

6th 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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## 1. Accomplishments

### 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.

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

#### **NURail Consortium**

- Rotating series of Strategic Development Plan working group webinars presented to consortium members.
- NURail University Affiliate members met at the NURail annual meeting in August 2014.
- Six Hay Seminar Series lectures – Total of 571 in-person and on-line attendees.
- The NURail Annual Meeting was held in Altoona, PA in August 2014 in conjunction with the TRB Summerail Conference.

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

##### *Research*

- Analytical modeling of Concrete Crossties and Fasteners: Documentation of results of parametric analyses using the FE model to investigate the frictional performance of the system. Completion and initial results gained from additional FE model focusing on the longitudinal load path.
- 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 concrete crosstie fastening systems.
- Railroad Capacity and Optimization: Continued work to investigate interaction of three train types on shared rail corridors. Continued work on optimal siding expansion strategy for operation of long trains. Continued detailed study of cost of freight train delay and relationship to maintenance planning. Completed work on incremental capacity of lines with variable siding spacing. Submitted 11 conference papers on these topics.
- Railway Energy Efficiency: Continued projects on commuter rail energy efficiency and operational considerations for alternative fuel locomotives with five conference papers submitted.

##### *Outreach and Education:*

- Hay Seminar Series: Hosted six on-campus seminars from industry experts that were also broadcast online. Total both online and in person attendees for the seminars was 571.

##### *Technology Transfer:*

- Hosted 13th Global Level Crossing and Trespass Symposium (GLXS 2014) in August 2014.
- Planning began for the 2015 Railroad Environmental Conference (RREC) in October 2015.

##### *International Cooperation:*

- Continued to interact with students and faculty from Southwest Jiaotong University (SWJTU) located in Chengdu, China.
- Faculty from UIUC and KTH (Swedish Royal Institute of Technology) continued to develop the framework and curriculum for a joint Master's Degree Program.

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

##### *Vehicle and Infrastructure Modeling:*

- Wheel-rail contact. Continued basic study of wheel climb and derailment at large angle of attack.

Showed that Nadal's criterion cannot be considered as conservative criterion.

- Switch modeling. Proposed new procedure for modeling the geometry of switches and turn-outs. Used higher order absolute nodal coordinate formulation finite elements. Simulation results demonstrated feasibility of proposed procedure. Results in conference paper and journal paper.
- Liquid Sloshing. Proposed new formulation for studying liquid sloshing in multibody system applications. Low and high fidelity models were proposed. One model based on the floating frame of reference formulation; the other on the absolute nodal coordinate formulation.
- Coupled track and infrastructure model. Study conducted on "Railroad Substructure/ Foundation Model for Integrated Simulation of Vehicle-Track Interaction."

#### *Railway Infrastructure Materials and Design:*

- Continued assessing the feasibility of implementing the next generation of recycled plastic (HDPE) rail cross-ties. Original experimental testing program completed. Additional testing deemed necessary and were performed and completed as well.
- Special problem rail engineering course "CME 496 Special problems: Railroad Engineering" was offered for the first time in summer 2014.
- New technical elective course developed: "CME 404 Railroad Track Engineering" for both graduate and undergraduates students. Will be offered starting in fall 2015.
- Three technical seminars on railroad engineering, high speed rail and experimental/field testing research were hosted by UIC-COE featuring industry professional and NURail researchers.

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

Four research projects: Value Capture Coordination (VC), Rail Crossing Safety (Rail Safety), GIS Analysis of Environmental Impacts of Rail Development (GIS), and Economic Impacts of Freight Mode Choice (Freight).

- VC: Worked to finalize case study report. Began submitting to journals and conferences. Responded to TRB comments (paper not accepted), working their constructive criticism into new draft.
- Rail Safety: Presentation at GLXS2014.
- GIS: Project completed in December 2014. Rail sustainability metrics and interactive mapping tools updated and upgraded. Separate metrics developed for transit rail, commuter passenger rail, and freight rail. Upgraded web tool supports more interactive functions, including a free hand drawing tool for user to specify an area of interest and obtain environmental data and maps related to rail infrastructure in Illinois.
- Freight: Completed study by analyzing property assessment data to identify impacts of BNSF Logistics Park Chicago on commercial properties.

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

- Successfully recruited four excellent graduate students who started in Sept 2014 to work on NURail projects. Two are self-funded from Central Japan Railway and are interested in Maglev.
- Team participated in several outreach meetings on the NEC and made useful contributions to the discussions based on NEC work by the research team.

#### **Michigan Tech University**

- Blue Marble Security Enterprise project is an internally sponsored project in the Electrical & Computer Engineering (ECE) Department, "Mobile Train Monitoring System" for the fall, 2014-spring, 2015 semesters. Purpose is to create a complete system of individual systems to collect rolling stock data in motion in an effort to improve potential defect detection and train safety.
- Union Pacific and NURail co-sponsoring an Enterprise project in ECE titled "System to Measure the Effectiveness of a Rail Shunt". Proposal develops system to measure effectiveness of rail shunts and Inform the signalmen when a good shunt is achieved.

- Annual Summer Youth Program in Rail and Intermodal Transportation was held in July 2014 for high school students. Record number of 24 students participated, including 8 minority students (4 African American, 1 Latino, 1 Multi-ethnic, and 2 female).
- 2<sup>nd</sup> Michigan Rail Conference organized in August 2014 at Macomb Community College, Wixom, MI, in collaboration with Michigan DOT. 1.5 day conference had 150 participants.
- Several presentations made to K-12 students, including segment on rail for the Women in Engineering camp (150 female high school students) and Engineering Scholars Program (150 gifted high school students). Also short presentations for two local elementary school summer camp programs.
- 1<sup>st</sup> Rail Day/Expo organized on campus on October 14, 2014. 22 industry companies participated. Included showcase of rail industry equipment and technology. 140 people attended the 10<sup>th</sup> Annual Railroad Night and 50 students were present in the Meet the Industry session.
- Dr. Lautala made presentations on rail/freight transportation and Upper Peninsula railroads to Western Lake Superior Area Maritime Security Committee - "Eastern Sector" & UP Port Area Committee, and to Northwoods Rail Transit Commission.
- *Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras*; Developed supervised learning algorithm that takes thermal images of sliding and rolling wheels and automatically categorizes images. Preliminary results show high probability of detection with a low false-positive rate.
- *The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety*; Updated virtual rail crossing scenarios. Have working active lights and gates in driving simulator in addition to ability to modify passive signs on the scenario. Developed new eye-tracking data analysis program that can analyze drivers' eye movement data when they approach rail crossings, according to time frame as well as the location. Designed and gathered auditory warning signals and evaluated in terms of preference and urgency. Analyzing data. Study can serve as basis for further auditory warning research.
- *Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway*; Second round of fieldwork for rail embankment stabilization needs project on Hudson Bay Railway was undertaken on October 03 & 04, 2014. Goal of fieldwork was to perform seismic and electrical resistivity tests at critical locations along the rail embankment to understand subsurface conditions and verify observations from Ground Penetrating Radar (GPR). Fall was chosen for fieldwork because this is when active layer of the subsurface is fully thawed. Preliminary results show electrical resistivity provides detailed subsurface profile to study permafrost conditions.
- *Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors*; New rescheduling/optimization model called “Hybrid Optimization of Train Schedule” (HOTS) was developed. Can provide conflict-free and compressed timetable to improve outcomes of almost any commercial simulation software based on user-defined criteria. Model is applicable to various types of rail operations. Capabilities of HOTS model were tested for 2 case studies developed earlier in the research and outcomes were compared to those obtained from the commercial software.
- *Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels*; Completed construction of high temperature coils for EM permeability sensor, set up furnace and testing equipment in preparation for isothermal aging tests. Created and used MATLAB routine to analyze DSC data using Pearson VII peak fitting.

