2009

Rapik Saat joined RailTEC as the first postdoctoral fellow and was promoted in 2011 to Research Assistant Professor to lead and support research and educational programs.



2010

Rail Transportation and Engineering Center (RailTEC) formed to facilitate the railroad industry through education, research and service efforts.



TC Kao taught the first High-Speed Rail (HSR) class in the spring of 2010.



RailTEC planned and hosted the Joint Rail Conference (JRC) on the Illinois campus.



## 2012

Led successful seven university coalition for a \$3.5 million grant for the first rail-focused USDOT University Transportation Center, the National University Rail (NURail) Center.



First International Crosstie and Fastening System Symposium was hosted. The bi-annual symposium has continued to grow and serve as a critical technology transfer for the industry.



## 2013

Designed and constructed the 3,500 sq ft Research and Innovation Laboratory (RAIL)



## 2014

The 2014 Global Level Crossing Safety & Trespass Prevention Symposium (GLXS) was hosted at Illinois.



U.S. Federal Railroad Administrator Joseph C. Szabo visited RailTEC.



## 2015

The first Railway Engineering Short Course course was held.

The Research and Innovation Lab (RAIL) held its Grand Opening with Gregory Winfree, Assistant Secretary for Research and Technology for the U.S. DOT and Joseph Leader, Senior Vice President for NYCT in attendance.



## 2016

RailTEC was featured in the BBC's "Great American Railroad Journeys".



The Railway Academic Conference (TRAC) is hosted.



## 2017

The Railway Infrastructure and Vehicle Inspection Technology (RIVIT) was hosted on University of Illinois Urbana-Champaign campus.



Senator Tammy Duckworth and UI Chancellor Robert Jones met with RailTEC members and toured the Research and Innovation Laboratory (RAIL).



## 2019

RailTEC hosted Dr. Maryam Allahyar, Director, Office of Research, Development & Technology, Federal Railroad Administration.



## 2020

Federal Railroad Administrator Ron Batory visited RailTEC.



## 2023

U.S. Secretary of Transportation Pete Buttigieg visits RailTEC and University of Illinois alongside Senator Dick Durbin and Congresswomen Nikki Budzinski.



# RAILTEC BY THE NUMBERS



**15**

Doctoral Degrees  
Awarded



**105**

Masters Degrees Awarded



**12**

Railroad  
Courses



**8**

Instructors



**+1,750**

Students



**+147**

Journal Papers



**+210**

Conference  
Presentations

International  
Students

**+18**

Countries

**5**

Continents





**187**  
Scholarships



**26**  
CN Fellowships



**22**  
K-12 Programs



**11**  
Short Courses



**35**  
Conferences Hosted



**193**  
Hay Seminars

# RAILTEC ALUMNI IMPACT



RailTEC alumni are having a worldwide impact through their work with major US and overseas railroads, rail engineering and supply firms, federal and state DOTs, transit agencies, trade associations, research organizations, and universities. As demand has grown for new talent in the industry, RailTEC has met that call with our exceptional alumni that benefit from not just the rich academic environment on campus, but their involvement in rail research, seminar and conference attendance, field trips, and hands-on, practical experience. RailTEC is also supporting the growth of the U.S. rail academic community; most of the young faculty hires in new or expanded university rail programs in the past decade are Illinois graduates.

# ALUMNI EXPERIENCE

“The University of Illinois, with tremendous faculty and course options in engineering, computer science, and business, is a unique place to pickup ‘tools’ that you will use throughout your career.

Dr. Rapik Saat

Director Operations Analysis  
Association of American Railroads



RailTEC ... provided a number of opportunities to connect with experienced people in the industry, and created a great launching pad to a career in railroading.

Kevin Day

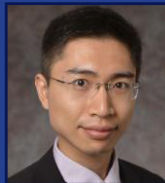
Independent Railway Consultant



RailTEC inspired my pursuit of being a railroad educator and researcher. The Univ. of Illinois is the incubator of many railroad academics in the United States.

Dr. Xiang Liu

Associate Professor Rail & Transit  
Rutgers University



RailTEC empowered me to own my research projects. The skills learned leading, analyzing, and presenting research catapulted my career into the next level.

Samuel Sogin

Manager of Operations Evaluation  
Union Pacific Railroad



RailTEC was a fantastic program to be a part of ... The faculty and staff not only gave me a solid background in rail engineering, but also continue to support my professional and personal growth.

