

8th Quarterly Program Progress Performance Report  
for  
National University Rail (NURail) Center:  
Tier 1 University Transportation Center



**National University Rail Center - NURail**  
USDOT OST-R Tier I University Transportation Center (UTC)

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A handwritten signature in black ink that reads "Chris Barkan". The signature is fluid and cursive, with the first name "Chris" and last name "Barkan" clearly legible.

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## 1. Accomplishments

### a. What are the major goals of the program?

The NURail Center's principal goals are, as stated in the proposal, to achieve a set of Research, Education, Technology Transfer Collaboration and Leadership objectives that will not only fulfill center objectives, but support and assist achievement of goals beyond the consortium members. These include rail industry, AAR and FRA research and workforce development goals. They also include working with other colleges and universities, both domestically and internationally to advance academic rail education and research quality and quantity.

### b. What was accomplished under these goals?

#### University of Illinois Urbana-Champaign (UIUC)

- **Railroad Capacity and Optimization:** Completed a Master's thesis on incremental capacity of lines with variable siding spacing and siding expansion strategy for operation of long trains. Presented at two conferences on these topics.
- **Railway Energy Efficiency:** Completed a Master's thesis on commuter rail energy efficiency. Presented at one conference.
- **Hosted the 2015 TRB SummeRail Conference** on the UIUC campus in August. Attendees from the railway industry were briefed on a variety of NURail research activities.
- **Conducted inaugural UIUC Railway Engineering Short Course** to provide working professionals with training and increased knowledge of fundamental railroad engineering concepts.
- **Developed content and presented at the Passenger Railway Engineering Education Symposium (p-REES)** to train other university professors on railway engineering concepts and principles related to passenger service.
- **Hay Seminar Series:** Hosted 3 on-campus seminars from industry experts that were also broadcast online. Total both online and in person attendees for the 3 seminars was 321.
- **K-12 Outreach:** Partnered with local STEM summer camp to develop hands-on activities and demonstrations related to railway engineering concepts. Hosted 12 fourth and fifth-grade students on campus to participate in the railway engineering activities.
- **Analytical Modeling of Concrete Crossties and Fasteners:** Work continued on a project to investigate the performance of bolted rail joints in rail transit systems, building on FE model knowledge gained under prior projects.
- **Research and Innovation Laboratory (RAIL) at Schnabel (railway engineering research facility):** Continued testing on the full-scale trackbed test structure, with detailed investigations into the lateral load path for multiple types of concrete crosstie fastening systems. Began focused research on flexural performance of concrete crosstie using a new experimentation testing apparatus, with promising results obtained to date.

#### University of Illinois Chicago – College of Engineering (COE)

- All US DOT and UIC matching funds allocated in federal FY11/FY12 are expended.
- Research on four major projects complete. Final reports being written for: 1) Integrated Dynamic Modeling of Rail Vehicles and Infrastructure, 2) Modeling of Rail Track Substructure, 3) Immersive Visualization of Rail Simulation Data and 4) Rail Infrastructure Materials for High Speed Rail
- Fifth project is finishing in spring 2016: Informed Railroad Traveler (phone app)

#### University of Illinois Chicago – College of Urban Planning and Public Affairs (CUPPA)

UIC-CUPPA has 4 research projects. VC (Value Capture Coordination): Drafted survey that is

final step of research, began drafting final report. Rail Safety (Rail Crossing Safety): Drafted final report. GIS (GIS Analysis of Environmental Impacts of Rail Development): Submitted to journal, awaiting final acceptance. Drafted final report. Freight (Economic Impacts of Freight Mode Choice): Outline for report has been developed, two research reports being edited/ revised to fit into the report format.

### **Massachusetts Institute of Technology (MIT)**

Recruited two graduate students who started in Sept 2015 to work on NURail projects. Includes work on NEC, CA HSR, Midwest HSR (Chicago to Urbana) and the relation of HSR to urban transportation systems (case study of Penn Station and the Hudson River Tunnels in NYC).

### **Michigan Tech University (Michigan Tech)**

#### **Started three new student projects**

- A civil engineering senior design project to plan improvements in the Lake State Railway Saginaw Rail Yard.
- Initiated a materials science undergraduate enterprise project to investigate potential improvements to identify cracks in cutout rails.
- Electrical engineering senior design project to find a system for identifying contaminated wheels at a hump yard before the retarders get contaminated.

#### **Outreach and Technology Transfer:**

- Dr. William Sproule, Dr. Pasi Lautala and David Nelson contributed to development of first pREES event, organized by the American Public Transportation Association (APTA). Dr. Sproule participated in the event. Jul 8-10<sup>th</sup>
- RTP and Railroad Engineering and Activities Club (REAC) supported an expo event for the Engineering Scholars Program (150 top level high school students). July 8<sup>th</sup>
- Dr. Lautala provided lessons in transportation and railways for the Designing A Sustainable Future Teacher Institute, Jul 23<sup>rd</sup>
- Summer Youth Program in Rail and Intermodal Transportation was run for 6<sup>th</sup> consecutive time in 2015 – 23 students involved in exploration of the rail industry and its connections with other transportation modes. July 26<sup>th</sup>- August 1<sup>st</sup>, 2015
- Led organization of 3<sup>rd</sup> Annual Michigan Rail Conference with over 170 participants, Aug 19-20<sup>th</sup>
- Rail Info Night– Students and industry representatives gathered to discuss industry opportunities. Sept 29<sup>th</sup>
- Dr. Pasi Lautala gave two presentations: “*Railroad Careers And Programs*”, “*Rail/ Multimodal Research at Michigan Tech*” and “*Upper Peninsula Freight (Rail) Study and Michigan Tech Rail Transportation Program*, Upper Great Plains Transportation Institute/North Dakota State University, Oct. 1-2, 2015
- Railway Interchange –12 students attended conference with Dr. Lautala and David Nelson and participated in AREMA student activities. Dr. Lautala presented paper co-authored by four NURail faculty partners. Oct 3-7<sup>th</sup>
- REAC conducted a Fall Field Trip to Loram Headquarters, Hamel, MN – Oct 3<sup>rd</sup>
- Rail Day and Student Expo – Eleven industry companies supported the event with demonstrations, student discussions, and industry recruiting activities. Oct. 20<sup>th</sup>
- Railroad Night XI – Over 120 students, industry and community representative gathered to discuss industry opportunities in a relaxed dinner atmosphere. Art Guzetti, APTA’s VP of Public Policy was the keynote speaker. Oct 20<sup>th</sup>
- Dr. Lautala presented on RTP and related undergraduate student projects at the Michigan Railroad Association winter meeting, Dec. 9<sup>th</sup>
- Dr. Lautala presented on the *Rail in Michigan and the Upper Peninsula Freight (Rail) Study*