### **University of Kentucky**

- Additional work completed on multimodal textbook directed by Professor Jerry Rose.
- Professor Rose provided 2 college semester courses in railroad engineering and instruction for REES; lectured at several universities including Purdue Road School and the Hay Seminar at UIUC.
- Completed collection of accelerometer data for rail crossing surface projects.
- Kinect scanner was tested and further work being conducted on merging images.
- Worked with UIC to further calibrate a vehicle dynamic model for crossing roughness and compared the results to actual field accelerometer data.

- Worked with the University of Tennessee (UT) to develop a tie ballast testing platform.
- Load frame was designed, ordered and delivered for tests in 2015.
- Worked with UIUC to monitor tie ballast interaction at several field locations of bridge approaches and other features.
- Report developed and presented to the KYTC on rail crossing management practices.
- Work completed on lock and dam closure effects culminating in a white paper.

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

- Full-scale lateral impact testing facility designed and constructed.
- Data acquisition system finalized. Records impact data to analyze behavior of specimen during impact. Trial impact test was conducted in November 2014 in order to evaluate the whole experimental system.
- Cody Mitchell successfully defended master's thesis in December 2014 with research funded/obtained from work on this project.

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

- CE 490 Railroad Engineering Course - Incrementally updated and modified over the past three years. Ten week, 40 class interdisciplinary railroad engineering course offered during spring quarter. Anticipated enrollment is 12 students
- RHIT AREMA Student Chapter - 80 RHIT participants, with 22 students registered as AREMA members. Students from variety of academic majors make up the membership. Since its founding the Chapter has held 19 meetings and conducted 14 rail industry site visits.

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

#### **NURail Consortium**

Results of both NURail research and education programs were presented by NURail faculty and students at numerous industry conferences, workshops and symposia both domestically and internationally throughout the reporting period as detailed in other parts of this report.

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

*Conference Presentations:* Papers and presentations were delivered at:

- ASCE Shale Energy Engineering Conference in Pittsburgh in July.
- Global Level Crossing Symposium at UIUC in August.
- NURail Annual Meeting in Altoona in August.
- AREMA Annual Conference in Chicago in September.
- Railroad Environmental Conference (RREC) in Urbana in October.
- INFORMS Annual Meeting in San Francisco in November.

*Railroad Capacity and Optimization:*

- Summary report on Rail Capacity Research submitted to Association of American Railroads.
- Two papers received publication recommendations for the Transportation Research Record (TRB).
- Helped develop "Big Data for Railways" workshop at 2014 INFORMS Annual Meeting in San Francisco in November.

*Concrete Cross-tie Fastener Sub-System Testing and Modeling:*

- Results disseminated through journal publications & presentations at industry conferences
- Industry partners meeting held with the AREMA Committee 30 meeting in October 2014.

*Safety and Hazardous Materials Risk:*

- Besides conference presentations, informal presentations on the research were made to representatives from AAR, BNSF Railway and American Petroleum Institute.

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

- VC: Three webinars; submitted to two conferences – ARES in April was accepted.
- Rail Safety: Article published in Encyclopedia of Transportation.
- GIS: Rail sustainability metrics and interactive mapping tools are shared through project website, [nurail.uic.edu](http://nurail.uic.edu). Results presented at Association of Collegiate Schools of Planning (ACSP) Annual Conference and RREC, and a webcast hosted at the Center for Urban Transportation Research (CUTR) Webcast Series, University of South Florida.

### **Massachusetts Institute of Technology**

- Results primarily disseminated through professional publications and presentations.
- Participated in several NEC public-participation meetings at which results were discussed or were implicit in our comments. Much of our work appears on: <http://web.mit.edu/hsr-group/index.html>

### **Michigan Tech University**

- Poster session highlighting student research projects at Michigan Tech organized as part of the 1<sup>st</sup> Rail Day/Expo and 10<sup>th</sup> Annual Railroad Night at Michigan Tech.
- Myoungsoon Jeon presented paper at GLXS 2014.
- Pasi Lautala presented at 2nd Annual Michigan Rail Conference.
- Hamed Pouryoucef presented paper at INFORMS.
- Pasi Lautala presented a poster at the UTC Spotlight Conference.

### **University of Kentucky**

- Journal papers submitted and accepted, conference papers accepted and presented, reports developed, meetings with industry

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

- Research team submitted one abstract to 2015 Joint Rail Conference Committee. It was accepted.
- One complete conference paper titled “Lateral Impact of Railroad Bridges: Impact Testing Setup and Data Acquisition” has been accepted.

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

- NURail Annual Meeting –August 2014
- Education and Curriculum Development – James McKinney
- CE 490 Railroad Engineering: 60’ TRACK CONSTRUCTION PROJECT – James McKinney
- RHIT NURail AREMA Student Chapter – James McKinney

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

### **NURail Consortium**

- Project proposals submitted by faculty at NURail partner institutions will be reviewed both internally and by members of the Technical Advisory Committee.
- Strategic Development Planning working groups will continue to work on plans with updates given during weekly NURail teleconferences.
- Technology Transfer & Leadership: Hold 4 - 6 seminars as part of the Hay Seminar Series during the Fall 2014 semester that will be also broadcast online.

