

4th Quarterly Program Progress Performance Report
for
National University Rail (NURail) Center:
Tier 1 University Transportation Center



National University Rail Center - NURail

USDOT-RITA Tier I University Transportation Center (UTC)

Submitted to
U.S. Department of Transportation
Research and Innovative Technology Administration

Grant Period:
1 January 2012 through 31 January 2014

Reporting Period:
1 July 2013 through 31 December 2013

Submitted:
30 January 2014

Submitted to:

Lydia Elena Mercado
University Programs Grant Manager
Transportation Workforce Development
Coordinator
US Department of Transportation
Tel (202) 366-3372
Lydia.Mercado@dot.gov

Submitted by:

Christopher P.L. Barkan, PhD

A handwritten signature in black ink that reads "Chris Barkan".

Professor
University of Illinois at Urbana -
Champaign
PI and Director - NURail
Tel (217) 244-6338
cbarkan@illinois.edu

Grant: DTRT12-G-UTC18

Duns: 04-154-4081

EIN: 37-6000511

Table of Contents

1. Accomplishments.....	3
a. What are the major goals of the program?.....	3
b. What was accomplished under these goals?.....	3
c. How have the results been disseminated?.....	6
d. What do you plan to do during the next reporting period to accomplish the goals?.....	8
2. Products: What has the program produced	9
a. Publications, conference papers, and presentations:.....	9
b. Journal publications:	13
c. Books or other non-periodical, one-time publications:.....	14
d. Other publications, conference papers and presentations:	14
e. Website(s) or other Internet site(s):	14
f. Technologies or techniques:	15
g. Inventions, patent applications and/or licenses:.....	15
h. Other products:	15
3. Participants and Other Collaborating Organizations	15
a. Partners	15
b. Additional collaborators	16
4. Impact	17
a. What is the impact on the development of the principal discipline(s) of the program?	17
b. What is the impact on other disciplines?	17
c. What is the impact on the development of transportation workforce development?.....	18
d. What is the impact on physical, institutional and information resources at the university or other partner institutions?.....	19
e. What is the impact on technology transfer?.....	19
f. What is the impact on society beyond science and technology?	19
5. Changes/Problems	20
a. Changes in approach and reasons for change	20
b. Actual or anticipated problems or delays and actions or plans to resolve them	20
c. Changes that have a significant impact on expenditures	20
d. Significant changes in use or care of human subjects, vertebrate animals and/or biohazards	20
e. Change of primary performance site location from that originally proposed.....	20

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

Call for Project Proposals:

- Call for research and education project proposals distributed in Fall 2013.

Research: Strategic Development Planning (SDP):

- SDP working groups presented status reports, refined project scopes and timelines, and gained input at the 2013 NURail Annual Meeting.

Technology Transfer & Leadership:

- Four Hay Seminar Series lectures – Total of 333 people in house and 218 on-line attendees.

Management:

- Formed NURail Executive Advisory Board and Technical Advisory Committee.
- First NURail Annual Meeting held September 11-12, 2013. The 100 participants included the Technical Advisory Committee, Executive Advisory Board, Student Leadership Council, faculty and students from NURail partner institutions, industry partners, and the FRA.

University of Illinois Urbana-Champaign

Research:

- Concrete Crossties and Fasteners: Continued to refine and validate the FEM using laboratory and field experiments. A simplified analytical tool was developed that incorporates the FEM output and provides interpolation of performance data for a variety of loading and design scenarios.
- Schnabel Research Lab (railway engineering research facility): Full-scale track test bed structure and site improvements for access to the lab and storage of materials were completed.
- Safety and Hazardous Materials Risk: Developed a semi-quantitative risk analysis model to investigate the frequency and severity of adjacent-track accidents on shared rail corridor. A simple GIS-based liquid flow model was developed to identify the potential affected areas in a release of petroleum crude oil.
- Railroad Capacity and Optimization Strategic Development Plan: Continued formal work on projects related to shared corridor capacity model components. Work began on the yard-mainline capacity interaction model component.

Outreach and Education:

- Hay Seminar Series: Hosted four on-campus seminars from industry experts that were also broadcast online. Total of both online and in person attendees for the 4 seminars was 551.
- Transportation Safety and Risk Course Development: New course was taught.
- Railway Transportation and Engineering Course Updates: Remaining content in the Railway Transportation and Eng. Course was revised for fall.
- Advanced Track Engineering Course: Began development for new course for 2014-2015.

Technology Transfer:

- Concrete Crosstie and Fastening Systems Workshop was conducted as part of the AREMA Committee 30 meeting held in conjunction with the RTA annual meeting in October 2013.
- Railroad Environmental Conference was held in November 2013 with over 500 attendees and 70 spoken presentations.
- Planning 13th Global Level Crossing and Trespass Symposium (GLXS 2014) to be held on the UIUC campus in August 2014.