(NURail project) to the Upper Peninsula Association of County Commissioners, Nov. 5, 2015

### **Research Projects**

- Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras: Developed method to extract feature descriptors that were later employed by Support Vector Machine to build fast classifier with good detection rate. Trained algorithm using simulated images of sliding wheels and tested on several thermal images. Developed method that can find mean temperature of extracted bearing region to detect hot bearing if existed.
- The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety: Preliminary pilot study to validate setup of prototype evaluation study. Webcams captured visual search behavior of participants on approach to a simulated RR crossing. Preliminary results suggest auditory alerts improved visual scanning behaviors of the pilot participants, as well as encouraged more compliant driving behavior on approach to RR crossings.
- Integrated Life Cycle Assessment (LCA) and Life Cycle Cost Analysis of Multi Modal Freight Transportation Alternatives to Copperwood Project: Completed data collection for different tasks. Completed LCA runs in SimaPro for all the options of ore and concentrate transportation. Converted results of LCA to costs using a unit cost for the emissions. Different LCCA and economic analysis methods were reviewed and work to identify conceptual design for LCCA evaluation was initiated.
- Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors: Research work completed and two journal publications were submitted for review/re-review.
- Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels: Thermodynamic phase field mapping was conducted and test alloys selected for production. Equipment issues delayed test alloy production, so only one composition could be poured during the reporting period.
- Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway: Combined analyses revealed previous characterization of permafrost conditions have changed with more regions now classified as discontinuous permafrost. Potentially significant factor to the increased maintenance issues observed along the Hudson Bay Railway.

### **University of Kentucky (UKY)**

- Finished work on 3D rail sensor data analysis.
- Completed analysis of accelerometer data and developed roughness index measure.
- Used 3D point cloud to obtain the roughness index/test reliability of that process.

### **University of Tennessee, Knoxville (UT)**

- “What is Extent of Harm in Rail Pedestrian Crashes”: Developed a work plan, accomplished substantial work, draft final report almost ready. Project already resulted in several technical papers in refereed journals and presentations at conferences. Relevance to practice and papers published have implications for Highway Safety Manual procedures related to rail safety.
- Network Capacity Analysis group working to use historical data to verify rail yard capacity model. A Ph.D. student is applying the model.
- Hybrid Composite Beam (HCB) team reduced collected lateral impact testing data and developed a finite element model using the Abaqus software package. Submitted journal paper which is under review by Structural Concrete.
- “Impact of Reduced Coal Consumption on the Southeastern Railroad Network” team gathered information, modified the railroad network to reflect coal points of production and demand. Demand data prepared from CWS and matched to railroad network structure using GIS tools.
- Terminal Capacity work on optimization issues in railway planning and operations is being incorporated into IE 522, introducing railroad related content to students.

### **Rose-Hulman Institute of Technology**

- CE 445 Construction Methods & Equip: Incorporated class modules covering RR construction and maintenance-of-way equipment and methods as well as a grade crossing renewal project.
- K-12 Outreach: Program to provide introduction to RR and RR engineering to secondary students. Acquired laptop, software and locomotive desktop cab controller. AREMA students developing operations & classification scenarios using wood track components and toy trains.
- Partnership Wabash Valley Railroaders Museum: Initiated partnership to develop railroad displays and hands-on activities. Rail components being acquired from the Indiana Rail Road.

### **c. How have the results been disseminated?**

#### **University of Illinois Urbana-Champaign**

- Conference Presentations: Papers and presentations were delivered at eight conferences.
- Railroad Capacity and Optimization: Six TRB papers from 2015 published in the Transportation Research Record journal, one TRB paper scheduled presented in 2016 received early publication recommendation for the Transportation Research Record journal.
- Presentations to senior operations personnel from CSX and Union Pacific during campus visits.
- Railroad Infrastructure: Three papers presented at the 2015 AREMA Conference in October.

#### **University of Illinois Chicago – CUPPA**

- VC: Interim report sent to stakeholders who participated in the study as well as preliminary survey recipients.
- GIS: Continued meetings with stakeholders, journal submission and editing.

#### **Massachusetts Institute of Technology**

- Results continue to be disseminated through professional publications and presentations.
- Participated in several NEC public-participation meetings at which results were discussed or were implicit in comments.

#### **Michigan Tech University**

- Final design presentations/posters/reports conducted for 16 senior design projects on “Preliminary Design Saginaw Rail yard Site Improvements”.
- Student posters at Rail Day and Railroad Night activities on October 20.
- Papers submitted to JRC2016, TRB2016 (accepted for poster presentation and will be published in proceedings) and presented at the Materials Science and Technology conference.

#### **University of Kentucky**

- Through project final reports.

#### **University of Tennessee, Knoxville**

- Refereed journals, the internet and conference presentations, e.g., for the TRB Annual Meeting and 2015 Road Safety & Simulation International Conference, Orlando, FL.

#### **Rose-Hulman Institute of Technology**

- Reviewed CE 483 Railroad Engineering class recommended changes and enhancements. A new Bridge Engineering module will be developed for the next offering of the class.

### **d. What do you plan to do during the next reporting period to accomplish the goals?**

### **University of Illinois Urbana-Champaign**

- **Railroad Capacity/Optimization:** Draft PhD dissertation and several journal papers on the impact of passenger train operation on freight train efficiency in shared corridors are under development. Dissertation anticipated by late 2016, completing this project.
- **Railway Energy Efficiency:** Completed Master's thesis will be developed into NURail final report to conclude project.
- **Railroad Infrastructure:** Continue modeling, lab experimentation and field work investigating the performance of concrete tie and fastening systems.
- **Outreach and Education:** Hay Seminar Series: Host (and broadcast online) several on-campus seminars from industry experts during the spring semester. Engineering Open House (EOH): With UIUC AREMA Student Chapter, NURail will sponsor railway engineering exhibits at UIUC Engineering Open House event that is attended by primary and secondary students. Minority Student Outreach: At EOH, UIUC will host minority students nominated by their schools for interest in STEM topics. Boy Scout Merit Badge Clinic: With AREMA Student Chapter, a Railroading merit badge clinic will be hosted at UIUC on two April weekends.
- **The Railway Academic Conference (TRAC):** Continue coordination and planning of TRAC event held on the UIUC campus in July 2016. Event will bring railway academics and industry practitioners together to discuss current and future challenges related to workforce development, student recruiting and collaborative research for the railway industry. Event will serve as 2016 Railway Engineering Education Symposium to train other university professors on railway engineering concepts and principles related to passenger service.

