

5th Quarterly Program Progress Performance Report  
for  
National University Rail (NURail) Center:  
Tier 1 University Transportation Center



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US DOT OST-R Tier 1 University Transportation Center

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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?

#### NURail Consortium

##### *Research: Strategic Development Planning (SDP):*

- Rotating series of SDP working group webinars presented to consortium members.

##### *Outreach and Education:*

- Railway Engineering Education Symposium (REES) was staged in June with NURail members providing the majority of the presented academic content.
- NURail University Affiliate Program was officially launched and by-laws developed for voting. 14 universities have signed up for the program.

##### *Technology Transfer & Leadership:*

- Three Hay Seminar Series lectures – Total of 205 in-person and on-line attendees.
- Two special sessions on NURail education and research projects were conducted at the 2014 Joint Rail Conference (JRC) in April.
- Planning began for the NURail Annual meeting to be held in Altoona, PA in August.

#### University of Illinois Urbana-Champaign

##### *Research:*

- Concrete Crossties and Fasteners: Documentation of initial parametric analyses using the FE model to investigate the frictional performance of the system. Development of an additional FE model focusing on the longitudinal load path.
- Schnabel Research Lab (railway engineering research facility): First tests were made on the full-scale trackbed test structure.
- Wood Engineering Lab: Began an evaluation of existing lab equipment to determine functionality and to estimate cost to restore the lab to service. Began a literature review of accelerated aging processes and techniques.
- Safety and Hazardous Materials Risk: Submitted a paper on a semi-quantitative risk analysis model of adjacent-track accidents on shared rail corridor to the journal of Safety Science. An enhanced GIS-based liquid flow model was developed to identify the potential affected areas in a release of petroleum crude oil.
- Railroad Capacity and Optimization: Initiated work to investigate interaction of three train types on shared rail corridors. Initiated work on optimal siding expansion strategy for operation of long trains. Initiated detailed study of cost of freight train delay and relationship to maintenance planning. Continued work on incremental capacity of lines with variable siding spacing. Work continued on the yard-mainline capacity interaction model component.
- Railway Energy Efficiency: Initiated projects on commuter rail energy efficiency and operational considerations for alternative fuel locomotives.

##### *Outreach and Education:*

- 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 205.
- Advanced Track Engineering Course: New course was taught.
- Engineering Open House: Together with the UIUC AREMA Student Chapter, NURail sponsored railway engineering exhibits at the UIUC Engineering Open House event that was attended by 20,000 people, including over 12,000 primary and secondary students.
- Minority Student Outreach: At Engineering Open House in March, hosted 30 minority students from Springfield, IL nominated by their schools for interest in STEM topics.
- Boy Scout Merit Badge Clinic: With UIUC AREMA Student Chapter, a Railroading merit badge clinic was hosted by NURail on the UIUC campus on two April weekends.

***Technology Transfer:***

- Cost of Railway Congestion Workshop conducted by NURail faculty and students at the TRB Annual Meeting in Washington D.C. in January.
- International Concrete Crosstie and Fastening Systems Symposium held on the UIUC campus in June with over 90 attendees from industry and presentations from NURail students and faculty.
- Planning 13th Global Level Crossing and Trespass Symposium (GLXS 2014) to be held on the UIUC campus in August 2014.
- Planning began and a Call for Papers issued for the 2014 Railroad Environmental Conference (RREC) in November 2014.

***International Cooperation:***

- Faculty/students participated in a research forum with SNCF and UIC in Paris in March.
- Announcement of the High-Speed Rail Education research and Development Initiative with Southwest Jiaotong University (SWJTU) located in Chengdu China in April.
- 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:***

- Conducted study assessing the feasibility of implementing a next generation of recycled plastic (HDPE) rail crossties.
- New technical elective rail engineering course developed: "CME 404 Railroad Track Engineering" for both graduate and undergraduates students. Will start in summer 2014.

**University of Illinois Chicago – CUPPA**

***Value Capture Coordination (VC):***

- Several presentations and meetings during this half of the year including a presentation at Transport Chicago as well as preliminary presentations to case study research partners.
- Webinar allowed for AICP professional development credit.

### ***Rail Crossing Safety (Rail Safety):***

- TRB presentation (January) and webinar (June) about pedestrian safety at rail grade crossings. Webinar allowed practitioners to participate "live" and obtain PDH's.

### ***GIS Analysis of Environmental Impacts of Rail Development (GIS):***

- Incorporating suggestions from project stakeholder meeting in December 2013. Focused on revising rail sustainability metrics and upgrading the environmental impact assessment tool on our project web site. Web site upgrade should be completed at the end of summer.
- Completing final project report.
- Submitted abstracts for presentations at 54 ACSP conference and Railroad Environmental Conf.

### ***Economic Impacts of Freight Mode Choice (Freight):***

- Study completed by analyzing property assessment data to identify impacts of BNSF Logistics Park Chicago on commercial properties. Student has defended thesis based on this study and has graduated with a Master's degree in Urban Planning and Policy.

## **Massachusetts Institute of Technology**

- In September 2014 two new graduate students will join the MIT team. Their work will include Northeast Corridor (NEC), CA HSR, Midwest HSR (Chicago to Urbana/Champaign) and the relation of HSR to urban transportation systems (case study of Penn Station in New York City).
- The MIT team participated in outreach meetings on the NEC and made useful contributions.