Dr. Samantha Chadwick

General Engineer  
US DOT Federal Transit Administration



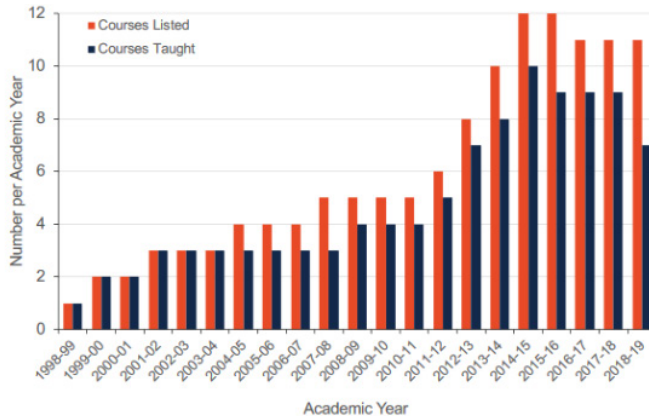
# RAILROAD COURSES



Illinois has the strongest academic program in railroad engineering of any university in North America. In the past 25 years, the academic program has grown from one course in railroad track engineering to multiple courses on a spectrum of railway transportation and engineering topics. RailTEC has a unique partnership with KTH, the Swedish Royal Institute of Technology in Stockholm offering joint courses in a virtual exchange program in railway civil, mechanical, and electrical engineering topics.

Illinois offers B.S., M.S., and Ph.D. programs in civil engineering with a rail transportation focus. RailTEC is also addressing the need for continuing education and distance learning options for the professional rail transportation community. We offer two annual Railway Engineering Short Courses and all of our rail courses include an online section through the Illinois CEE Online program. Online students can pursue a Railroad Certificate and an M.S. degree. RailTEC also organizes and hosts numerous rail-focused conferences, workshops, seminars, and other educational activities such as K-12 STEM outreach.

## RailTEC Courses Developed and Taught





# CONTINUING EDUCATION & K-12



Mike Franke of Amtrak (retired) presenting "Career Experiences of a U of I Railroad Engineering Graduate" in April 2018.

## William W. Hay Railroad Engineering Seminars

The William Hay Seminars are held periodically during the academic year and are open to all including students, faculty, staff, and interested members of the community. They feature speakers from Class I railroads, engineering firms, academia, Federal Railroad Administration, and many other organizations. Hay Seminars are also offered on-line and 100s of participants from all over the country and the world participate. Attendees can receive PDHs for their participation.

## Railway Engineering Short Courses

RailTEC began hosting Railway Engineering Short Courses in 2015 and since then more than 400 professionals have completed one or more courses with us. In response to changing demands of the industry, we switched to a virtual format in 2021 enabling a broader, more diverse group of students to participate including from Federal agencies, Class I railroads, transit authorities, engineering firms, academics and many others.

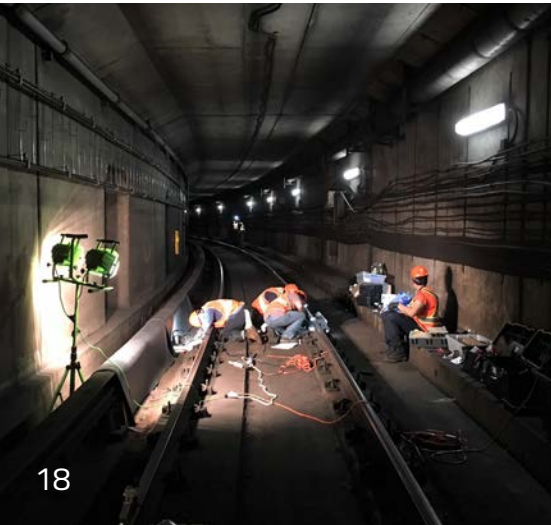
## K-12 Outreach

RailTEC hosts students of all ages ranging from elementary through high school to engage interest in rail engineering and STEM education. Beyond campus visits, Professor Tyler Dick developed the Guidebook for Railway-Themed K-12 STEM Outreach Activities for teachers and parents to use in their classrooms and homes.



# RESEARCH

RailTEC research benefits from extensive institutional knowledge and understanding of rail freight, passenger, and transit engineering and operations, combined with expertise in emerging disciplines critical to advancing railway safety, efficiency, and reliability. We are engaged in a broad range of research on the railroad track system, bridges, train operating safety, tank car design and hazardous materials risk, energy efficiency and environment, planning and design, train control systems, transport economics and advanced rail transportation and inspection technologies.