### **University of Illinois Chicago – COE**

- Research and develop software and smartphone apps for transfers to/from rail-stations.

### **University of Illinois Chicago – CUPPA**

- VC, Rail Safety, GIS and Freight: Finish and submit final reports.

### **Massachusetts Institute of Technology**

- Recruited 2 undergrads to work as part of the MIT Undergrad Research Opportunities Program.

### **Michigan Tech University**

- All 3 student projects currently underway will be completed under the NURail – Tier 1 Center.
- Rail and Intermodal Transportation Summer Youth Program will be conducted July 18-22, 2016 expecting another 23-25 participants.
- Guest speakers planned for three REAC meetings and five Rail Seminar sessions
- Wheel Anomalies: Finalize project report. Edit and resubmit a journal paper under review.
- Auditory Warnings & Driver Distraction: System prototype evaluation experiment will be run, analyzed, written up, and presented as a graduate student's master's thesis.
- LCA: Next phase is to make recommendations on the LCCA method for the analysis. Includes economic impacts of the region.
- Rescheduling/ Timetable Optimization: submit final report and update journal papers.
- Austempered Ductile Iron; Project finished within next few months. Model produced to relate composition & heat treatment parameters to microstructural stability at elevated temps.
- Rail Embankment Stabilization: Case of Hudson Bay Railway: Project will conclude technical activities in January 2016. Will focus on final reporting and result dissemination.

### **University of Tennessee, Knoxville**

- Finalize project report for crossing and non-crossing safety project and two additional papers.



- Continue in-depth FE modeling of HCB to calibrate collected impact testing data, verify testing results, perform parametric study to evaluate collision and damage caused by over-height vehicles.
- Evaluate scenarios for coal market, evaluate changes in flow patterns within the rail network.

### **Rose-Hulman Institute of Technology**

- Partner with Wabash Valley Railroaders Museum & Indiana Rail Road to develop displays and hands-on activities used by RHIT students and classes and the greater Terre Haute community.
- AREMA Student Chapter will develop an outreach program for secondary schools. Program will initially work with local Girl Scouts as well as area secondary schools.

## **2. Products: What has the program produced**

### **a. Publications, conference papers, and presentations**

#### **University of Illinois Urbana-Champaign**

- Qian, Y., E. Tutumluer, Y.M.A. Hashash and J. Ghaboussi. 2015. Effects of Ballast Degradation on Shear Strength Behavior from Large-scale Triaxial Tests. In: Proceedings of the XV Pan American Conference on Soil Mechanics and Geotechnical Engineering, Buenos Aires, Argentina, November 2015.
- Lautala, P.T., C.T. Dick, D. Rizos and D.B. Clarke. 2015. Toward the Next Generation of Railroad Professionals – Collaboration by NURail and Rail Industry. In: Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference, Minneapolis, Minnesota, September 2015.
- Dick, C.T. 2015. Incremental Capacity Expansion of Single-Track Rail Lines for Multiple Types of Trains. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Saat, M.R. 2015. FRA Draft Guidance Document for Risk Assessment of Hazards Associated with HSR Operations Adjacent to Conventional Tracks. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Lin, C-Y. 2015. Safety and Risk Analysis of Shared-Use Rail Corridors. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Wolf, H. 2015. Field Investigation of Concrete Crosstie Flexural Performance Under heavy-Haul Freight Railroad Loads. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Lovett, A.H. 2015. Evaluation of Track Maintenance Aggregation in Extended Work Windows on Freight Railroad Lines. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Barkan, C.P.L. 2015. Rail Transportation Risk Analysis of Flammable Liquids in Unit Trains. Presented at the 2015 TRB Summerail Conference, Urbana, IL, August 2015.
- Barkan, C.P.L. 2015. Rail Workforce Development. Presented at the 2015 FRA Program Delivery Conference, Washington, D.C., October 2015.
- DiDomenico, G.C. and C.T. Dick. 2015. Methods of Analyzing and Comparing Energy Efficiency of Passenger Rail Systems to Competing Modes. Presented at the 2015 Railroad Environmental Conference, Urbana, IL, October 2015.
- Wang, Z., C.P.L. Barkan and M.R. Saat. 2015. Comparative Train Accident Analysis for Class I US Freight Railroads. Presented at the 2015 INFORMS Annual Meeting, Philadelphia, PA, November 2015.
- Lin, C-Y, C.P.L. Barkan and M.R. Saat. 2015. Fault Tree Analysis of Train Accidents on Shared-use Rail Corridor. Presented at the 2015 INFORMS Annual Meeting, Philadelphia, PA, November 2015.



- Shih, M-C and C.T. Dick. 2015. Method to Measure the Impact of Railway Traffic Heterogeneity from Field Operations Data. Presented at the 2015 INFORMS Annual Meeting, Philadelphia, PA, November 2015.
- Lovett, A.H. and C.T. Dick, 2015. Evaluating Track Maintenance Aggregation in Extended Work Windows on Freight Railroad Lines. Presented at the 2015 INFORMS Annual Meeting, Philadelphia, PA, November 2015.
- Ramos, J.M.M. and M.R. Saat. 2015. Potential Areas Affected by a Liquid Hazardous Material Release. Presented at the 2015 INFORMS Annual Meeting, Philadelphia, PA, November 2015.
- Barkan, C.P.L. and C.T. Dick. 2015. Rail Transportation Engineering Big Data and Analytics at the University of Illinois at Urbana-Champaign. Presented at the Big Data in Railroad Maintenance Planning Conference, Newark, DE, December 2015.

#### University of Illinois Chicago – CUPPA

GIS: Journal paper awaiting approval, final report.

#### Michigan Tech University

- Final design reports for the undergraduate student project: “*Preliminary Design Saginaw Rail Yard Site Improvements*”, Civil and Environmental Engineering senior design project, fall semester (sixteen students)
- Kalluri, S., Lautala, P.; *Comparative Life Cycle Assessment of Road and Multimodal Transportation Options – A Case Study of Copperwood Project*; Proceedings of the TRB 2015, Washington-DC, Jan. 2016
- Addison, P., Baeckerfoot, J., Oommen T., Lautala P., Koff K., and Vallos Z. (2015) *Rail embankment investigation using remote sensing for a permafrost region*, ASCE International Conference on Cold Regions Engineering. pp. 90-101 doi: 10.1061/9780784479315.009.Salt Lake City, UT, July 19-22, 2015 **Received the best student paper award**
- Lautala, P., Dick, T., Rizos, D., Clarke, D., *Toward Next Generation of Railroad Professionals – Collaboration by NURail and Rail Industry*, Railway Interchange, Minneapolis, MN, Oct 4-7, 2015
- Pouryousef, H, Lautala, P., *Investigating the Trade-off between Level of Service and Capacity Parameters in Train Scheduling*, INFORMS 2015 Annual Conference, Philadelphia, PA, Nov 1-4, 2015
- Warsinski, K., Sanders, P. *Characterization of ADI Response at Elevated Temperatures*, Materials Science & Technology 2015, Columbus, OH, Oct 4-8, 2015.
- Addison, P., Oommen T., and Lautala P. (2015) *Characterizing the vulnerable sections along a railway corridor underlain by permafrost using remote sensing* 58th Annual Meeting of the Association of Environmental & Engineering Geologists, Pittsburgh, PA Sep 19-26, 2015.