## **Michigan Tech University**

### ***Four undergraduate projects completed:***

- Grade Crossing Surface Evaluation (for Michigan Department of Transportation, MDOT)
- Re-purposing a Centerbeam Rail Car for use in hauling frac-sand pods (with Escanaba & Lake Superior Railroad)
- Design for an Intelligent Railroad Crossing Signal Maintainer (for Norfolk Southern and Union Pacific Railroads)
- Market Study on Railroad Balises (an electronic transponder used for train communications) technology and use in the rail industry (for Technical Expert Network (TEN)).

### ***Five new graduate / faculty research projects started:***

- *Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras*; Developed algorithm to detect wheel and bearing in the thermal image of the train wheel. In addition, algorithm able to detect and extract the hot spot (if there is any) and hot bearing. Able to categorize the defected wheels and define how severe the defect is.
- *The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety*; Work includes collection of sound samples, design a series of experiments, develop an experimental program.
- *Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway*; Work to date includes literature review, building GIS database with data and insights obtained from past engineering reports, remote sensing analysis of temperature and vegetation data, and summer 2014 fieldwork (general site reconnaissance, route characterization and strength testing).
- *Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors*; Work has concentrated on analysis of NEC and collaboration with MDOT to secure corridor data for Michigan. NEC corridor has been implemented in RTC, RailSys and OpenTrack software and speed analysis has been conducted, in addition to trials for various improvement strategies.
- *Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels*; Tested 45 ADI samples in the DSC and working on peak extrapolation and statistical analysis for the full data set.

### ***Technology Transfer – Rail Day and 9<sup>th</sup> Annual Railroad Night:***

- Rail Transportation Program (RTP) and Rail Engineering and Activities Club (REAC) organized the 9th Annual Railroad Night and related Rail Day activities on February 18th, 2014. Over 150 participants (80+ students) and 15 industry company sponsors.

### University of Kentucky

- One Master's student completed a thesis involved in updating Kentrack software for layered analysis of the track structure.

### University of Tennessee, Knoxville

- Continued one NURail research project and moved towards completion of three others.
- Researchers given the go-ahead to begin five new projects.
- Offered one session of the bridge inspection class, one roadway worker protection class, and four track inspection classes to industry personnel, with total attendance of 136 persons.
- Presented one new college class in railway operations.
- Research presentations made at technical conferences, including TRB and the 2014 JRC. UTK participated in the delivery of the 2014 REES in Overland Park, KS.

### Rose-Hulman Institute of Technology

- Developed CE 490 Railroad Engineering - 10 week, 40 class period interdisciplinary railroad engineering course. Enrollment for 2014 Spring Quarter was 12. Course highlight was construction of 60' track section displaying WW II troop car at the Wabash Valley Railroaders Museum.
- RHIT AREMA Student Chapter has 54 RHIT members, with 22 students registered as AREMA members. Sam Beck, Vice President, was awarded the AREMA Maintenance of Way Scholarship and Zach Ehlers, Secretary Treasurer was awarded the CN Scholarship. Since its founding the Chapter has held 19 meetings and conducted 17 rail industry field trips.

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

#### NURail Consortium

**Research and Education:** 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:

- TRB Annual Meeting in Washington D.C. in January.
- Research Forum with SNCF and UIC in Paris in March.
- Joint Rail Conference in Colorado Springs in April.
- International Concrete Crosstie and Fastening Systems Symposium at UIUC in June.
- ASCE Transportation and Development Institute Congress in Orlando in June.

**Railroad Capacity and Optimization:**

- Two journal papers were accepted for publication in the Transportation Research record.
- The project team delivered the "Cost of Railway Congestion" workshop at the 2014 TRB Annual Meeting in Washington D.C. in January.

**Concrete Crosstie 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 June 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 – COE**

- The findings of these projects were disseminated in part through presentations and posters at the American Society of Civil Engineers Engineering Mechanics Institute and the 2014 Joint Rail Conference in Colorado Springs. Please refer to publications section for additional details.

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

- **VC:** Preliminary drafts of the report have been sent to partners for review, however we are currently preparing materials for submission to TRB and other journals.
- **Rail Safety:** Previous webinar was posted onto a website for later viewing.
- **GIS:** Rail sustainability metrics and interactive mapping tools are shared through project web site, nurail.uic.edu, which will be ready to be released to the public by the end of this summer.
- **Freight:** Made presentation of findings to a panel including Will County Executive, Mr. Larry Walsh, CEO and President of Will County Center for Economic Development, Mr. John Greuling, and Ms. Alicia Hanlon, Will County Senior Transportation Planner. Alexandra McNally also presented the findings at Transport Chicago Conference.

### **Massachusetts Institute of Technology**

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

### **Michigan Tech University**

#### ***Student Projects***

- Members of three student teams made a project presentation at the 2014 JRC in April.
- All teams made internal presentations and posters.

#### ***Research Projects***

- Influences on Driver Behavior at Railroad Crossings. Presenting paper at the 2014 Global Level Crossing Safety & Trespass Symposium in August.
- Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels project was in the conference proceedings at the 2014 IEEE/ASME Joint Rail Conference titled "Austempered Ductile Iron Performance at Rail Wheel Operating Conditions". Shared Corridor Capacity research was presented at the TRB Annual Meeting in January 2014 and JRC 2014.
- UP Freight Rail Study presented, "Synthesis of Multimodal Freight Transport and Emissions Cost and Application in the Upper Peninsula (UP) of Michigan" at the Logistics, Trade and Transportation Symposium in February, 2014.