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

- *Research: Analytical Modeling of Concrete Crossties and Fasteners:* Document parametric analyses results using FE model to investigate frictional performance of system. Completion and initial results gained from additional FE model focusing on longitudinal load path. *Research and Innovation*

*Laboratory (RAIL) at Schnabel:* Continue testing on full-scale trackbed test structure, detail investigations into lateral load path for concrete crosstie fastening systems. *Safety and Hazardous Materials Risk:* Analyze available data on conventional freight and passenger train accidents and operations to further understand relevant adjacent-track rail operation risk. Develop and submit paper for publication on GIS-based liquid flow model. Work to evaluate petroleum crude oil transportation release risk. *Railroad Capacity and Optimization:* Continue work on all projects, 2 pending Master's thesis. *Railway Energy Efficiency:* Continue work on all projects, 1 pending Master's thesis.

- *Outreach and Education: Hay Seminar Series:* UIUC will host (and broadcast online) several on-campus seminars from industry experts.
- *International Cooperation: Rail Research and Educational Cooperation with KTH:* Continue to develop framework and curriculum for a joint Master's Degree Program offered by both institutions.

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

- *Wheel Climb Derailment* research will continue because this is a dangerous derailment scenario and needs further investigation to be fully understood.
- *Railroad Substructure/Foundation Model for Simulation of Vehicle-Track Interaction* will next verify an advanced viscoplastic material model to include inelastic deformation of the soil.
- *Testing and Performance Simulation of Plastic Rail Ties* will continue with the analytical modeling and validation. Full-scale modeling of complete system will be constructed for accelerated bridge construction (ABC) applications.
- *Education* will offer railroad engineering course “CME 404 Railroad Track Engineering” in fall 2015. Additional technical seminars on Railroad engineering and application in the US will continue to be offered featuring distinguished speaker speakers from the academia and industry
- *The Informed Rail Traveler* Crowds information is often available for passenger railroad stations and other public places. Work on software services for crowds tracking and mining of crowds info.

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

- VC: Finalize report and submit to both NCTR and NURail. Plans for publication include JPT, ARES, and other yet to be identified transportation, land use, and real estate academic journals. Two researchers will travel to the ARES conference in April for their annual conference.
- Rail Safety: Article being prepared for review in an academic journal.
- Freight: Will submit paper for presentation at the 2015 International Urban Freight Conference (I-NUF) in California in October, 2015.

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

- Graduate students are underway and achieving substantial progress.
- Recruited undergraduates to work as part of the MIT Undergraduate Research Opportunities Program.
- Expecting 3 completed master's thesis and 1 PhD dissertation in June 2015.
- Students will attend and present at the January 2015 TRB annual meeting and beyond.

#### **Michigan Tech University**

- Student Projects: Current projects will be completed. One new Senior Design project for CE students sponsored with SteelPro. Two projects being explored with BNSF and Wisconsin Southern.
- Outreach and Technology Transfer: Annual Summer Youth Program in Rail and Intermodal Transportation will be July 2015 for high school students. 3<sup>rd</sup> Michigan Rail Conference planned for August 2015 in collaboration with the Michigan Department of Transportation (MDOT).
- New Research Projects: Contracted with MDOT for NURail, the ‘Life Cycle (LCA) and Life Cycle Cost (LCCA) Analysis of Freight Transportation Alternatives to Copperwood Mine’ study will analyze the costs involved in construction of infrastructure and equipment, operations and maintenance costs and final salvage or recycling value.



- *Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras*; Propose a tiered machine learning approach that automatically detects and identifies sliding wheels in thermal and visible spectrum video. Using a score produced for each wheel it helps identify wheels that may have flat spots or other defects that cause non-uniform heat patterns under braking. Method will be validated using imagery collected of a car with four sliding wheels on a Union Pacific railway in the Rocky Mountains region.
- *The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety*; Develop multiple virtual rail crossing scenarios and conduct experiments with different types of visual and auditory warnings using a driving simulator.
- *Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway*;
- Electrical resistivity (ERT) results obtained show great promise in identifying permafrost layers and strong correlation with past data by EBA. Intend to use ERT data as validation points for GPR survey which will cover a wider area of the study section. Compare subsurface condition observed from geophysical techniques to maintenance records to identify any potential relationship. Conduct another set of ERT in Spring 2015 to image subsurface at time when most of it is frozen, allowing us to understand the changes in active layer depth.
- *Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors*; Under final review, dissertation will be submitted based on comments and feedback. Extension of HOTS model is under development and current model will be used for capacity analysis and operational improvement for a capacity-related project funded by Center for Freight and Intermodal Research and Education (CFIRE - University of Wisconsin-Madison). Paper describing development of HOTS model will be submitted for publication.
- *Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels*; Isothermal testing delayed, but will start shortly. Plan to publish journal articles covering both DSC and isothermal testing results for baseline alloy and one describing the phase transformation monitoring technique. Modeling new alloy compositions and plan to pour first new test samples and begin characterizing them. Several alloy variations will be produced over the next six months.

#### **University of Kentucky**

- Finish work on 3D rail sensor data analysis.
- Complete analysis of accelerometer data and develop roughness index measure.
- Use 3D point cloud to obtain roughness index/test reliability.
- Continue work on bridge approach track performance in collaboration with UIUC and UTK.

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

- Lateral impact testing of Hybrid Composite Beam (HCB) Bridge
- Continue work on the in-depth finite element (FE) modeling of HCB.

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

- Material from REES 2014 will be incorporated into CE 490 Railroad Engineering syllabus. Class will be promoted as a viable technical elective for Civil/Mechanical/Electrical Engineering students.
- RHIT AREMA Student Chapter Outreach - Continue to offer a monthly program of meeting and field trips to promote railroad engineering. Chapter developing outreach program for area K-12 students.

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

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

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

- Williams, B.A., J.R. Edwards, M.S. Dersch, C.P.L. Barkan and R.G. Kernes. 2014. Experimental Field Investigation of the Effects of Lateral Load Distribution on Concrete Crosstie Track. In: Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference, Chicago, IL, September.
- Dick, C.T. and L.E. Brown. 2014. Design of Bulk Railway Terminals for the Shale Oil and Gas Industry. In: Proceedings of the 2014 ASCE Shale Energy Engineering Conference, Pittsburgh, PA, July.
- DiDomenico, G.C. and C.T. Dick. 2014. Comparison of Passenger Train Energy Consumption with Competing Modes. Presented at the *2014 Railroad Environmental Conference*, Urbana, IL, October.
- Fullerton, G.A. and C.T. Dick. 2014. Operational Consideration of Transitioning to Ultra-Low Emission Locomotive Technologies for Line-Haul Freight Rail Applications. Presented at the *2014 Railroad Environmental Conference*, Urbana, IL, October.
- Atanassov, I.H., C.T. Dick, and C.P.L. Barkan. 2014. Capacity of Single-Track Railway Lines with Short Sidings to Support Operation of Long Trains. Presented at the 2014 INFORMS Annual Meeting, San Francisco CA, November.
- Shih, M.S. and C.T. Dick. 2014. Analysis of Rail Line Capacity on Shared Corridors with Multiple Freight Train Types. Presented at the 2014 INFORMS Annual Meeting, San Francisco CA, November.
- Liu, H.H., J.A. Serrano, M.R. Saat and C.P.L. Barkan, 2014. Unit-Train Multiple Car Expected Quantity of Release Modeling. Presented at the 2014 INFORMS Annual Meeting, San Francisco CA, November.
- Lin, C.Y. and M.R. Saat. 2014. Semi-quantitative Risk Assessment of Adjacent Track Accidents on Shared-use Rail Corridors. Presented at the 2014 INFORMS Annual Meeting, San Francisco CA, November.
- Bedini, F. 2014. Understanding the Transition Behavior of Railroad Track at Grade Crossings on High Speed Rail Shared Corridors. Presented at the 2014 Global Level Crossing Symposium, Urbana IL, August.
- Dick, C.T. 2014. Optimal Grade Crossing Project Selection for Improved Running Time on Passenger Rail Corridors. Presented at the 2014 Global Level Crossing Symposium, Urbana IL, August.
- Chadwick, S. 2014. Highway-Rail Grade Crossing Safety Challenges for Shared Operations. Presented at the 2014 Global Level Crossing Symposium, Urbana IL, August.