#### University of Tennessee, Knoxville

- Jing, Y., Ma, Z. J., Bennett, R. M., and Clarke, D. B., *Full-Scale Lateral Impact Testing of Prestressed Concrete Beam*, 2016 Precast/Prestressed Concrete Institute Convention and National Bridge Conference (2016 PCI/NBC).
- Lautala, P.T., Dick, C.T., Rizos, D., and Clarke, D.B., *Toward Next Generation of Railroad Professionals –Collaboration by NURail and Rail Industry*, 2015 Annual Conference, American Railway Engineering and Maintenance-of-Way Association, Oct. 7, 2015.
- Clarke, D.B., *Railroad Intermodal Transportation*, Invited Lecture, Passenger Railroad Engineering Education Symposium, American Public Transportation Association, Philadelphia, PA, July 8, 2015.
- Clarke, D.B., *Train Performance*, Invited Lecture, Passenger Railroad Engineering Education Symposium, American Public Transportation Association, Philadelphia, PA, July 9, 2015.

- Clarke, D.B., *Rail Intermodal Transportation*, Invited Presentation, China Academy of Railway Sciences, Beijing, PRC, July 17, 2015.
- Clarke, D.B., *Railway Workforce Development Activities*, Invited Presentation, American Association of Railway Superintendents Annual Meeting, Baltimore, MD, July 20, 2015.
- Clarke, D.B., *University Role in Transportation Workforce Development Activities*, Invited Presentation, Southeastern Association of State Highway and Transportation Officials Annual Meeting, Nashville, TN, August 4, 2015.

## **b. Journal publications:**

### **University of Illinois Urbana-Champaign**

- Atanassov, I. and C.T. Dick. 2015. Capacity of single-track railway lines with short sidings to support operation of long freight trains. *Transportation Research Record: Journal of the Transportation Research Board*. 2475: 95-101.
- Shih, M.-C., C.T. Dick and C.P.L. Barkan. 2015. Impact of passenger train capacity and level of service on shared rail corridors with multiple types of freight trains. *Transportation Research Record: Journal of the Transportation Research Board*. 2475: 63-71.
- Lovett, A.H., C.T. Dick, C.J. Ruppert, Jr. and C.P.L. Barkan. 2015. Cost and delay of railroad timber and concrete cross-tie maintenance and replacement. *Transportation Research Record: Journal of the Transportation Research Board*. 2476: 37-44.
- Fullerton, G.A., G.C. DiDomenico and C.T. Dick. 2015. Sensitivity of freight and passenger rail fuel efficiency to infrastructure, equipment, and operating factors. *Transportation Research Record: Journal of the Transportation Research Board*. 2476: 59-66.
- Tang, H., C.T. Dick and X. Feng. 2015. Improving regenerative energy receptivity in metro transit systems: Coordinated train control algorithm. *Transportation Research Record: Journal of the Transportation Research Board*. 2534: 48-56.
- DiDomenico, G.C. and C.T. Dick. 2015. Methods of analyzing and comparing energy efficiency of passenger rail systems. *Transportation Research Record: Journal of the Transportation Research Board*. 2475: 54-62.
- Greve, M.J., M.S. Dersch, J.R. Edwards, C.P.L. Barkan, H. Thompson, T.R. Sussmann, Jr. and M.T. McHenry. 2015. Examination of the effect of concrete cross-tie rail seat deterioration on rail seat load distribution. *Transportation Research Record: Journal of the Transportation Research Board*. 2476: 1-7.
- Qian, Y., E. Tutumluer, Y.M.A. Hashash and J. Ghaboussi. 2015. Ballast settlement ramp to mitigate differential settlement in a bridge transition zone. *Transportation Research Record: Journal of the Transportation Research Board*. 2476: 45-52.
- Van Dyk, B.J., A.J. Scheppe, J.R. Edwards, M.S. Dersch and C.P.L. Barkan. 2015. Methods for quantifying rail seat loads and a review of previous experimentation. *Journal of Rail and Rapid Transit*. DOI: 0954409715569862.
- Sogin, S.L., Y-C. Lai, C.T. Dick and C.P.L. Barkan. 2015. Analyzing the transition from single- to double-track railway lines with nonlinear regression analysis. *Journal of Rail and Rapid Transit*. DOI: 10.1177/0954409715616998.
- Williams, B.A., D. Holder, J.R. Edwards, M.S. Dersch and C.P.L. Barkan. 2015. Quantification of the lateral forces in concrete sleeper fastening systems. *Journal of Rail and Rapid Transit*. DOI: 10.1177/0954409715616997.
- Saat, M.R. and J. Aguilar Serrano. 2015. Multicriteria high-speed rail route selection: application to Malaysia's high-speed rail corridor prioritization. *Transportation Planning and Technology*. 38 (2): 200 - 213.

- Qian, Y., E. Tutumluer, D. Mishra and H. Kazmee. 2015. Characterization of geogrid reinforced ballast behavior at different levels of degradation through triaxial shear strength test and discrete element modeling. In Press, *Geotextiles and Geomembranes*.
- Medina, J.C. and R.F. Benekohal, R.F. 2015. Macroscopic Models for Accident Prediction at Railroad Grade Crossings: Comparisons with the U.S. Department of Transportation Accident Prediction Formula. *Transportation Research Record: Journal of the Transportation Research Board*. 2476: 85-93.