### **University of Kentucky**

- Three papers prepared and presented at the ASME/ASCE/TRB JRC, three were prepared for and presented at the 3rd International Conference on Transportation Infrastructures - ICTI 2014, Pisa, Italy and two posters were presented at the TRB annual conference.
- Research results were discussed in our spring semester transportation courses.

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

- Collaborated in TRB Workshop on Cost of Rail Congestion; several presentations at 2014 TRB.
- Presentations at GeoShanghai 2014, Tongji University, China South University, and the 2014 JRC. UTK assisted in 2014 REES.



## Rose-Hulman Institute of Technology

Three Railway Engineering Education Symposium (REES) 2014 presentations:

- Train Energy, Power and Traffic Control – James L. McKinney
- Railway Course/Program Development and Coordination – James L. McKinney
- Raising Student Interest and Recruiting Through Student Chapters – James L. McKinney

### d. 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.
- The second NURail Annual Meeting will be held in August 2014 on the campus of NURail Affiliate institution PSU-Altoona.

## University of Illinois Urbana-Champaign

- **Research: Concrete Crossties and Fasteners:** Continue to run parametric analyses with FE model to investigate the impact of key design parameters on the performance of the system. Continue to develop the FE model focusing on the longitudinal load path. **Schnabel Research Lab:** Conduct crosstie fastening system experiments that are representative of field conditions. **Wood Engineering Lab:** Complete plans to reopen the lab to begin wood crosstie research activities. **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 a paper for publication on the GIS-based liquid flow model. Work to evaluate petroleum crude oil transportation release risk. **Railroad Capacity and Optimization:** Work on all projects will continue with multiple papers being developed and submitted for publication. **Railway Energy Efficiency:** Work on all projects will continue with multiple papers being developed and submitted for publication.
- **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 the framework and curriculum for a joint Master's Degree Program to be offered by both institutions. **HSR System Education Center.** Host student and faculty visit from SWJTU of China in August to discuss possible research collaboration.

## 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 dynamic testing program; as well as further analytical modeling and validation. Full-scale modeling of the complete system will be constructed for accelerated bridge construction (ABC) applications.



- **Education** will offer railroad engineering course “CME 404 Railroad Track Engineering” in summer 2014 as well as several technical seminars on High Speed Rail application in the US featuring speakers from the global consulting firm “Parsons Brinckerhoff”.

### University of Illinois Chicago – CUPPA

- **VC:** Finalize draft versions of literature review & final report to submit to conferences and journals.
- **Rail Safety:** Publish article about rail crossings in the Encyclopedia of Transportation.
- **GIS:** Complete web site upgrade by the end of summer 2014. Complete final project report and full papers to present at the ACSP and Railroad Environmental Conference in October/November 2014. Prepare formal journal publications.
- **Freight:** Write an academic paper based on this study.

### Massachusetts Institute of Technology

- Graduate students are recruited and research underway so substantial progress is being made in research efforts. For some areas of research undergraduates will be recruited to work as part of the MIT Undergraduate Research Opportunities Program (UROP).
- Four completed MST theses (June 2014) and expect two more in June 2015. In June 2015, expect a PhD dissertation to be completed.
- Many students will participate in the TRB annual meeting in January 2015 in Washington and beyond.

### Michigan Tech University

- **Research** –
  - *Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Camera.* Further analysis with Union Pacific data pending additional clarifications on parameters. Use University thermal camera and collect data for analysis in August. Using it to evaluate and improve the algorithm.
  - *The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety.* Conduct preliminary auditory cue selection experiment, prepare for next experiment, including updating rail scenarios and adding distraction conditions.
  - *Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway.* Complete literature review, update GIS database with findings from Summer 2014 fieldwork, conduct second fieldwork in Fall 2014.
  - *Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors.* Concentrate on completing NEC improvement analysis and complete development of necessary databases for the Michigan corridor.
  - *Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels.* Conduct isothermal aging studies on sample materials, produce experimental alloys to improve phase stability.
- **Student Projects** – Soliciting new round of student projects for 2014-2015 and will initiate within next reporting period.
- **Outreach and Tech Transfer** – Summer Youth Program in Rail and Intermodal Transportation will run July 27-August 1. Program is full with 24 students, including 7 minority and 2 female students. Second annual Michigan Rail Conference will take place on August 26-27.

### University of Kentucky

- Continue work on 3D rail sensor data analysis, correlate 3D points cloud to quantitative (acceleration) and qualitative (rideability) data.
- Establish performance indices and thresholds for repair.
- Begin work on bridge approach track performance in collaboration with UIUC and UT El Paso.

## Rose-Hulman Institute of Technology

- Review CE490 Railroad Engineering student evaluations. Class modules will be reviewed and updated as appropriate. Material from REES 2014 will be incorporated in the class syllabus.
- Rail sponsored Senior Design Projects are being solicited for the 2014/2015 academic year.
- RHIT AREMA Student Chapter Outreach- Continues a monthly program of meeting and field trips. Major effort undertaken to expose RHIT students to summer rail related internships and availability of permanent rail jobs for graduates. 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