- Planning for the Capacity Workshop for the TRB Annual Meeting in January 2014.

International Cooperation:

- Faculty from UIUC and KTH (Swedish Royal Institute of Technology) continued to develop the framework and curriculum for a joint Masters Degree Program.
- Plans continued to develop High Speed Rail (HSR) System Education Center rail curriculum jointly with Southwest Jiaotong University (SWJTU) located in Chengdu China.
- Planning began for second research forum with SNCF and UIC to be held in Paris in Spring 2014.
- US-China Transportation research forum organized by the US DOT and China Ministry of Railways.
- HSR forum sponsored by Korea Rail Research Institute and held as part of the US-Korea Conf.

University of Illinois Chicago – COE

Vehicle and Infrastructure Modeling:

- **Wheel-rail contact.** Basic study of wheel climb and derailment at a large angle of attack. Discovered forces developed at the point of contact cannot be captured by a planar force balance. Additional research underway to understand wheel-climb derailments for complex geometries.
- **Switch modeling.** Developed elementary switch components model where rail vehicle travels through the switch without incident. This may lay foundation for modeling switch derailments.
- **Coupled track and infrastructure model.** Study conducted on “Railroad Substructure/Foundation Model for Integrated Simulation of Vehicle-Track Interaction.”
 - Created linear elastic finite element (FE) model of track and substructure.
 - Modal analysis performed. Modes have been imported into the multi-body system code SAMS/Rail for the dynamic analysis of an idealized suspended wheel set. Model has been verified against literature, and the force and displacement response has been analyzed. Output of model successfully exported to a 3D visualization platform.
 - Developed and implemented an elasto-viscoplastic ballast/soil model into a finite element code. Verification still in progress.

Railway Infrastructure Materials and Design:

- Conducted study assessing the feasibility of implementing a next generation of recycled plastic (HDPE) rail crossties. Initial stage completed: static testing and model validation. Second stage initiated: cyclic testing and modelling of full-scale applications. Results illustrate potential in terms of performance, environmental benefits and life-cycle economy.
- Developed new technical elective rail engineering course: “CME 404 Railroad Track Engineering” for both graduate and undergraduates students, to start in summer 2014.

The Informed Rail Traveler (Intelligent Traveler Systems)

- Produced four peer-reviewed studies of issues affecting multi-modal rail travelers, including parking and ridesharing information systems.

University of Illinois Chicago – CUPPA

Value Capture Coordination (VC):

- Completed all literature review as well as all case study site visits.
- Scheduled two Chicago-area focus groups with developers for late January; team will write final reports after the meeting.

Rail Crossing Safety (Rail Safety):

- Commenced with literature review to identify issues with pedestrian safety at rail grade crossings in general, and transit rail grade crossings, in particular.
- Reviewed current grade crossings in northeastern Illinois region to understand the location-specific attributes that will inform the site selection process.

Analysis of Environmental Impacts of Rail Development (GIS):

- Gathered benchmarking data for “Illinois Sustainable Rail Scorecard” that the team developed and continuously defined.
- Revised “Scorecard” in alignment with US DOT strategic goals.
- Included risk assessment data in the web GIS database.

- Completed spatial data collection corresponding to the “Scorecard”.
- Developed a web site (at nurail.uic.edu) for the research project.
- Organized and hosted a stakeholder meeting that solicited comments and feedback on research results from transportation practitioners.

Economic Impacts of Freight Mode Choice (Freight):

- Obtained Will County property tax assessment data, truck AADT and water shipment volumes along Chicago River in Will County, and historical list volumes for intermodal terminals in the Chicago region.
- Analyzed data of rise and fall of business activities related to the intermodal rail yards.
- Met with commercial real estate tax assessor of Will County to understand how the assessed property captures the market value of the properties.

Massachusetts Institute of Technology

- Recruited four graduate students to work on NURail projects. This includes: NEC, CA HSR, Midwest HSR and relation of HSR to urban transportation systems.
- Weekly meetings where various members present their work.
- Participated in several outreach meetings on the NEC and made useful contributions to the discussions based on the NEC work by the research team.

Michigan Tech University

Undergraduate Student Projects:

- *Promotional Rail Transportation Program* video is complete. Highlights importance of rail education, career opportunities in rail, Michigan Tech Rail Education opportunities.
- *Grade Crossing Surface Evaluation* is close to completion. Project investigated highway-rail grade crossing surface materials performance; developed improved procedure for inspecting & reporting condition of grade crossing surfaces in Michigan.
- Initiated three new undergraduate student projects:
 - Proposal for *Re-purposing a Centerbeam Rail Car* for use in hauling frac-sand pods.
 - Design an *Intelligent RR Crossing Signal Maintainer* that prevents grade crossing signals from remaining disabled if workers forget to remove a maintenance jumper cable.
 - Develop a *Market Study on Railroad Balises* (an electronic transponder used for train communications) technology and use in the rail industry.