#### **University of Illinois Chicago – COE**

- B. Zou, N. Kafle, O. Wolfson and J. Lin, “A Mechanism Design Based Approach to Solving Parking Slot Assignment in the Information Era”, *Transportation Research Part B: Methodological*, Vol. 81, Part2, Nov. 2015, pp. 631-653
- J. Booth, B. DiEugenio, I. Cruz, O. Wolfson, “Robust Natural Language Processing for Urban Trip Planning”, *Applied Artificial Intelligence (AAI)*, Vol. 29(9), DOI:10.1080/08839514.2015.1082280, Oct. 2015, pp. 859-903.
- S. Ma, Y. Zheng, O. Wolfson, “Real-Time City-Scale Taxi Ridesharing”, (invited paper) *IEEE Transactions on Knowledge and Data Eng.*, Vol. 27(7), July 2015, pp. 1782-1795.
- O’Shea, J.J., Shabana, A.A., “Analytical and Numerical Investigation of Wheel Climb at Large Angle of Attack”, *Nonlinear Dynamics*, Vol. 83, 2016, pp. 555 - 577.
- A.I. El-Ghandour, M.B. Hamper, and C.D. Foster. “Coupled Finite Element and Multibody Dynamics Systems Modeling of a 3D railroad system”. *Journal of Rail and Rapid Transit*, Vol. 230, No. 1, 2016, pp. 283-294.

#### **Massachusetts Institute of Technology**

- Levy S., Pena-Alcaraz M., Prodan A., Sussman JM. Analyzing the Financial Relationship between Railway Industry Players in Shared Railway Systems: The Train Operator's Perspective. (In press)
- Pena-Alcaraz M., Sussman JM., Webster M. Analysis of Capacity Pricing and Allocation Mechanisms in Shared Railway Systems: Lessons for the Northeast Corridor. (In press) Carlson S. Joel, Sussman J.M., (2014) Understanding Crude Oil Transport Strategies in North America (p.pdf ESD-WP-2014-03) Submitted to the Journal of the Transportation Research Forum
- Heywood, R and Joseph Sussman, Regional Governance and Hub Stations: The Impact of Development and Transport Connections, accepted for the ASCE 2016 International Conference on Transportation and Development, Houston, TX, June 2016 – to be submitted to follow-on journal based on the conference proceedings
- HSR as Transit: The continuing transportation-driven evolution of metropolitan form (.pdf ESD-WP-2014-24) Submitted to the Journal of the Transportation Research Forum

#### **Michigan Tech University**

- Deilamsalehy H., Havens T. and Lautala P., An automatic method for detecting sliding railway wheels and hot bearings using thermal imagery. *Journal of Rail and Rapid Transit* (Under review), 2016.
- Pouryousef, H., Lautala P., Watkins, D., *Development of Hybrid Optimization of Train Schedules Model for Railway Corridors*, *Transportation Research Part C* (accepted pending minor revisions).
- Pouryousef, H., Lautala P., *Hybrid Simulation Approach for Improving Railway Capacity and Train Schedules*, *Journal of Rail Transport Planning & Management* (2015), <http://dx.doi.org/10.1016/j.jrtpm.2015.10.001>

- Lautala, P., Haas, P., Velat, J., *HIGH SPEED RAIL LEARNING SYSTEM (HSRLS) – Taking Advantage of Online Technologies in Railway Education*, International Journal of Transportation Science and Technology · vol. 4 · no. 2· 2015 – pages 179 – 196, July, 2015
- Pouryousef, H, Lautala, P., White, T.; *Railroad Capacity Tools and Methodologies in the U.S. and Europe*; Journal of Modern Transportation, (2015) 23(1):30–42

#### University of Kentucky

- Malloy, B., J. Rose, and R. Souleyrette, “Rehabilitation of Railway/Highway At-Grade Crossings: Recommendations and Guides,” under consideration of publication in *Transportation Research Record (TRR), Journal of the Transportation Research Board*.
- Wang, T., R.R. Souleyrette, D. Lau, A. Aboubakr and E. Randerson. “A Dynamic Model for Quantifying Rail-Highway Grade Crossing Roughness.” Journal of Transportation Safety and Security. Online. DOI: 10.1080/19439962.2015.1048016, 05 November 2015.
- McHenry, M., M. Brown, J. LoPresti, J. Rose, and R. Souleyrette, “The Use of Matrix Based Tactile Surface Sensors to Assess the Fine Scale Ballast-Tie 1 Interface Pressure Distribution in Railroad Track,” *Transportation Research Record (TRR), Journal of the Transportation Research Board*. No. 2476, 2015, pp. 23-31.
- Xu, P., Q. Sun, R. Liu, R. Souleyrette, and Y. Tang, “A model for automating linear milepoint referencing for subway geometry cars,” Accepted for publication in the ASCE Journal of Transportation Engineering

#### University of Tennessee, Knoxville

- Wang X., A. Khattak, J. Liu, & D. Clarke, Non-crossing rail-trespassing crashes in the past decade: a spatial approach to analysis of injury severity, *Safety Science*, Volume 82, February 2016, Pages 44–55.
- Liu, J., A. Khattak, S. Richards, & S. Nambisan, What are the differences in driver injury outcomes at highway-rail grade crossings? Untangling the role of pre-crash behaviors, *Accident Analysis & Prevention*, Volume 85, December 2015, pp. 157–169.
- Liu, J., X. Wang, A. Khattak, J. Cui, J. Ma & J. Hu. How does Big Data Serve for Freight Safety at Highway-Rail Grade Crossings? A Spatial Approach Fused with Path Analysis, Forthcoming in *Neurocomputing*, 2016.
- H. Li, M. Jin, R. Song, S. He, and J. Song, *Dynamic Railcar Connection Planning in Classification Yards*, accepted by Transportation Letters, The International Journal of Transportation Research, DOI: <http://dx.doi.org/10.1179/1942787515Y.0000000010>, 2015.
- H. Li, M. Jin, and S. He, *Sequencing and Scheduling in Railway Classification Yards*, *Transportation Research Record, Journal of Transportation Research Board*, Volume 2475, pp. 72-80, 2015.
- Jing, Y., Ma, Z. J., and Clarke, D. B., *Full-Scale Lateral Impact Testing of Prestressed Concrete Girder*, *Structural Concrete*, manuscript ID: suco.201500224. (under review)

#### c. Books or other non-periodical, one-time publications:

##### Michigan Tech University

- Dr. Lautala quoted by Detroit Free Press, “*Michigan might create logistics district in Detroit*” (September, 2015)

##### Massachusetts Institute of Technology

- Ogunbekun, T. (2015). The Impact of Amtrak Performance in the Northeast Corridor (Master of Engineering in Transportation)

- Levy, S. (2015). Capacity Challenges on the California High-Speed Rail Shared Corridors: How Local Decisions have Statewide Impacts. (Master of Science in Transportation)
- Agosta, B. (2015). Development of a methodology for evaluating investments in infrastructure for the sustainable exploitation of shale energy in Argentina. (Master of Science in Transportation)

#### d. Other publications, conference papers and presentations:

##### University of Illinois Urbana-Champaign

- Barkan, C.P.L, X. Liu and M.R. Saat. 2015. Enhanced Tank Car Design Improves the Safety of Transporting Crude Oil and Alcohol by Rail. TR News. 298: June - August, pp. 41-43.