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

- Wang, L., Octavio, J.R.J., Wei, C., Shabana, A.A., "Low Order Continuum Based Liquid Sloshing Formulation for Vehicle System Dynamics", Proceedings of the ASME 2014 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, Buffalo, New York, August 17-20, 2014.
- Hamper, M.B., Wei, C., and Shabana, A.A., Use of ANCF Surface Geometry in the Rigid Body Contact Problem: Application to Railroad Vehicle Dynamics", Proceedings of the ASME 2014 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, Buffalo, New York, August 17-20, 2014.
- Wei, C., Wang, L., and Shabana, A.A., "Solution of MBS Liquid Sloshing Problems Using A Total Lagrangian ANCF Approach", Technical Report # MBS2014-10-UIC, Department of Mechanical Engineering, The University of Illinois at Chicago, July 2014.
- Wang, L., and Shabana, A.A., "A New Liquid Sloshing Model for vehicle Dynamics", Presented at the SAE 2014 Commercial Vehicle Engineering Congress, Rosemont, Illinois, October 7-9, 2014.
- M. H. Motamedi and C.D. Foster. "Three-Invariant Elasto/Viscoplastic Modeling for the Analysis of Rail Ballast", U.S. National Association on Theoretical and Applied Mechanics. June 15-20, 2014. East Lansing, MI.

- N. Padhariya, O. Wolfson, A. Mondal, V. Gandhi, S. K. Madria, "E-VeT: Economic Reward/Penalty-based System for Vehicular Traffic Management", Proc. of the 15th IEEE International Conference on Mobile Data Management (MDM), Brisbane, Australia, July, 2014.
- Farhat M, Rahman M, Ibrahim M and Issa M A," Design, Fabrication, Modeling and Experimental Study of a Totally Precast Concrete Counterfort Retaining Wall System for Highways" Proc. of the 2014 PCI convention and national bridge conference, Washington, DC, September 8, 2014.
- Lotfy I, Farhat M, and Issa M A, "Experimental testing of fastening system used for plastic composite crossties" Accepted for publication and presentation in the 2015 Joint Rail Conference.
- Shibli A and Issa M A, "Structural Adhesive Behavior Experimental and Computational Study", In proceedings of the 2014 International Conference on Reliable Engineering Computing, Illinois Institute of Technology, Chicago, Illinois, May 27, 2014, pp. 251-260.
- O. Wolfson, J. Lin, "A Marketplace for Spatio-temporal Resources and Truthfulness of its Users", Proc. of the 7th ACM SIGSPATIAL International Workshop on Computational Transportation Science, Dallas, TX, Nov. 2014, pp. 1-6.
- S. Ma, O. Wolfson, B. Xu,"UPDetector: Sensing Parking/Unparking Activities Using Smartphones", Proc. of the 7th ACM SIGSPATIAL International Workshop on Computational Transportation Science, Dallas, TX, Nov. 2014, pp. 1-10.

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

- Ning Ai. "Sustainability Metrics and Mapping Tool for Environmental Assessment of Rail Infrastructure in Illinois." Center for Urban Transportation Research (CUTR) Webcast Series, University of South Florida, December 11, 2014.
- Ning Ai, Marcella Bondie, and Anthony Grande. "Sustainability Metrics and Environmental Assessment of Rail Infrastructure in Illinois." Paper presentation at the Association of Collegiate Schools of Planning (ACSP) Annual Conference, Philadelphia, PA, October 30 to November 2, 2014. Tracking ID: 4750/Abstract Index #: 148.
- Ning Ai, Marcella Bondie, Anthony Grande, and Shuo Ma and Shi Yin. "Environmental Assessment of Rail Infrastructure in Illinois," Railroad Environmental Conference, Urbana-Champaign, October 28-29, 2014.

#### **Michigan Tech University**

- Lautala, P., Graman, G., Pentti, F., Nelson, D., Rasul, I., Tafesse, A., Pengelly, S., Kalluri, S., Rural Freight Rail and Multimodal Transportation Improvements – the Upper Peninsula of Michigan , July 18, 2014, Prepared for Michigan Department of Transportation, Contract 2010-0295.
- Vitton, S., Brienbacher, K., Assessment of Aggregate Sources in Michigan for High Speed Rail Ballast, July 2014, Prepared for Michigan Department of Transportation, Contract 2010-0295.
- Pouryousef, H, Lautala, P.; *Capacity Evaluation of Directional and Non-directional Operational Scenarios along a Multiple-track U.S. Corridor*; presented at INFORMS 2014 and TRB 2015 Annual Conference Meeting (Under review for publication in the Journal of Transportation Research Records-TRR)
- Hardy, A., Hill, J., Jeon, M., & Lautala, P. (2014). Driver response to various railroad grade crossings and hazard detection, Proceedings of the 2014 Global level crossing safety and trespass prevention symposium (GLXS-2014), IL, August 3-6.
- P. Lautala presented overview of Michigan Tech's Railroad Engineering & Activities Club (REAC) to Oregon State student chapter of AREMA, November 13, 2014.
- Pasi Lautala presented in 2nd Annual Michigan Rail Conference, "University Rail Programs", Detroit, MI, August 26, 2014.