## Recent Examples of Impact on Practice

AAR, AREMA, FRA, and RAC have used RailTEC's translational research results to improve the safety, efficiency, and operation of railroads:

- AAR Tank Car Committee and industry executives used RailTEC research to inform their decision to adopt new, safer tank car design standards to prevent releases of hazardous materials
- AREMA committees used RailTEC research to develop eleven different revisions that were incorporated in AREMA's Manual for Railway Engineering
- RailTEC results were used to improve the clarity and interpretation of the FRA's Track Safety Standards Compliance Manual
- The Railway Association of Canada used RailTEC research to evaluate the impact of restrictions on Dangerous Goods train speeds on rail line capacity





## Rail Safety & Risk

RailTEC is engaged in a broad-based rail safety research program related to train operation, derailment and collision prevention, rolling stock design, infrastructure condition, and highway/rail grade crossing safety performance. The objective is development of objective, quantitative results to inform policy decisions that will improve the safe transport of people and goods in the most effective and efficient manner. Principal methods include advanced data analytics, operations research and optimization techniques, and computer simulation.

Both public and proprietary rail operational, safety, traffic, and hazardous materials data are used. This includes integration, analysis, and synthesis of large datasets and interpretation of results in the broader context of the North American railway operating environment.

Recent research includes analysis of the safety performance of new tank car designs for toxic inhalation hazard materials and flammable liquids, placement of hazardous materials cars in trains to minimize their involvement in derailments, effect of train length and distributed power on derailment rate and severity, analysis of train collision causes and characteristics - including adjacent track collisions, comparison of unit and manifest train derailments, and analysis of grade-crossing-collision-caused derailments.

## Railway System Operational Performance, Capacity & Efficiency

RailTEC conducts research on railway systems to improve operational performance and energy efficiency of the rail network. Growth in heavy-axle-load freight traffic and higher-speed passenger trains on the same infrastructure is increasingly straining North American rail capacity, resulting in delay, unreliable service, and lost efficiency. Maintaining a high level of service under anticipated traffic volumes while meeting industry decarbonization goals will require profound changes in operating strategies, infrastructure investment, and the adoption of new technologies such as alternative energy locomotives, advanced moving block control systems, and autonomous trains.

Through its railway systems research, RailTEC is increasing our knowledge of fundamental rail system relationships between transportation, energy, train performance, and automation in the context of railway mainlines and sidings, and yards and terminals. The objective is deeper understanding of how these elements interact to determine overall rail network performance, capacity, and efficiency.





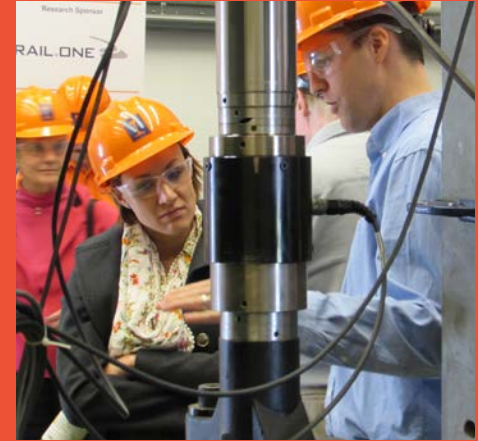
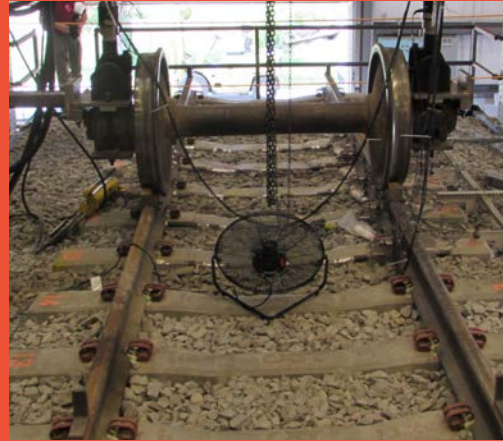
## Railroad & Rail Transit Track Infrastructure & Components

RailTEC conducts multi-faceted research to improve railway track and infrastructure safety, increase reliability, and reduce maintenance and life cycle costs. Premature component failure and excess maintenance substantially reduce operational performance and rail line capacity. Accurate quantification of the demands on track is necessary to determine the appropriate design life of components and properly match this to the diverse demands on heavy-axle-load freight, high-speed passenger, and rail-transit services. RailTEC addresses this using an array of approaches including simulation (finite element modelling), laboratory work (testing at the Research and Innovation Lab) field experimentation (instrumented revenue service sites), and use of big data analytics on very large track inspection datasets.