##### University of Illinois Chicago – COE

- G. Zhao, M. Zhang, T. Li, S. Chen, O. Wolfson, N. Rishe, "Moving Video Mapper and City Recorder with Geo-Referenced Videos", *Proc. of the 16th Web Information System Engineering (WISE)*, Springer (LNCS), Miami FL., Nov. 2015. pp. 324-321.
- Q. Guo, O. Wolfson, "PRESENTs: Probabilistic REsource-SEarch NeTworks", *Proc. of the 23rd ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (ACM GIS)*, Seattle, WA, Nov. 2015.
- Q. Guo, O. Wolfson, D. Ayala, "A Framework on Spatio-Temporal Resource Search", *Proc. 11th IEEE International Wireless Communications & Mobile Computing Conference (IWCMC)*, Aug. 2015.

##### University of Tennessee, Knoxville

- Liu, J., A. Khattak & S. Richards. *What Are the Consequences of Drivers Trespassing Highway-Rail Grade Crossings Equipped with Gates? A Spatial Approach Integrated with Path Analysis*, 2015 Road Safety & Simulation International Conference, Orlando, FL, 2015.
- Zhang, M., A. Khattak, J. Liu & D. Clarke, *The Role of Rail-Trespassing Crashes at Highway-Rail Grade Crossings and Non-crossing Tracks? A Comparative Study on Injury Severity*, NURail Annual Meeting, Chicago, IL, 2015. This paper to be presented at 2015 Road Safety & Simulation International Conference, Orlando, FL, 2015.
- Wang X., A. Khattak, J. Liu, & D. Clarke, *Non-crossing Rail-Trespassing Crashes in the Past Decade: A Spatial Approach to Analysis of Injury Severity*, TRB paper # 15-0955, Presented at the Transportation Research Board, National Academies, Washington, D.C., 2015, and NURail Annual Meeting, Chicago, IL, 2015.

#### e. Website(s) or other Internet site(s):

##### University of Illinois Chicago – CUPPA

GIS: GIS web tool accessible by public, served by NURail.

##### Massachusetts Institute of Technology

Much of MIT's work appears on this website: <http://web.mit.edu/hsr-group/index.html>

##### Michigan Tech University

- 4<sup>th</sup> Annual Michigan Rail Conference, Rail and Intermodal Transportation SYP 2016, and 3<sup>rd</sup> Annual Rail Day/Expo and Railroad Night XII web pages opened.
- General reorganization of Michigan Tech's Rail Transportation Program website.

##### University of Tennessee, Knoxville



The Transportation Engineering & Science Program, Civil & Environmental Engineering, website disseminates results of research and/or program activities at <http://tesp.engr.utk.edu/>.

**f. Technologies or techniques:**

**University of Illinois Chicago – CUPPA**

GIS: GIS web tool accessible by public, served by NURail.

**Michigan Tech University**

Acquired new NADS MiniSim driving simulator to use in crossing and other driver behavior research. Developing new tiles for crossings.

**g. Inventions, patent applications and/or licenses:**

Nothing to Report

**h. Other products:**

**University of Illinois Urbana-Champaign**

UIUC developed several new hands-on activities and demonstrations related to railway engineering concepts appropriate for use in outreach to K-12 students.

**University of Kentucky**

- Rose, J., L. Saladin, and R. Souleyrette, “Systematic Life-Cycle Analysis and Performance of Enhanced Trackbed Support,” USDOT Tier 1 University Transportation Center Final Report, NURail Project No. NURail2013-UKY-R04. 2015. 350 pp.
- Blandford, B. and R. Souleyrette, “Impact of lock and dam closures on rail system,” SDOT Tier 1 University Transportation Center Final Report, NURail Project No. NURail2012-UKY-R01. 2015. 13 pp.
- Souleyrette, R. and T. Wang, “3D Methodology for Evaluating Rail Crossing Roughness,” USDOT Tier 1 University Transportation Center Final Report, NURail Project Nos. NURail2012-UKY-R03 and NURail2013-UKY-R06. 2015. 27 pp.
- Brock, T. and R. Souleyrette. “An Overview of U.S. Commuter Rail.” Kentucky Transportation Center and NURail.” Report No. KTC-13-18/NURail2012-UKY-R02. University of Kentucky, Lexington KY. May 2013. 74 pp.
- Rose, J., R. Souleyrette, M. McHenry, T. Greenwell, P. Xu, M. Brown and J. LoPresti, “Tie-Ballast Interaction,” SDOT Tier 1 University Transportation Center Final Report, NURail Project Nos. NURail2013-UKY-R05 and NURail2013-UKY-R07. 2015. 163 pp.

**University of Tennessee, Knoxville**

UT faculty is working to develop software for visualization of crash data at RR grade crossings.

**3. Participants and Other Collaborating Organizations**

**a. Partners**

<b>Organization Name:</b>	<b>Location of the Organization:</b>	<b>Partner's Contribution to the Project:</b>	<b>Name (First and Last)</b>	<b>University</b>
CSX	Jacksonville, FLA	In kind, facilities	Sam Carter	Kentucky
TTCI	Pueblo, CO	In kind, facilities	Mike Brown,	Kentucky

			Mike McHenry	
NS	Norfolk, VA	funding	NS Corporate Partnership	Kentucky
NS	Norfolk, VA	funding	NS Foundation	Kentucky
Nichols Foundation	Jacksonville, FL		Gerald Nichols	Kentucky
KY Transportation Cabinet	Frankfort, KY	Funding	Jennifer McCleave	Kentucky
Indiana Rail Road	Indianapolis, IN	In-Kind, Technical Assistance, Student Project Materials, Collaborative	Peter Ray, Justin Cronin	Rose-Hulman
Wabash Valley Railroaders Museum	Terre Haute, In	Hands On Education Opportunities	Bill Roster	Rose-Hulman
University of Porto	University of Porto	Contributions from students visiting MIT Joint proposal to FCT in Portugal	University of Porto	University of Porto
IST (University)	Lisbon, Portugal	Contributions from students visiting MIT Joint proposal to FCT in Portugal	IST (University)	IST (University)
University of Coimbra	Coimbra, Portugal	Contributions from students visiting MIT Joint proposal to FCT in Portugal	University of Coimbra	University of Coimbra
East Japan Railway Company	Tokyo, Japan	Research sponsor; sponsors grade students in residence	East Japan Railway Company	
Central Japan Railway Company	Tokyo, Japan	Sponsors graduate students in residence	Central Japan Railway Company	
Region 1 UTC	MIT, Cambridge, MA	Research sponsor	Region 1 UTC	
Pontificia Universidad Catholica Argentina	Buenos Aires, Argentina	Developing joint project with YPF, a major energy provider based in Argentina	Prof. Roberto Agosta	Pontificia Universidad Católica Argentina Buenos Aires, Argentina
Tennessee DOT	Nashville, TN	Matching request & data	N/A	
ORNL	Oak Ridge, TN	Collaborative support	N/A	
National Science Foundation	Washington, D.C.	Support of Big Data from CAVs	N/A	
Southeastern Transportation Center, UTK	Knoxville, TN	Collaborative support on safety at railroad grade crossings	S. Richards & D. Flinchum	
Beijing University of Transportation	Beijing, China	Research collaboration	Haodong Li	
MDOT	Lansing, MI	Financial and Collaborative	Tim Hoeffner, Nikkie Johnson	MTU
Omnitrax	Colorado/Canada	Financial &	Ken	MTU