### **University of Kentucky**

- “Intermodal Freight Network Model of Coal Diversions from Lock Closures” a white paper prepared by Ben Blandford was submitted to UIUC (Tim Gress) on July 2, 2014.
- Wang, T., R. Souleyrette, A. Aboubakr and E. Randerson, “Quantifying Grade Crossing Condition as an Input to Modeling Safety,” in the proceedings of the 2014 Global Level Crossing Safety & Trespass Prevention Symposium, Urbana, IL, August 3 - 8, 2014.
- Wang, T., R.R. Souleyrette, D. Lau, A. Aboubakr and E Randerson. Quantifying Rail-Highway Grade Crossing Roughness: Accelerations and Dynamic Modeling. Proceedings of the 92nd Annual Meeting of TRB, Washington, DC, Jan. 2015. 11 pages.
- 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,” 92<sup>nd</sup> Annual Meeting of the TRB.

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

- Jing, Y., Mitchell, C., Ma, J., Bennett, R. M., and Clarke, D. B., “Lateral Impact of Railroad Bridges: Impact Testing Setup and Data Acquisition”, paper number JRC2015-5706, Proceedings-2015 Joint Rail Conference, American Society of Mechanical Engineers, 2015.
- H. Li, M. Jin, and S. He, “Sequencing and Scheduling in Railway Classification Yards,” Transportation Research Board, Washington, DC, January 2015.
- H. Li, R. Song, M. Jin, and S. He, “Dynamic Railcar Connection Plan in a Classification Yard,” Transportation Research Board, Washington, DC, January 2014.
- H. Li and M. Jin, “Classification Track Assignment in Railway Hump Yards,” INFORMS Annual Meeting, San Francisco, CA, November, 2014.

## **b. Journal publications:**

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

- Rapp, C.T, R.G. Kernes and M.R. Saat. 2014. Overview of issues and research related to special trackwork for shared high-speed-rail passenger and heavy-axle-load freight operations. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit. 228 (5): 557-565.

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

- Recuero, A.M., and Shabana, A.A., “A Simple Procedure for the Solution of Three-Dimensional Wheel/Rail Conformal Contact Problem”, *ASME Journal of Computational and Nonlinear Dynamics*, Vol. 9, 2014, pp. 034501-1 – 034501-6.
- Wang, L., Octavio, J.R.J., Wei, C., and Shabana, A.A., “Low Order Continuum-Based Liquid Sloshing Formulation for Vehicle System Dynamics”, *ASME Journal of Computational and Nonlinear Dynamics*, accepted for publication.
- Wei, C., Wang, L., and Shabana, A.A., “A Total Lagrangian ANCF Liquid Sloshing Approach for Multibody System Applications”, *ASME Journal of Computational and Nonlinear Dynamics*, accepted for publication.
- A. 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*. In press.
- Lotfy I, Farhat M, Al-Obaidi M, Ibrahim M, and Issa M A, “Flexural Behavior of High Density Polyethylene Railroad Crossties” *Journal of Rail and Rapid Transit*; accepted for publication on 17 November 2014. DOI: 10.1177/0954409714565655.
- Lotfy I, Farhat M, and Issa M A, “Temperature Effect on the performance of High Density Polyethylene Railroad Crossties” *Journal of Rail and Rapid Transit*; In review.
- Lotfy I, Farhat M, and Issa M A, “Experimental Investigation of Rail Fastening Assembly Components

for HDPE Crossties” Journal of Rail and Rapid Transit; In review.

- Lotfy I, Farhat M, and Issa M A, “Static and Dynamic testing of HDPE crossties and rail system” Drafting.
- Y. Zheng, L. Capra, O. Wolfson, H. Yang, ”Introduction to the Special Section on Urban Computing”, ACM Transactions on Intelligent Systems and Technology. Vol. 5(3), Sept. 2014.
- Y. Zheng, L. Capra, O. Wolfson, H. Yang, ”Urban Computing: Concepts, Methodologies, and Applications”, ACM Transactions on Intelligent Systems and Technology Vol. 5(3), Sept. 2014.
- P. Sistla, O. Wolfson, B. Xu, ”Continuous Nearest-Neighbor Queries with Location Uncertainty”, accepted to appear in the VLDB Journal.
- S. Ma, Y. Zheng, O. Wolfson, “Real-Time City-Scale Taxi Ridesharing”, (invited paper) accepted to appear in a special issue of IEEE Transactions on Knowledge and Data Engineering.

### **Massachusetts Institute of Technology**

- Pena-Alcaraz M., Perez-Arriaga I., Sussman J.M., (2014). Capacity Pricing Schemes to Implement Open-Access Rail in Tanzania. Network Industry Quarterly, Vol. 16, No. 2, pp. 18-22. Link to the paper: <http://mir.epfl.ch/files/content/sites/mir/files/NIQ20142/Capacity%20pricing%20schemes%20to%20implement%20open-access%20rail%20in%20Tanzania.pdf>
- Levy S., Pena-Alcaraz M., Prodan A., Sussman J.M., (2014). Analyzing the Financial Relationship between Railway Industry Players in Shared Railway Systems: The Train Operator's Perspective. Revision submitted to TRR on November 15, 2014.
- Link to the paper: <http://esd.mit.edu/WPS/2014/esd-wp-2014-25.pdf>
- 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
- Kaewunruen, S., Sussman, J. M., Einstein, H.H., (2014). Strategic framework to achieve carbon-efficient construction and maintenance of railway infrastructure systems. Submitted to Frontiers in Environmental Sciences
- Westrom, Ryan and Sussman, J.M. HSR as Transit: The continuing transportation-driven evolution of metropolitan form (p.pdf ESD-WP-2014-24) Submitted to the Journal of the Transportation Research Forum
- S. Krezo, O. Mirza, Y. He, S. Kaewunruen, J.M. Sussman (2014) Carbon Emissions Analysis of Rail Resurfacing Work: A Case Study, Practical Guideline, and Systems Thinking Approach, Proceedings of the Second International Conference on Railway Technology: Research, Development and Maintenance, Civil-Comp Press, Stirlingshire, UK, submitted to Transportation Research D: Transport and Environment)

### **University of Kentucky**

- Submitted a paper on rail crossings to the *Journal of Transportation Safety and Security*: Wang, T., R.R. Souleyrette, D. Lau, A. Aboubakr and E. Randerson. “A Dynamic Model for Quantifying Rail-Highway Grade Crossing Roughness.”
- Had a paper accepted for publication in *Transportation Research Record (TRR)*, *Journal of the Transportation Research Board*: 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.”

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

- A.A. Khaled, M. Jin, D. Clarke, and M.A. Hoque, “Train Design and Routing Optimization for Evaluating Criticality of Freight Railroad Infrastructures,” *Transportation Research B*, 71 (1) 71-84, 2015.
- X. Zhu, A. Garcia-Diaz, M. Jin, and Y. Zhang, “Vehicle Fuel Consumption Minimization in Routing

Over-Dimensioned and Overweight Trucks in Capacitated Transportation Networks,” *the Journal of Cleaner Production*, 85, 331-336, 2014.