- Liu, X., C.T. Dick and M.R. Saat. 2014. Optimizing Ultrasonic Rail Defect Inspection to Improve Transportation Safety and Efficiency. In: *Proceedings of the Second ASCE Transportation and Development Institute Congress*, Orlando, FL, June 2014.
- Fullerton, G., G.C. DiDomenico, M-C. Shih and C.T. Dick. 2014. Congestion as a Source of Variation in Passenger and Freight Railway Fuel Efficiency. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- DiDomenico, G.C. and Dick, C.T. 2014. Analysis of Trends in Commuter Rail Energy Efficiency. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Dick, C.T. and Dirnberger, J.R. 2014. Advancing the Science of Yard Design and Operations with the CSX Hump Yard Simulation System. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Greve, M., Dersch, M.S., Edwards, J.R., Barkan, C.P.L., Mediavilla, J. and Wilson, B.M. 2014. Analysis of the Relationship Between Rail Seat Load Distribution and Rail Seat Deterioration in Concrete Crossties. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Serrano, J.A. and Saat, M.R. 2014. Flammable Liquid Fire Consequence Modeling. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- do Carmo, T.B., Edwards, J.R., Kernes, R.G., Andrawes, B.O. and Barkan, C.P.L. 2014. Laboratory and Field Investigation of the Rail Pad Assembly Mechanistic Behavior. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Lin, C-Y. and M.R. Saat. 2014. Semi-Quantitative Risk Assessment of Adjacent Track Accidents on Shared-Use Rail Corridor. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Atanassov, I., Dick, C.T. and Barkan, C.P.L. 2014. Siding Spacing and the Incremental Capacity of the Transition From Single to Double Track. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Williams, B., Edwards, J.R., Kernes, R.G. and Barkan, C.P.L. 2014. Analysis of the Lateral Load Path in Concrete Crosstie Fastening Systems. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Manda, K.R., M. Dersch, R. Kernes, J.R. Edwards and D. Lange. 2014. Vertical Load Path under Static and Dynamic Loads in Concrete Crosstie and Fastening Systems. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.

- Wei, S., D.A. Kuchma, J.R. Edwards, M.S. Dersch and R.G. Kernes. 2014. Gauging of Concrete Crossties to Investigate Load Path in Laboratory and Field Testing. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Hamper, M.B., Ruppert, C., Wei, C., and A.A. Shabana. 2014. A Spatial Geometry Approach to Variable Cross-Section Rail Modeling: Application to Switches and Turnouts. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, April 2014.
- Tang, H., Wang, Q. and Dick, C.T. 2014. Optimizing Train Speed Profiles to Improve Regeneration Efficiency of Transit Operations. In: *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, USA, 2014.

### University of Illinois Chicago – COE

- Shabana, A.A. and O'Shea, J., 2013, "Large Angle of Attack Wheel Climb", Proceedings of the ASME 2013 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDET/CIE, August 4-7, 2013, Portland, Oregon, USA. DETC2013-12382.
- A. El-Ghandour, M. H. Motamedi and C. D. Foster. "Dynamic Modeling of Rail Ballast and Subgrade." EMI Conference, Evanston, IL, August 4-7, 2013. (poster)
- B. Xu, O. Wolfson, J. Yang, L. Stenneth, P. Yu, P. Nelson, "Real Time Street Parking Availability Estimation", *Proceedings of the 14th International Conference on Mobile Data Management (MDM)*, Milan, Italy, June 2013.
- Roland Varriale, Shuo Ma, Ouri Wolfson. "VTIS: A Volunteered Travelers Information System." In Proceedings of *6th Intl Workshop on Computational Transportation Science, IWCTS 2013*.
- Shuo Ma and Ouri Wolfson. "Analysis and Evaluation of the Slugging Form of Ridesharing." In Proceedings of *21st ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems, 2013*.
- 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.
- 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.
- Lotfy I, Farhat M, and Issa M A, "Experimental testing of fastening system used for plastic composite crossties" Abstract submitted to the 2015 Joint Rail Conference.
- Lotfy I, Farhat M, and Issa M A, "Recycled Plastic Composite Crossties in Accelerated Bridge Construction" Abstract submitted to the 2015 ASCE Structural Congress.
- 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.

### University of Illinois Chicago – CUPPA

- Ning Ai, Marcella Bondie, and Anthony Grande. "Sustainability Metrics and Spatial Tools for Environmental Impact Assessment of Rail Infrastructure in Illinois" Abstract submitted to the 2014 Railroad Environmental Conference.

### Michigan Tech University

- Pouryousef, H., Lautala, P.T., Evaluating Two Capacity Simulation Tools on Shared-use U.S. Rail Corridor, Transportation Research Board 93rd Annual Meeting of the National Academies, January 12-16, 2014.
- Joint Rail Conference: "Austempered Ductile Iron Performance at Rail Wheel Operating Conditions"

- by Karl Warsinski, Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors (by Dr. Pasi Lautala on behalf of Hamed Pouryousef). Undergraduate presentations.
- 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.
  - Fakhr Hosseini, S. M., Hardy, A., Jeon, M., & Lautala, P. (2014). Driver behaviors with various visual warnings at the railroad grade crossings. Proceedings of the Upper Peninsula Interdisciplinary Student Research Conference (UPISRC-2014), p.8, MI: Houghton. Available from: <https://sites.google.com/a/mtu.edu/upirs/>
  - Croschere, J., Landry, S. G., Perelman, B., Jeon, M., & Lautala, P. (2014). Sonic in-vehicle auditory warnings for grade crossings interactions at immersive virtual environment. Proceedings of the Upper Peninsula Interdisciplinary Student Research Conference (UPISRC-2014), p.4, MI: Houghton. Available from: <https://sites.google.com/a/mtu.edu/upirs/>