RailTEC is advancing the understanding of cross-tie design and performance; testing recommendations, installation, and use of fastening systems and other resilient materials such as under-tie pads; and development of proactive, data-driven maintenance recommendations. RailTEC achieve this via its robust collaborative network of private and public-sector rail sponsors and partners including strong support from the railway supply community.



# RESEARCH & INNOVATION LAB (RAIL)



In 2014, RailTEC opened the new Research and Innovation Laboratory (RAIL) with the objective of expanding North American track research capabilities. The development of this 3,500 sq. ft lab was supported by a diverse group of public and private sector sponsors and partners who shared our interest in novel testing capabilities. RAIL has unique track system and component testing capabilities unmatched by any other university in North America. It supports projects that will make rail freight, passenger, and transit infrastructure safer, and more resilient, reliable, and cost-effective.

RAIL boasts five separate multi-purpose test frames that are used to investigate the track system, its sub-systems, and individual components. At the heart of the laboratory is the full-scale track loading system encompassing an eleven-cross-tie panel with full-depth substructure (ballast, sub-ballast, and subgrade). Key research findings developed at RAIL have led to new or revised AREMA recommended practices including:

- Development of instrumented concrete crossties to quantify field-bending demands
- Quantification of lateral load paths through development of novel fastener instrumentation
- Development of a new design of joint-bar for a heavy rail transit system
- Identification of failure modes and potential solutions for broken spikes in elastic fasteners

# FIELD EXPERIMENTATION LOCATIONS



RailTEC works extensively with freight and passenger railroads, rail transit systems, and other research organizations developing focused instrumentation plans and installing a variety of integrated sensor technologies including rail and crosstie-mounted strain gauges, displacement measurement systems, accelerometers, digital image correlation, and UAVs. These are used to collect track and component response data at field experimentation sites under a broad array of revenue service loading conditions. Data are collected continuously and autonomously in extended duration tests, or manually for shorter tests, depending on the project and sponsor requirements and objectives.



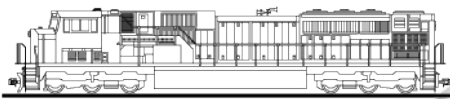
# CONFERENCES

## Railroad Environmental Conference

The Railroad Environmental Conference has been hosted on the Illinois campus since 1999. We are honored to have played a role in its development from the small gathering of 150 people and five supporter companies in 1999 to its present scope. Interest and attendance at the conference has grown considerably in the years since then and it has emerged as the principal annual gathering of the railroad environmental professional community. In 2022, more than 400 people attended from throughout North America and abroad, including railroaders, consulting engineers, environmental control equipment suppliers, regulators, industry attorneys, academics and other rail transportation professionals.

This annual conference enables rail industry employees to meet with peers throughout the railroad environmental community to exchange views, learn about new techniques and technologies, and generally stay in touch with the direction of the railroad industry's environmental programs.

## RAILROAD ENVIRONMENTAL CONFERENCE



John Cech of BNSF Railway presents the Keynote Address at the 2022 International Crosstie & Fastening System Symposium.

## International Crosstie & Fastening System Symposium

Professor J. Riley Edwards established the bi-annual International Crosstie and Fastening System Symposium in 2012. The objective of the symposium was to further international communication and collaboration on design and performance challenges and solutions for crossties and fastening systems. The symposium includes technical presentations, research discussion topics and technical tours that focused on the state of the art in timber, concrete, steel, and composite crosstie and fastening system design, performance, research, modeling, and inspection.



# National University Rail Center

US DOT OST-R Tier 1 University Transportation Center



The NURail Center was the first rail-focused USDOT OST-R University Transportation Center. The seven-university consortium was led by the RailTEC at UIUC. NURail's principal goals were to achieve a set of Research, Education, Technology Transfer Collaboration and Leadership objectives that not only fulfill center objectives, but support and assist achievement of goals beyond the consortium members. These included the rail industry, AAR and FRA research and workforce development goals. They also included working with other colleges and universities, both domestically and internationally, to advance academic rail education and research quality and quantity.

- 485 journal articles and conference papers
- 581 conference and workshop presentations
- 341 rail and transit courses taught
- 5,100+ students enrolled
- 1,534 students at rail and transit conferences
- 171 MS and PhD theses
- 250 rail and transit internships
- 196 hired in full-time rail and transit jobs
- 233 technology transfer activities
- 281 industry and government collaborations



# RAILTEC SPONSORS & PARTNERS



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