- Huang, B., Rutherford, T., Wang, Z., Shu, X., Clarke, D.B, “Laboratory Investigation into Mechanical Properties of Cement Emulsified Asphalt Mortar”, *Construction & Building Materials*, 75 (2015) 25–30.

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

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

Rail Safety: An article was published in the Encyclopedia of Transportation.

#### **Michigan Tech University**

- Livingston Daily Press, December 11, 2014. “Teen Gets a Look at Railroad Life”
- Progressive Railroading, September 2014. “Colleges, universities develop courses, degree programs for rail-minded engineering students”
- Trains Magazine, November 2014. “Training the Next Generation”
- Trains Magazine, December 2014. “Nuts, Trains and Drones”

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

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

On several dozen occasions, NURail principals from UIUC delivered a briefing on the NURail Center to representatives from the railway industry or international railway research institutes.

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

- Ouri Wolfson, Keynote speaker, The first ACM SIGSPATIAL 2014 PhD Symposium, Dallas TX, Nov. 2014.
- Ouri Wolfson, Keynote speaker, The 7th ACM SIGSPATIAL International Workshop on Computational Transportation Science, Dallas TX, Nov. 2014.
- Graduate students presented the research progress at the 2014 JRC in Colorado Springs:
- Ibrahim Lotfy, Maen Farhat, (with Prof. Mohsen Issa), “Assessment of HDPE railroad crossties performance using static and cyclic testing.”
- Mustafa Al-Obaidi, Ibrahim Lotfy, Maen Farhat, (with Prof. Mohsen Issa), “Effect of temperature on the mechanical properties of HDPE railroad crossties.”
- Maen Farhat , Ibrahim Lotfy, (with Prof. Mohsen Issa), “Finite element analysis for pullout, lateral restraint and flexural behavior of HDPE crossties.”
- PhD student presented the research progress at the REC 2014 in Chicago:
- Shibli A and Issa M A, "Structural Adhesive Behavior Experimental and Computational Study", In session VI of the 2014 International Conference on Reliable Engineering Computing, Illinois Institute of Technology, Chicago, Illinois, May 27, 2014.
- Research progress presented at the 2014 NURail annual meeting in Altoona, PA (August 18-19):
- Mohsen Issa, “Status of NURail Structural and Materials Testing Progress at UIC” Poster and presentation.
- Ibrahim Lotfy, “Experimental Evaluation and Modeling of Fastening System for Plastic Composite Crossties” Poster and presentation.
- Maen Farhat “Totally Prefabricated Counterfort Substructure System for Highway and Railway Applications.” Poster and presentation.

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

Rail Safety: Two papers published in TRB conference proceedings; several presentations in TRB Annual meetings and local meetings in Chicago; a presentation at a global congress

### **Massachusetts Institute of Technology**

- Capacity Allocation and Pricing on Shared Rail Infrastructure, Pena-Alcaraz M., Sussman J.M., (2014), NURail Annual Meeting, August 2014, Altoona, PA
- Capacity Pricing Schemes to Implement Open-Access Rail in Tanzania, Pena-Alcaraz M., Perez-Arriaga I., Sussman J.M., (2014) , 3rd Florence Conference on the Regulation of Infrastructures, June 2014, Florence, Italy;
- Presented also at Annual Meeting of the Council of Engineering Systems (CESUN), Stevens Institute of Technology, June 2014, Hoboken, NJ
- Rail Infrastructure Manager Problem: Determining Capacity Pricing and Allocation in Shared Railway Systems, Pena-Alcaraz M., Webster M., Ramos A., Sussman J.M., (2014)
- Annual Meeting of the Council of Engineering Systems (CESUN), Stevens Institute of Technology, June 2014, Hoboken, NJ, June 2014, Hoboken, NJ, Working paper link: <http://esd.mit.edu/WPS/2014/esd-wp-2014-06.pdf>
- REFER/IST/MIT Trilateral Conference on Future Rail Research, Lisbon Portugal (via Video) Nov 2014 (Two presentations)
  - Economic Benefits of Agglomeration Enabled by HSR
  - Allocation and Pricing Rail Infrastructure Used by Multiple Train Operators
- NSF Conference on Service Systems and Industry/Academic Relations, MIT, Nov 2014
  - Building a Long-Term Strategic Relationship Between Academia and Industry: The 25-Year Case of JR East and MIT
- Building a Process for Decision-Making: JR East’s Approach to the International Market for HSR Hardware, Software and Operations, Tokyo, Japan Oct 2014
- CEE “Speed Dating” Event: HSR and Economic Development, MIT Feb 2014
- NURail Video – Thoughts on the NURail research environment Dec 2014
  - <https://www.dropbox.com/s/czc13t00v2xx1ia/Railway%20Academia.dv?dl=0>

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

- H. Li, R. Song, M. Jin, and S. He, “Dynamic Railcar Connection Plan in a Classification Yard,” *Transportation Research Board*, Washington, DC, January 2014.
- H. Li and M. Jin, “Classification Track Assignment in Railway Hump Yards,” INFORMS Annual Meeting, San Francisco, CA, November, 2014.
- Clarke, D.B., “The North American Railway Industry,” Invited Presentation, China Academy of Railway Sciences, Beijing, PRC, July 15, 2014.
- Clarke, D.B., “The Panama Canal Railroad,” Invited Presentation, TRB Summerail, Altoona, PA, August 21, 2014.

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

- NURail Annual Meeting –August 2014, Education and Curriculum Development – James McKinney
- CE 490 Railroad Engineering: 60’ TRACK CONSTRUCTION PROJECT – James McKinney
- RHIT NURail AREMA Student Chapter – James McKinney

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

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

Continued to update and expand content on existing NURail website; started development of new site.

**University of Illinois Chicago – CUPPA**  
GIS: nurail.uic.edu

**Massachusetts Institute of Technology**

Much of the work appears on the following website. <http://web.mit.edu/hsr-group/index.html>

**Michigan Tech University**

Michigan Rail Conference web site: <http://www.rail.mtu.edu/mi-rail-conf/>

**f. Technologies or techniques:**

**University of Illinois Chicago – CUPPA**

GIS: Interactive web tool for environmental impact assessment of rail infrastructure at nurail.uic.edu

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

Nothing to Report

**h. Other products:**

**University of Illinois Chicago – CUPPA**

- VC: Webinar presentation for NCTR.
- Rail Safety: Preparing database of video monitoring of non-motorist behavior at selected grade crossings in Chicago area.