### University of Kentucky

- Rose, J. and R. Souleyrette, "Hot-Mix Asphalt (Bituminous) Railway Trackbeds: In-Track Tests, Evaluations, and Performances -- A Global Perspective: Part I -- Introduction to Asphalt Trackbeds and International Applications and Practices," Proceedings of the 3rd International Conference on Transportation Infrastructures - ICTI 2014, Pisa, Italy, April 22-25, 2014.
- Rose, J. and R. Souleyrette, "Hot-Mix Asphalt (Bituminous) Railway Trackbeds: In-Track Tests, Evaluations, and Performances -- A Global Perspective: Part II -- United States Asphalt Trackbed Applications and Practices," Proceedings of the 3rd International Conference on Transportation Infrastructures - ICTI 2014, Pisa, Italy, April 22-25, 2014.
- Rose, J. and R. Souleyrette, "Hot-Mix Asphalt (Bituminous) Railway Trackbeds: In-Track Tests, Evaluations, and Performances -- A Global Perspective: Part III -- U.S. Asphalt Trackbed Materials Evaluations and Tests," Proceedings of the 3rd International Conference on Transportation Infrastructures - ICTI 2014, Pisa, Italy, April 22-25, 2014.
- Rose, J. S. Liu, and R. Souleyrette, "Kentrack 4.0: A Railway Trackbed Structural Design Program," Proceedings of the 2014 Joint Rail Conference, Colorado Springs, CO, April 2-4, 2014.
- Malloy, B., J. Rose and R. Souleyrette, "Rehabilitation, Assessment and Management Practices to Ensure Long-Life, High Performance Highway-Railway At-Grade Crossings," Proceedings of the 2014 Joint Rail Conference, Colorado Springs, CO, April 2-4, 2014.
- Wang, T., R. Souleyrette, D. Lau and P. Xu, "Rail Highway Grade Crossing Roughness Quantitative Measurement Using 3D Technology," Proceedings of the 2014 Joint Rail Conference, Colorado Springs, CO, April 2-4, 2014.
- McHenry, M., R. Souleyrette, P. Xu, J. Rose, and T. Greenwell, "Developing a Calibration Method for Tactile Pressure Sensors Applied to Non-Uniform, Rough Contact Surfaces: A Case Study at the Ballast-Tie Interface of Railroad Track," *Proceedings of the 91st Annual Meeting of TRB*, Washington, DC, Jan. 2014.
- Liu, S., R. Souleyrette and J. Rose, "Kentrack 4.0: A Revised Railway Structural Design Program," *Proceedings of the 91st Annual Meeting of TRB*, Washington, DC, Jan. 2014.

### University of Tennessee, Knoxville

- Clarke, D.B. "Case Study: Application of Delay Cost to a Network Routing Problem," Workshop on Cost of Railway Congestion, Transportation Research Board, Washington, DC, January 12, 2014.
- Clarke, D.B., and Hua Liu, "Rail Freight in China; Past, Present, Future," Invited Presentation, Committee on Freight Rail Transport, Trans. Research Board, Washington, DC, January 14, 2014.
- Clarke, D.B., "The North American Railway Industry," Invited Presentation, School of Civil Engineering, Central South University, Changsha, PRC, May 23, 2014.

- Clarke, D.B., “Geotechnical Challenges for the U.S. Railway Industry,” Invited Presentation, GeoShanghai 2013, Shanghai, PRC, May 26, 2014.
- Clarke, D.B., “The North American Railway Industry,” Invited Presentation, School of Transportation Engineering, Tongji University, Shanghai, PRC, May 27, 2014.
- Clarke, D.B., “The North American Railway Industry,” Invited Presentation, China Academy of Railway Sciences, Beijing, PRC, July 15, 2014.
- Yuan Jing, Z. John Ma, Richard M. Bennett, and David B. Clarke, “Lateral Impact of Railroad Bridges with Hybrid Composite Beams: finite element modeling and preliminary dynamic behavior study of HCB”, 2014 Joint Rail Conference, Colorado Springs, CO, April 4, 2014.
- Hua Liu and David B. Clarke, “Analysis of rolling stock leasing market potential in China”, 2014 Joint Rail Conference, Colorado Springs, CO, April 4, 2014.
- Tyler Rutherford and Sheng Zhao, “Laboratory Investigation into Mechanical Properties of Cement Emulsified Asphalt Mortar”, Poster Presentation, Annual Meeting of the Association of Asphalt Paving Technologists, Atlanta, GA, March 17, 2014.
- Ma, Z. J. “Assessment of Existing Railroad Bridges to Accommodate a Higher Speed Considering Chinese Practices,” Joint Rail Conference 2014, Colorado Springs, April 4, 2014.

## b. Journal publications:

### University of Illinois Urbana-Champaign

- Chadwick, S.G., N. Zhou and M.R. Saat. 2014. Highway-Rail grade crossing safety challenges for shared operations of high-speed passenger and heavy freight rail in the U.S. In Press, *Safety Science*.
- Shih, M.C., Y-C Lai, C.T. Dick and M-H Wu. 2014. Optimization of siding location for single-track lines. Accepted, *Transportation Research Record: Journal of the Transportation Research Board*.
- Shih, M-C., C.T. Dick, S.L. Sogin and C.P.L. Barkan. 2014. Comparison of capacity expansion strategies for single-track railway lines with sparse sidings. Accepted, *Transportation Research Record: Journal of the Transportation Research Board*.
- Liu, X., A. Lovett, C.T. Dick, M.R. Saat and C.P.L. Barkan. 2014. Optimization of Rail Defect Inspection Frequency for the Improvement of Railway Transportation Safety and Efficiency. In Press, *Journal of Transportation Engineering*.
- Liu, X., M.R. Saat, and C.P.L. Barkan. 2014. Probability Analysis of Multiple-Tank-Car Release Incidents in Railway Hazardous Materials Transportation. In Press, *Journal of Hazardous Materials*. 276: 442-451.