		Collaborative	Koff/Zachary Vallos	
<b>Union Pacific</b>	Omaha, NE	Financial & Collaborative	Tom Bartlett	MTU
<b>RoadScanners</b>	Finland	Collaborative	Mika Silvast	MTU
<b>NEW AFS</b>	Northeast Wisconsin	Funded Undergraduate Assistance	N/A	MTU
<b>Engineered Rail Solutions</b>	McHenry, IL	Project Review and Guidance	David Thomson	MTU
<b>Lake State Railway</b>	Saginaw, MI	Project sponsor	John Rickoff	MTU
<b>Pathfinder Engineering</b>	Byron Center, MI	Student mentoring/ project review	Robert Goodheart	MTU
<b>BNSF</b>	Fort Worth, TX	Project Review and Guidance	Craig Morehouse	MTU
<b>Wisconsin &amp; Southern Railroad</b>	Madison, WI	Project Review and Guidance	Brad Peot	MTU
<b>University of Wisconsin/Superior</b>	Superior, WI	Support for SYP	Richard Stewart	MTU
<b>CN</b>	Montreal, Quebec	Financial Support	Stephen Schlickman	University of Illinois-Chicago

## b. Additional collaborators

### University of Illinois Chicago – CUPPA

Staff from transit organizations and municipal authorities in Chicago, San Francisco, New York, and Washington, DC  
 Karin Allen, Regional Transit Authority  
 Donna Anderson, Regional Transit Authority  
 Lynnette Ciavarella, Metra  
 Ron Collman, Natural Resources Conservation Service  
 Bola Delano, Illinois Dept of Transportation  
 Rebecca Geissler, Chicago Transit Authority  
 Robert Ginsburg  
 Anne Haaker and Andrew Heckenkamp, IL Historic Preservation Agency  
 Craig Heither, Chicago Metropolitan Agency for Planning  
 Brad Koldehoff, Illinois Dept of Transportation

Lois Kimmelman  
 David Kralik, Metra  
 Andrew Martin, FRA  
 Jennifer McNeil Dhadwal, URS  
 Jacquelyn Murdock and Elizabeth Panella, Chicago Metropolitan Agency for Planning  
 Greg Newmark, Center for Neighborhood Tech.  
 Janet O'Toole, URS  
 Lynne Otte, TranSystems  
 Leanne Redden, Regional Transit Authority  
 Nicole Sandidge, IL Commerce Commission  
 Michael Stead, Illinois Commerce Commission  
 Brad Thompson, Regional Transit Authority  
 Gina M. Trimarco, TranSystems  
 Robert VanderClute, AAR  
 Patrick Waldron, CN Rail

### University of Kentucky

- Dan Lau, Department of Electrical Engineering, and Visualization Center, UKY has contributed his time, technology and resources to the 3D rail crossing project.
- Ahmed Shabana and team, UI - Chicago (vehicle dynamics simulator for grade crossings).
- Tim Stark, UIUC, initial work on performance of bridge approaches.
- Baoshan Huang, Dave Clarke, UT, tie ballast interface and rail performance using test pit.

#### **University of Tennessee, Knoxville**

- Collaborations are underway between UT Civil & Environmental Engineering, UT Industrial and Systems Engineering, UT Mechanical Aerospace and Biomedical Engineering, Electrical Engineering and Computer Science, & UT Department of Geography.
- International collaborations in safety during the reporting period include Beijing Jiaotong University and COTA-Chinese Overseas Transportation Association.

#### **Rose-Hulman Institute of Technology**

Dr. John Aidoo PhD PE – Assistant Professor of Civil Engineering - RHIT

### **4. Impact**

#### **a. What is the impact on the development of the principal discipline(s) of the program?**

##### **University of Illinois Chicago – CUPPA**

VC: Our project could assist transit and rail capital planners in making more effective decisions concerning the use and development of value capture strategies for funding. Rail Safety: Project will continue research in the area of pedestrian safety at rail crossings and expand on it with additional data and analysis. GIS: Project expected to advance the existing environmental impact assessment of rail infrastructure and services by providing a system view of sustainability and one-stop database. Freight: Project will strive to develop a tool to quantify the impacts of increase/decrease/shifts in freight activities based on broad assumptions of General Equilibrium of the Economy.

##### **Massachusetts Institute of Technology**

Issues are inherently interdisciplinary in content and approach. Advancements in deeper understanding of regional economics, land use planning, engineering systems and other fields.

##### **University of Tennessee, Knoxville**

Enhancing railroad safety through research. In addition to publications in top safety journals, we have worked on the implementation of Highway Safety Manual, which will be useful for crossing and non-crossing safety studies. The research activity completed at UT delivered the knowledge and foundation needed for crossing and non-crossing safety countermeasures. We worked on injury severity and highlighted the need for quantifying the impacts of countermeasures on not only crash frequencies but also on injury severity. Due to NURail funding, we have made methodological advances in safety modeling of crashes at railroad grade crossings and non-crossings.

##### **Rose-Hulman Institute of Technology**

- CE 483 Railroad Engineering is a technical elective for Civil Engineering students.
- RHIT AREMA Student Chapter is an opportunity for Civil Engineering and other engineering students to learn about the rail industry and explore career opportunities in the industry.