**Michigan Tech University**

- Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels Project; High temperature magnetic permeability sensor. Instrument meant to monitor magnetic permeability as an indicator of microstructural changes within a sample while inside a furnace at temperatures up to 450C.
- MATLAB routine to process DSC curves to extract peak onsets for activation energy determination.

**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>
Indiana Rail Road	Indianapolis, IN	In-Kind, Collaborative, Technical Assistance Student Proj Materials	Thomas Hoback Peter Ray	Rose-Hulman
Wabash Valley Railroaders Museum	Terre Haute, In	60 ft Rail Project- Design and Construct	Bill Foster	Rose-Hulman
CSX	Jacksonville, FL	In kind, facilities	Sam Carter	Kentucky
TTCI	Pueblo, CO	In kind, facilities	Mike Brown, Mike McHenry	Kentucky
NS	Norfolk, VA	funding	NS Corporate Partnership	Kentucky
NS	Norfolk, VA	funding	NS Foundation	Kentucky
Nichols Foundation	Jacksonville, FL		Gerald Nichols	Kentucky
KY Transp. Cabinet	Frankfort, KY	Funding	Jennifer McCleave	Kentucky



MDOT	Lansing, MI	Financial and Collaborative	Tim Hoeffner, Nikkie Johnson	MTU
CN	Illinois	Financial	Matt Glynn	MTU
University of Wisconsin Superior	Superior, WI	Financial & Collaborative	Richard Stewart	MTU
Omnitrax	Colorado/Canada	Financial & Collaborative	Ken Koff	MTU
Union Pacific	Omaha, NE	Financial & Collaborative	Tom Bartlett	MTU
HyGround Engineering	Williamsburg, MA	Collaborative	Jim Hyslip	MTU
RoadScanners	Finland	Collaborative	Mika Silvast	MTU
CSX	Jacksonville, FL	Research Collaboration	Yu Wang	UT
NS	Atlanta, GA	Research Collaboration	Edward Lin & Clark Cheng	UT
East Japan Railway Co.	Tokyo, Japan	Research sponsor	East Japan Railway Co.	MIT
Region 1 UTC	MIT, Cambridge, MA	Research sponsor	Region 1 UTC	MIT
Pontificia Universidad Católica Argentina	Buenos Aires, Argentina	Developing joint project with YPF, a major energy provider based in Argentina	Prof. Roberto Agosta	MIT
IST (University)	Lisbon, Portugal	Contributions from students visiting MIT Joint proposal to FCT in Portugal	IST (University)	MIT
University of Porto	Porto, Portugal	Contributions from students visiting MIT Joint proposal to FCT in Portugal	University of Porto	MIT
CN	Montreal, Quebec	Financial Support	Stephen Schlickman	UIC
National Taiwan University	Taipei, Taiwan	Collaborative Support	Yung-Cheng (Rex) Lai	UIUC
Beijing Jiaotong University	Beijing, China	Collaborative Support	Nie Lei and Gao Liang	UIUC
Southwest Jiaotong University	Chengdu, China	Collaborative Support & Joint teaching prog	Feng, Xiao Yuan	UIUC
Hong Kong Polytechnic Univ.	Hong Kong	Teaching	Geoffrey Shen	UIUC
National Science and Tech. Dev. Agency	Bangkok, Thailand	Collaborative Support	Nakon Chantasom	UIUC
KTH (Royal Institute of Tech.	Stockholm, Sweden	Collab. Support, Joint Class Dev.	Sebastian Stichel	UIUC

## b. Additional collaborators

### University of Illinois Chicago – CUPPA

VC: Staff from transit organizations and municipal authorities in Chicago, San Francisco, New York, and Washington, DC

GIS: Karin Allen, Regional Transit Authority; Donna Anderson, Regional Transit Authority; Christopher Barkan, University of Illinois; Lynnette Ciavarella, Metra; Ron Collman, Natural Resources Conservation Service; Bola Delano, Illinois Department of Transportation; Rebecca Geissler, Chicago Transit Authority; Robert Ginsburg Anne Haaker, Illinois Historic Preservation Agency; Andrew Heckenkamp, Illinois Historic Preservation Agency; Craig Heither, Chicago Metropolitan Agency for Planning; Brad Koldehoff, Illinois Department of Transportation; Lois Kimmelman; David Kralik, Metra; Xiang Liu, University of Illinois; Andrew Martin, Federal Railroad Administration; Jennifer McNeil Dhadwal, URS; Paul Metaxatos, University of Illinois-Chicago; Jacquelyn Murdock, Chicago Metropolitan Agency for Planning; Greg Newmark, Center for Neighborhood Technology; Janet O'Toole, URS; Lynne Otte, TranSystems; Elizabeth Panella, Chicago Metropolitan Agency for Planning; Leanne Redden, Regional Transit Authority; Rapik Saat, University of Illinois; Nicole Sandidge, Illinois Commerce Commission; P.S. Sriraj, University of Illinois-Chicago; Michael Stead, Illinois Commerce Commission; Brad Thompson, Regional Transit Authority; Gina M. Trimarco, TranSystems; Robert VanderClute, Association of American Railroads; Patrick Waldron, CN Rail

### Michigan Tech University

Frank Pentti – independent contractor

### University of Kentucky

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

### Rose-Hulman Institute of Technology

Dr. Bill Eccles PhD PE - Emeritus Professor of Electrical & Computer Engineering - RHIT

## 4. Impact

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

#### University of Illinois Urbana-Champaign

The research, educational, technology transfer and cooperative activities that UIUC is engaged in will all have an impact on US DOT strategic goals in terms of railroad safety, state of good repair, economic competitiveness and sustainability.

#### University of Illinois Chicago – COE

*Vehicle and Infrastructure Modeling and Visualization:* Collaboration between Mechanical Engineering, Civil Engineering, and the Electronic Visualization Laboratory (EVL). The coupling of these 3 disciplines for a holistic model of the rail vehicle and infrastructure dynamic system is a significant innovation. *Railway Infrastructure Materials and Design:* Recycled plastic railroad

cross-ties put the railroad industry on the green, sustainable path with an enhanced performance and an efficient life-cycle cost. *The Informed Rail Traveler* contributes to rail research by focusing on rider tools as distinct from hardware such as vehicle and track engineering.

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

*VC*: Project could assist transit and rail capital planners make more effective decisions concerning use and development of value capture strategies for funding. *Rail Safety*: Safety at rail crossings has not been studied in great detail for specific user groups such as pedestrians and bicyclists. Project will expand on started work with additional data and analysis. *GIS*: Project expected to advance existing environmental impact assessment of rail infrastructure and services by providing system view of sustainability and one-stop database. *Freight*: Freight activities and economic outputs are intimately connected. Project will develop tool based on assumptions of General Equilibrium of the Economy.