### University of Illinois Chicago – COE

- José L. Escalona, Hiroyuki Sugiyama, and Ahmed A. Shabana, “Modeling of structural flexibility in multibody railroad vehicle systems,” *Vehicle System Dynamics*, Special Issue: State of the Art Papers of the 23rd IAVSD Symposium, Vol. 51.7, 2013, pp. 1027-1058.
- Recuero, A.M. and Shabana, A.A., “A simple procedure for modeling three-dimensional conformal contact: Application to wheel/rail contacts,” *Journal of Computational and Nonlinear Dynamics*. Accepted manuscript, published online, Dec. 5, 2013.
- Hamper, M. B., Wei, C., and Shabana, A. A., ‘Use of ANCF Surface Geometry in Rigid Body Contact Problems’, *Journal of Computational and Nonlinear Dynamics*, Submitted in October 2013 (\*accepted with revision 01/09/2014).
- O. Wolfson, and B. Xu, “A New Paradigm for Querying Blobs in Vehicular Networks.” *Computing Now. Special Issue: Multimedia Data Management in Mobile Computing*, in Press.
- 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 review.



- 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. Submitted.
- O. Wolfson, B. Xu, ”A New Paradigm for Querying Blobs in Vehicular Networks”, IEEE Multimedia, Vol. 21(1), Jan-Mar. 2014, pp. 48-58.

### **Massachusetts Institute of Technology**

- Clewlow R.L.L., Sussman J.M., Balakrishnan H. The Impact of High-speed Rail and Low-cost Carriers on European Air Passenger Traffic published on the May 2014 edition of Transport Policy.

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

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

- Ning Ai, Marcella Bondie, and Anthony Grande. “Sustainability Metrics and Environmental Assessment of Rail Infrastructure in Illinois.” Presentation at the 2014 Association of Collegiate Schools of Planning (ACSP) 54th conference. Books of abstracts are published at [http://www.acsp.org/sites/default/files/COMPLETED%20book%20of%20conference%20abstracts\\_0.pdf](http://www.acsp.org/sites/default/files/COMPLETED%20book%20of%20conference%20abstracts_0.pdf)

### **Massachusetts Institute of Technology**

- 2014, Jun. S. Kawakami, SM in ES. “Application of a Systems-Theoretic Approach to Risk Analysis of High-speed Rail Project Management in the US.”
- 2014, Jun. I. Mori, Masters in TPP, “Cross-border Barriers to the Development of HSR Projects: Analysis of the Singapore- Kuala Lumpur High Speed Rail Link.”
- 2014, Jun. R. Westrom, MST. “The Agglomerative Role of Transportation Investment: A Comparative Analysis of Portuguese And American High-speed Rail Proposals.”

### **Michigan Tech University**

- “Finding Sand with Sound”, Michigan Technological University Students Create new device with tubing and teamwork, special technology article in the June, 2014 edition of Trains Magazine

### **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**

- Wolfson, O. Panel on “Automated Mobility: How environment awareness technologies will drive intelligent transportation of the future”, 30th Intl Conf on Data Engineering (ICDE), April 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.

### University of Illinois Chicago – CUPPA

- **VC:** Jane Wilberding, Stephen Schlickman, Janet Smith, Tom Bothen, Yittayih Zelalem, Jordan Snow. “Value Capture Coordination: Analysis and Best Practices.” Transport Chicago Conference. Chicago, IL, 6/6/2014.
- **Rail Safety:** Metaxatos, P. and P.S. Sriraj (2013). Advancing Pedestrian Safety at Rail Grade Crossings. 92nd Transportation Research Board Annual Meeting, Washington, D.C.
- **Freight:**
  - Thesis: Alexandra McNally - Intermodal Logistics Centers and Their Impact on Transportation Corridor Industrial Property Value
  - Presentation - Economic Benefits of Truck-to-Rail Mode Shift (Transport Chicago, June 6)
  - Presentation - Impacts of Large-Scale Logistics Centers on Industrial Property Values (to a panel consisting of Will County Executive, CEO and President of Will County Center for Economic Development, and Will County Senior Transportation Planner (March 10)

### Massachusetts Institute of Technology

- Council of Engineering Systems Universities (CESUN) bi-annual meeting, hosted by Stevens Institute of Technology in Hoboken, NJ. June 10, 2014 Poster: Capacity Pricing Schemes to Implement Open-Access Rail in Tanzania, Peña-Alcaraz, M., Pérez-Arriaga, I., Sussman, J. M.
- Paper: Rail Infrastructure Manager Problem: Analyzing Capacity Pricing and Allocation in Shared Railway Systems, Peña-Alcaraz, M., Webster, M., Ramos, A., Sussman, J.M Joint Rail Conference in Colorado Springs, April 2014
- "Transportation for Tomorrow": The 2013-2014 MIT Transportation Showcase, February 13, 2014 - Implementation Challenges for Shared Railway Systems: Case Studies in California and the Northeast Corridor, Levy, Peña Alcaraz, Sussman  
- An Examination of the Interaction between Two Prospective Transport Technologies: Questioning the Importance of High Speed Rail in a Driverless Vehicle Society, Westrom
- 93rd Annual Meeting of the Transportation Research Board in Washington, D.C., January 2014
  - Productivity of Passenger Rail Transportation Services in the Northeast Corridor Archila A.F., Sakamoto R., Fearing R., Sussman J.M. (2014)
  - Uncertainty and Inter-Jurisdictional High-Speed Rail Planning: Insights from Portugal and the United Kingdom Stein N.E.G., Sussman J.M. (2014)
  - Transport Infrastructure Evaluation Using Cost-Benefit Analysis: Improvements to Valuing the Asset Through Residual Value - A Case Study (2014) poster Jones H., Domingos T., Moura F., Sussman J.M. (2014)