#### **b. What is the impact on other disciplines?**

##### **University of Illinois Chicago – CUPPA**

VC: Coordination mechanisms studied under this project will apply and be of use to economic developers, municipal stakeholders, and the private development community. Rail Safety:

Issues of safety will likely lead to an impact on rail crossing design, safety 19 devices, signs, and markings. On a related note, the attitudes and behavior of the specific user groups will also be documented and extend the body of knowledge in these areas. GIS: This project integrates safety, infrastructure, operations, planning, public transportation, and multimodal transportation into environmental impact assessment process. Freight: Tool can be used for federal and regional transportation planning.

#### **University of Tennessee, Knoxville**

Given the applied nature of the transportation field, the research sponsored by NURail at UT produced knowledge about risk factors at crossings and non-crossings. This can help us develop countermeasures and improve safety and health. The safety work is relevant to epidemiology analysis of spatial/geographical aspects of crossing and non-crossing safety has the potential to impact the field of geography.

#### **Rose-Hulman Institute of Technology**

- CE 483 Railroad Eng. is technical elective for Mechanical and Electrical Engineering students.
- RHIT AREMA Student Chapter is open to students in all majors to learn about the rail industry and careers opportunities in the rail industry.

### **c. What is the impact on the development of transportation workforce development?**

#### **University of Illinois Urbana-Champaign**

- Four rail courses in Fall 2015; total enrollment: 111 undergraduate and graduate students including 12 online students. Many students pursuing careers in rail transportation. Classes have dual impact of motivating student interest in such careers and improving their capabilities once they enter the workforce.
- In December 2015, the first working professional student in the CEE Online MS program to focus on railway transportation completed his degree. The degree program included multiple courses that have been created or modified with the aid of NURail funds. This program is an important workforce development opportunity for industry professionals with multiple railway practitioners currently enrolled in the CEE Online MS program with a rail focus.
- The Railway Engineering Short Course is an important workforce development opportunity for working railway industry professionals. Attendees learn various fundamental engineering concepts taught in full-semester courses without committing to a full degree program.

#### **University of Illinois Chicago – CUPPA**

Metra management training project will focus on developing current transportation employees into more effective managers. VC: Graduate students will continue to assist with research and case studies. Rail Safety: Educational tools that provide a better understanding about risks and impacts of safety at rail crossings will likely be developed and used in training of rail operators, and other stakeholders. GIS: Project supported two graduate research assistants; one is a female and minority (Mexican-American). Freight: Research will provide a case study of relationship between freight-related development project & regional economy that can be used as course material.

#### **University of Tennessee, Knoxville**

- The Center for Transportation Research & Civil & Environmental Engineering offered course: CE595 - Intelligent Transportation Systems during the reporting period.
- Grad students are co-authors of railroad related research papers and are being exposed to transportation safety through courses. Motivate them to seek careers in transportation.

- Dr. Clarke was a lecturer in the APTA p-REES Symposium held in Philadelphia in mid-Summer. This effort was undertaken to provide college engineering faculty with training and teaching materials to introduce rail transit content into their classes.

#### **Rose-Hulman Institute of Technology**

Expectations for CE/EE/ME students to consider railroad engineering internships as well as a potential career path.

### **d. What is the impact on physical, institutional and information resources at the university or other partner institutions?**

#### **University of Illinois Chicago – CUPPA**

Program will help solidify research connections between internal groups at CUPPA and further develop CN Fellowship program. GIS: Integrated environmental database may allow users to specify rail facility or land area of interest, access data from multiple departments, and evaluate the multi-facet environmental impacts in one database. Research may help facilitate coordination among multiple departments in both rail system planning and operation processes.

#### **Michigan Tech University**

Patterns produced for Austempered Ductile Iron project have been incorporated into general metal casting program. They are used to produce consistent samples for alloy analysis for both the Principles of Metal Casting course and undergrad projects (Senior Design and Enterprise).

#### **University of Tennessee, Knoxville**

- The Civil & Environmental Engineering Department at UT is in a newly constructed facility - the John D. Tickle building. It has ample space for transportation labs, and houses research facilities used for NURail studies.
- CEE and ISE Departments have several faculty members involved in NURail research.

### **e. What is the impact on technology transfer?**

#### **University of Illinois Chicago – CUPPA**

All projects will be in the public domain and available for use by public sector and rail industry.

#### **University of Tennessee, Knoxville**

- Worked on Speaker Series & Webinars, Fall 2015
- Assistance with editing of safety related journals, i.e., Journal of Safety and Security, and Journal of Intelligent Transportation Systems.
- Relevant results from all NURail research is being included in UTK's classes and railroad continuing education courses.

### **f. What is the impact on society beyond science and technology?**

#### **University of Illinois Chicago – CUPPA**

Research into environmental, safety, and economic issues surrounding freight and passenger rail positively impact society by trying to advance equitable and safe ideas for rail network development. Freight: Findings from this study will influence public policy toward prioritizing various needs for public support for economic development/job creation initiatives, including intermodal terminal development.

### **Massachusetts Institute of Technology**

Research directly affects mobility, economic development and potentially environmental impact and global climate change, all vital critical contemporary issues. Economic growth, environmental protection and social equity will all be advanced if the results of this study – concerned with intercity rail access and its interface to urban transportation -- leads to implementation. Understanding how policies and decisions are made in both the private and public sector can advance “public knowledge attitudes, skills and abilities.”

### **University of Tennessee, Knoxville**

- Highway Safety Manual improvements (a major research initiative at UT and TDOT) can lead to reductions in hazards and application of new countermeasures that save lives.
- Big Data applications in railroad crossing and non-crossing safety can provide a means to innovate in the growing area of data science.
- Efforts of UT faculty directly contribute to development of methods and applied knowledge in rail safety; they are training a skilled workforce, forming and expanding social networks that stimulate safety/risk research, and creating new solutions/countermeasures.

### **Rose-Hulman Institute of Technology**

Exposure of undergraduate engineering students to railroad engineering and career opportunities in the rail and related design, construction, rail support industries.

## **5. Changes/Problems**

### **a. Changes in approach and reasons for change**

Nothing to Report

### **b. Actual or anticipated problems or delays and actions or plans to resolve them**

#### **Michigan Tech University**

Extended equipment down-time (DSC and Foundry OES) forced back sample production for *Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels* and will influence characterization timeline of the final test samples. DSC has been repaired and updated, but requires precision balance for re-calibration. Balance ordered but arrival time is uncertain. One test alloy has been poured without real-time composition control. Analysis shows composition is acceptable. Foundry OES was serviced prior to production of the remaining test alloys (between end of reporting period & report submission).

### **c. Changes that have a significant impact on expenditures**

Nothing to Report

### **d. Significant changes in use or care of human subjects, vertebrate animals and/or biohazards**

Nothing to Report

### **e. Change of primary performance site location from that originally proposed**

Nothing to Report