Graduate/Faculty Research Projects:

- *The Upper Peninsula of Michigan Freight Rail Study* is nearing completion
- *Influences on Driver Behavior at Railroad Crossings, Phase 1* is near completion. Project has been investigating eye movement by drivers, as they approach types of grade crossings.
- *The Assessment in Michigan for High Speed Rail Ballast* is also nearing completion.

Five new graduate / faculty research projects have been initiated:

- Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras.
- The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety.
- Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway.
- Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors.
- Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels.

Technology Transfer:

- Michigan Rail Transportation Conference (with MDOT): Inaugural conference objective was to promote RR transportation, RR education, and the role of rail transportation in economic development in the state of Michigan. Michigan Tech led the conference organization.
- Commission for Supply Chain and Transportation Logistics Collaboration: Dr. Pasi Lautala was appointed by the Governor as 1 of the 7 members of the commission. This allows him to discuss outcomes of UTC activities with the leadership of Michigan.
- K-12; Summer Youth Program in Rail and Intermodal Transportation: 4th annual youth program conducted at Michigan Tech, 17 high school students from around the nation attended.

University of Kentucky

- Three masters student completed thesis (2) or creative component (1).
- Additional work completed on rail crossing sensor platform.

University of Tennessee, Knoxville

- Continued 4 NURail projects; research presentations made at technical conferences.
- One session of the track engineering class and two track inspection classes to industry personnel were offered with total attendance of 61 persons.
- Developed one new class in railway operations.

Rose-Hulman Institute of Technology

- AREMA Student Chapter, in its first year of existence, has 50 RHIT members, with 16 students registered as AREMA members - held 11 meetings and conducted 11 rail industry field trips.
- ASME Rail Transportation Division Conference awarded an Undergraduate Student Conference Scholarship to an RHIT student.
- Developed new ten week, 40 class period interdisciplinary railroad engineering course. Enrollment for 2013 Spring Quarter course was ten students.

c. How have the results been disseminated?

NURail Consortium

Research and Education: The results of both the NURail research and education programs were presented at the 2013 NURail Annual Meeting with other individual presentations being made 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:

- AREMA Annual Meeting in Indianapolis in September.
- Institute for Operations Research & Management Science Annual Mtg in Minneapolis in Oct.
- ASME Rail Transportation Division Conference in Altoona in October.
- Railroad Environmental Conference at UIUC in November.
- World Congress of Railway Research in Australia in November.

Railroad Capacity and Optimization Strategic Development Plan:

- Optimization model for passenger rail corridor upgrades given at 2013 AREMA Conference.
- Capacity research results presented in special session at the 2013 INFORMS conference. Three conference papers describing aspects of the research submitted for presentation in 2014.
- Informal presentations made to representatives from the Association of American Railroads.
- The project team continued work to organize and develop content for the “Cost of Railway Congestion” workshop to be held at the 2014 TRB Annual Meeting.

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 October 2013.

Safety and Hazardous Materials Risk:

- Besides conference presentations, informal presentations on the research were made to representatives from AAR and the University of Birmingham, U.K. Prof. Clive Roberts.

University of Illinois Chicago – COE

Findings of these projects were disseminated in part through presentations and posters at both the American Society of Civil Engineers Engineering Mechanics Institute, and the 2013 NURail annual meeting in Urbana-Champaign, IL. Please refer to publications section for additional details.

University of Illinois Chicago – CUPPA

All of the research projects have been at least discussed during poster presentations at major conferences. The VC, Rail Safety, and GIS projects were presented at the NURail Annual Meeting and the APTA annual conference. Rail Safety project featured at the Rail Summit in October 2013.

Massachusetts Institute of Technology

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

Michigan Tech University

Student Projects - Rail Transportation Promotional Video available on: www.rail.mtu.edu, YouTube, and is shown during events at Michigan Technological University.