### Rose-Hulman Institute of Technology

- REES 2014: Railway Engineering Education Symposium:
  - Train Energy, Power and Traffic Control – James L. McKinney
  - Railway Course/Program Development and Coordination - James L. McKinney
  - Raising Student Interest and Recruiting Through Student Chapters – James L. McKinney

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

#### University of Illinois Urbana-Champaign

Listing of initial research and education projects was uploaded to the NURail Center website and the TRB RiP database. UIUC implemented a plan to refresh and expand content on the RailTEC website.



### University of Illinois Chicago – CUPPA

**GIS:** Upgraded project web site of the environmental impact assessment tool at nurail.uic.edu

### Massachusetts Institute of Technology

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

#### f. Technologies or techniques:

### University of Kentucky

3D structured light scanner application at the large scale to scan the railroad and railroad highway crossing at relative low cost (\$5000 hardware) and high precision (0.1inch per pixel); Tekscan sensors for tie-ballast pressure measurement.

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

Nothing to report.

#### h. Other products:

### University of Illinois Chicago – COE

**Vehicle and Infrastructure dynamic modeling group:** New models include significant details developed using existing Multibody System code SAMS/Rail, which allows for the integration of detailed track and infrastructure models with nonlinear railroad vehicle models. The infrastructure dynamic modeling and its importation into the EVL Cave2 visualization platform are supported by NURail funding. Currently, these computer codes remain “in house” at UIC.

### University of Illinois Chicago – CUPPA

**Rail Safety:** Preparing a database of video monitoring of non-motorist behavior at selected grade crossings in the Chicago area.

**GIS:** Finalized the “Illinois Sustainable Rail Scorecard” in alignment with US DOT strategic goals.

**Freight:** Obtained additional assessment data from Will County that goes back to early 1990’s.

## 3. Participants and Other Collaborating Organizations

### a. Partners

Organization Name:	Location of the Organization:	Partner Contribution:	Name (First and Last)	University
IST (University)	Lisbon, Portugal	Joint proposal to FCT in Portugal	Visiting students	MIT
East Japan Railway Co.	Tokyo, Japan	Research sponsor		MIT
Region 1 UTC	Cambridge, MA	Research sponsor	MIT	MIT
Indiana Rail Road	Indianapolis, IN	In-Kind, Collab., Tech Assist., Student Proj Matl	Thomas Hoback Peter Ray	Rose-Hulman
Wabash Valley RR	Terre Haute, In	60’ Rail Project-	Bill Foster	Rose-Hulman

Museum		Design/Construct		
CSX	Jacksonville, FLA	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
CN	Montreal, Quebec	Financial Support	Stephen Schlickman	University of Illinois-Chicago
Union Pacific Railroad	Omaha, NE	Financial and collab.support	Tom Bartlett	Michigan Tech
Michigan Dept of Transportation	Lansing, MI	Financial and collab.support	Tim Hoeffner, Nikkie Johnson	Michigan Tech
Tech Expert Network	----	Financial	Carl Shade	Michigan Tech
Norfolk Southern Railroad	Norfolk, VA	Financial and collab.support	Brian Sykes	Michigan Tech
Escanaba & Lake Superior Railroad	Escanaba, MI	In-kind and collab. support	Tom Klimek, Mike Logan	Michigan Tech
Tangent Technologies	Aurora, IL	In-kind support	Mohsen Issa	University of Illinois-Chicago
Chicago Transit Authority (CTA)	Chicago, IL	In-kind support	Mohsen Issa	University of Illinois-Chicago
Norfolk Southern Corp.	Atlanta, GA	Data	Clark Cheng	UTK
Norfolk Southern Corp.	Atlanta, GA	Track materials, railcar truck	Les Hall, Wayne Strickland	UTK/UK
Beijing Jiaotong University	Beijing, PRC	Exchange personnel	Hua Liu	UTK
CSX	Jacksonville, FL	Data and Problem	Yu Wang, Dharm Acharya	UTK
TN Department of Transportation	Nashville, TN	Financial support	Tanisha Hall, Liza Jeffrion	UTK
HC Bridge, Inc	Wilmette, IL	In-kind support	John Hillman	UTK
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 Kentucky

- Dan Lau, Dept. of Electrical Engineering, and Visualization Center, University of Kentucky 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, UI – Urbana-Champaign, initial work on performance of bridge approaches
- Baoshan Huang, Dave Clarke, UT, tie ballast interface and rail performance using UT’s test pit.

### University of Tennessee, Knoxville

- Univ. of South Carolina, Columbia, SC, Partner in Railroad Operations class, Dr. Dimitris Rizos
- Dept. of Civil and Environmental Engineering, UTK, In-kind support, facilities
- Dept. of Industrial Engineering, UTK, In-kind support

### 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:** This group is a 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 crossties put the railroad industry on the green, sustainable path with an enhanced performance and an efficient life-cycle cost.