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

Issues being researched are inherently interdisciplinary in content and approach. While advancing the field of transportation, we do that in a context of deeper understanding of regional economics, land use planning, engineering systems and other related fields.

#### **Michigan Tech University**

Projects are distributed over multiple disciplines on campus with no single, principal discipline.

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

Dr. Jin's project helps introduce railway research to the Industrial Engineering and Operations Research program. It reinforces collaboration between UT and Beijing Jiaotong University. Helps connect UT with railroads such as CSX and NS, both of which provided data to the research team.

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

CE 490 Railroad Engineering – Technical Elective for Civil Engineering students  
RHIT AREMA Student Chapter – 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 Urbana-Champaign**

Work being conducted on statistical analysis of railroad tank car safety is being applied to highway truck hazardous materials transportation and the associated optimized risk-reduction methodology can be adapted to other transport modes as well.

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

*Railway Infrastructure Materials and Design*: Recycled plastic railroad cross-ties are manufactured with plastic waste that otherwise would be landfilled which reduces the waste products and additionally eliminating any pollution or deforestation associated with other materials. *The Informed Rail Traveler* contributes to the larger discipline of multimodal and sustainable transportation.

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

*VC*: Coordination mechanisms studied will apply and be of use to economic developers, municipal stakeholders, and private development community. *Rail Safety*: Issues of safety will likely lead to impact on rail crossing design, safety 19 devices, signs, and markings. Attitudes and behavior of specific user groups will be documented and extend the body of knowledge in these areas. *GIS*: 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.

#### **Michigan Tech University**

Students and faculty from a variety of disciplines are involved in research projects: Mechanical Engineering, Electrical Engineering, Materials Science Engineering, Civil Engineering, Geological and Mining Engineering and Cognitive Sciences.

#### **University of Kentucky**

Electric Engineering, using structured light to scan object at large scale.

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

CE 490 Railroad Engineering – Technical Elective for Mechanical and Electrical Engineering students  
RHIT AREMA Student Chapter – Open to all RHIT Students 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**

UIUC taught 5 rail courses in Fall 2014, two of which were new classes: *Rail Vehicle Technology*, and *Railway Terminal Design & Operations*. The total enrollment was 159 undergraduate and graduate students including 16 online students. Many of these students will be pursuing careers in rail transportation. These classes have the dual impact of motivating student interest in such careers and improving their capabilities once they enter the workforce.

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

Students involved in all major research thrusts: Rail Vehicle and Infrastructure dynamic modeling and computer graphic visualization; new materials for infrastructure (recycled plastic cross-ties); and Intelligent Transportation Systems for multimodal rail travelers. Students access upper undergraduate and graduate course in *Railroad Vehicle Dynamics* (previously a Special Topic). A new course, *Railroad Engineering*, was offered for the 1st time in summer 2014. The class will be offered in fall 2015 as an independent technical elective, “CME 404 Railroad Track Engineering”. A PhD graduate from the rail vehicle dynamics group is working at the Toyota Technical Center, Ann Arbor, MI.

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

Overall: Metra management training project will focus on developing current transportation employees into more effective managers. VC: Graduate students 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 be used in training of rail operators, and other stakeholders. GIS: Project supporting 2 Urban Planning and Policy graduate research assistants; 1 is a female minority (Mexican-American). Freight: Research will provide rich case study of relationship between freight-related development project and the regional economy that can be used as a course material.

#### **Michigan Tech University**

The Summer Youth Program in Rail and Intermodal Transportation provides industry exposure to high school students. Student research projects involve hands on experiences and field visits to industry sites. The annual Rail Day/Expo showcase industry to students of all disciplines on campus in an informal networking opportunity.

#### **University of Kentucky**

Educating undergraduate and graduate students in civil engineering is the principal impact.

**Rose-Hulman Institute of Technology**

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

**d. What is the impact on physical, institutional and information resources at the university or other partner institutions?****University of Illinois Urbana-Champaign**

Newly-opened track laboratory facility is equipped to support railway research activities involving both civil and mechanical engineering. Includes a full-scale track loading test bed that allows experimentation and testing of the complete track system (rail, ties and ballast).

**University of Illinois Chicago – CUPPA**

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

**Michigan Tech University**

Expanded multi-discipline rail research resulted in purchase of Ground Penetrating Radar (GPR) unit by VP for Research's office and multiple departments for enhanced rail research project development.

**University of Kentucky**

Instrumentation and mobile field test equipment; test pit (contribution of NS RR to donate track sections and rail car truck (double axle).

**e. What is the impact on technology transfer?****University of Illinois Urbana-Champaign**

As projects progress, value and impact of technology transfer will increase.

**University of Illinois Chicago – CUPPA**

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

**Michigan Tech University**

Under Michigan Tech's leadership, Michigan Rail Conference has been growing to a leading technology transfer event in rail topics in the State of Michigan. Rail Day/Expo offers opportunity to tech transfer from Michigan Tech research to industry stakeholders.

**f. What is the impact on society beyond science and technology?****University of Illinois Urbana-Champaign**

Efficient rail operations benefit society through improved mobility; increased economic competitiveness and activity; and a more sustainable transportation system with reduced environmental impacts.

**University of Illinois Chicago – COE**

Holistic simulation of the rail vehicle and infrastructure system could lead to better understanding of safe operation of rail vehicles in mixed-use corridors that could ultimately affect regulatory policies, economic competitiveness, and livable communities. Research into multimodal traveler information systems affects rail travelers as well as users of other modes. Implementation of new recycled plastic railroad cross-ties improves railroad industry public image as a green, sustainable industry. Inherent damping associated with plastic products is expected to decrease vibrations, which enhances the safety, rideability, and passenger comfort.

**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. Findings from the study on Economic Impacts on Freight Mode Choice 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 being conducted directly affects mobility, economic development and potentially environmental impact and global climate change, all vital critical contemporary issues. Through connections to the Engineering Systems Division at MIT, work contributes to methods to study Complex Sociotechnical Systems. The impact on society of this research beyond science and technology can be profound. We hope to create sustainable surface transportation systems. Economic growth, environmental protection and social equity will all advance if the results of this study – concerned with intercity rail access and its interface to urban transportation -- lead to implementation. One could imagine changing travel behavior; in the US people tend not to think of trains as the intercity mode of choice, but perhaps this research can help change that. Understanding how policies and decisions are made in both the private and public sector – using this research as a case study – can advance “public knowledge attitudes, skills and abilities.”

**Michigan Tech University**

The annual Michigan Rail Conference, hosted in collaboration with MDOT, allows opportunity for industry leaders, government entities, academia and consulting firms to engage in discussions on economic development of rail transportation in Michigan.

**University of Kentucky**

Safety and economy of the general public is impacted.

**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**

Nothing to Report.