#### University of Illinois Chicago – CUPPA

**VC:** Assist transit and rail capital planners in making more effective decisions concerning the use and development of value capture strategies for funding. **Rail Safety:** Continue the work started by the research team in the area of pedestrian safety at rail crossings and expand on it with additional data and analysis. **GIS:** Advance the existing environmental impact assessment of rail infrastructure and services by providing a system view of sustainability and one-stop database. **Freight:** Strive to develop a tool that can quantify the impacts of increase/decrease/shifts in freight activities based on broad assumptions of General Equilibrium of the Economy.

#### Massachusetts Institute of Technology

The kinds of issues we are researching are inherently interdisciplinary in content and approach. So while we advance the field of transportation, we do that in a context of a deeper understanding of regional economics, land use planning, engineering systems and other related fields.

### **Michigan Tech University**

Michigan Tech's program has no single discipline, but rather it reaches quite evenly across multiple departments. See the details in next section.

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

Research findings help bridge engineers understand how railroad bridges respond to higher speeds and heavier loads, and how bridges may be strengthened. Research also helps advanced new materials to be incorporated into railroad bridge construction.

## **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.

### **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:** 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. **Freight:** This 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, Social Sciences (cognitive sciences), and Humanities.

### **University of Kentucky**

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

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

Research program activities are not far enough advanced for impacts to be assessed.

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

CE490 RR Engineering is an elective for Mechanical and Electrical Engineering students. RHIT AREMA Student Chapter is open to all students to learn about the rail industry and career opportunities.

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

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

UIUC taught 4 rail courses in Spring 2014, one of which was a new class, Advanced Track Engineering. The total enrollment was 119 undergraduate and graduate students including 10 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 are 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 have access to upper undergraduate and graduate course in *Railroad Vehicle Dynamics* (previously a Special Topic). A new course, *Railroad Track Engineering*, will be offered for the first time in 2014. Regarding workforce development, a former MS student who worked on the NURail supported recycled plastic crossties project, which involved CTA collaboration, is now working on CTA rail projects as a consultant with HBM Engineering LLC. Another NURail supported PhD graduate is working in transportation modeling at Argonne National Laboratory.

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

The Metra management training project will focus on developing current transportation employees into more effective managers. **VC:** Graduate students assist with research and case studies for this project. **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 the training of rail operators, and other stakeholders. **GIS:** This project has been supporting two graduate research assistants in Urban Planning and Policy at UIC; one is a female and minority (Mexican-American). **Freight:** This research will provide a rich case study of the relationship between freight-related development project and the regional economy that can be used as a course material.

### **Massachusetts Institute of Technology**

MIT has two graduates of the Class of 2014 employed by Class I RR's and two undergraduate students interning with Class I RR's.

### **Michigan Tech University**

Summer Youth Program in Rail and Intermodal Transportation provided industry exposure to high school students. Student research projects expose students to industry and hands on experience. Rail Night event at Fall Career fair exposed students to industry representatives.

### **University of Kentucky**

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

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

Research portion of program supports several graduate students focusing on transportation careers. Program supports the UTK AREMA student chapter, and funds attendance of undergraduate students to industry events, including AREMA Annual Conference. Also provides speaker and chapter financial support. The program provides continuing education to help improve skills of railway industry workers. The program also provides railway content to undergraduate and graduate civil engineering classes at the university.

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

Expectations for CE/EE/ME students to consider railroad engineering 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 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 – COE**

New equipment, testing fixtures and machine improvements were acquired in the material testing lab to provide better accuracy and a more controlled environment. Established a bank of testing data for HDPE crossties and a collection of different analytical models addressing different aspects of the rail system.

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

Help solidify research connections between internal groups at CUPPA and develop further the CN Fellowship program. GIS integrated environmental database may allow users to specify the rail facility or land area of interest, access data from multiple departments and evaluate the multi-facet environmental impacts in one database.

#### **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).

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

New John Tickle building has state-of-the-art laboratories, including a high-bay structures lab with reaction walls/floor, geotechnical laboratory, and materials laboratory. These facilities immediately put to use in ongoing NURail research. A hybrid composite beam has already been moved to the lab for testing. UTK and UK are collaborating on a project to examine track response in the geotechnical lab.

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

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

Potential impacts include the study of how China improved railway infrastructure to boost railway operating performance and increase capacity. Second project assessing performance of high performance composite beams for railway bridge construction also has excellent potential.

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

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

More efficient rail operations can 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 a better understanding of the 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 the new recycled plastic railroad

crossties would improve the railroad industry public image as a green, sustainable industry. Inherent damping associated with these plastic products is expected to decrease vibrations, which in turn enhances the safety, rideability, and passenger comfort.

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

Our 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: The 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**

NURail research directly affects mobility, economic development and potentially environmental impact and global climate change, all vital critical contemporary issues.

#### **Michigan Tech University**

The 1st annual Michigan Rail Conference impacted the growth and use of rail transportation in Michigan corridors. Planning for the 2nd annual conference has begun under Michigan Tech leadership.

#### **University of Kentucky**

Safety and economy of the general public is impacted.

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

Increasing the stature and performance of rail transportation has broad potential societal benefits, including, but not limited to, economic, environmental, and quality of life. The UTK projects will add to the cumulative body of railway knowledge that does have the potential for broad societal impacts.

#### **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