Research Projects

- Assessment in Michigan for HSR Ballast project had 2 presentations, a Civil and Environmental Engineering Graduate Seminar & a Master Student's defense and Thesis.
- Influences on Driver Behavior at Railroad Crossings presented a paper at the Intl Conference on Automotive User Interfaces and Vehicular Applications in the Netherlands. Paper submitted for upcoming 2014 Global Level Crossing Safety & Trespass Symposium.
- Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels project has a paper accepted and will be in the conference proceedings at the 2014 IEEE/ASME Joint Rail Conference titled "Austempered Ductile Iron Performance at Rail Wheel Operating Conditions".
- UP Freight Rail Study has a paper accepted that will be presented at the Logistics, Trade and Transportation Symposium in February, 2014.
- Dr. Pasi Lautala was part of a panel on the topic of Strategic Initiatives in a Bi-National Transportation Corridor at the Bi-National Twin Sault's Regional Conference in Sault Ste. Marie. He presented to the Michigan House and Senate Transportation Committees in Lansing and focused on the status, needs, challenges, and growth of the freight rail industry in Michigan. He presented at the Northwoods Rail Transit Committee (Wisconsin) Meeting on Freight (Rail) Transportation Challenges and an update on UP Freight Rail study.

Michigan Rail Transportation Conference in collaboration with MDOT - 113 in-person attendees, 33 real-time webcast attendees, and 29 speakers joined the Lansing conference. Afterwards participants can access presentations and photos at the conference site and recordings were posted to High Speed Rail Learning System (HSRLS).

Summer Youth Program in Rail and Intermodal Transportation- Announced in major RR magazines, events, and promoted widely throughout the Midwest. Trains Magazine wrote an article on the event.

University of Kentucky

Two papers prepared and accepted at 2014 TRB annual conference (one on Kentrack 4 and one on the use of the Tekscan sensors). Research results also discussed in our fall semester transportation courses.

University of Tennessee, Knoxville

Developed and presented a course module on rail transportation at a transportation workshop for high school STEM teachers. Presentation to University of South Carolina AREMA student chapter. Presentations and conference papers have been prepared and delivered.

Rose-Hulman Institute of Technology

- Building a Railroad Engineering Program at a Primarily Undergraduate Institution, James L. McKinney PhD PE at the 2013 NURail Annual Meeting.
- RHIT AREMA Student Chapter: Formation /Presentations/Field Trips, Greg Frech, President and Zach Ehlers, Secretary/Treasurer at the 2013 NURail Annual Meeting.

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 Spring 2014 semester that will be also broadcast online. NURail will also co-sponsor the 2014 Joint Rail Conference (JRC). NURail will participate on the conference organizing committee and 2 full sessions at the conference will be devoted to NURail research and education projects.
- Planning will begin for the second NURail Annual Meeting to be held in August 2014 at a NURail Affiliate institution.

University of Illinois Urbana-Champaign

- **Research: Concrete Crossties and Fasteners:** Will continue to refine and validate the FEM using laboratory and field experiments. **Schnabel Research Lab:** Will officially open in Spring 2014 and have the capacity of conducting experiments that are representative of field conditions. Plans are also underway to reopen the Wood Engineering Lab facility. Research will be conducted on wood crossties through accelerated aging tests of crossties. **Safety and Hazardous Materials Risk:** Future direction of shared rail corridor safety and risk research will be identified. Work on petroleum crude oil transportation will continue. **Railroad Capacity and Optimization Strategic Development Plan:** Formal work on projects related to shared corridor capacity model components of the capacity and optimization strategic development plan continued. Work began on the yard-mainline capacity interaction model component.
- **Outreach and Education: Hay Seminar Series:** UIUC will host (and broadcast online) four on-campus seminars from industry experts. **Advanced Track Engineering Course:** Continue development of course curriculum for a new course on Advanced Track Engineering to be offered during the 2014-2015 academic year.
- **International Cooperation: Rail Research and Educational Cooperation with KTH:** Continue to develop the framework and curriculum for a joint Masters Degree Program to be offered by both institutions. **HSR System Education Center.** Continue plans to develop HSR curriculum jointly with SWJTU of China.

University of Illinois Chicago – COE

- **Wheel Climb Derailment** research will continue because this dangerous derailment scenario 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 introduce RR engineering course “CME 404 Railroad Track Engineering” and technical seminars on HSR application featuring speakers from a global consulting firm.

University of Illinois Chicago – CUPPA

- VC: Final report drafting will commence. Will begin presenting and publishing results in full in addition to the conference and committee meetings we've already reported at.
- Rail Safety: Preparation to conduct user surveys and video monitoring of non-motorized users at selected rail grade crossing locations.
- GIS: A research assistant will continue to improve previously-developed aspects of the project and will work to finalize a report.
- Freight: Will complete the preliminary analysis of the changes in the property values of parcels along major corridors in Will County.

Massachusetts Institute of Technology

- Graduate students are recruited and research is underway, now aiming for substantial progress in research efforts.
- Undergraduates will be recruited for each area of research as part of the MIT Undergraduate Research Opportunities Program.
- Within CY2014, we expect four MST theses (June 2014) and one PhD dissertation. Also, many students will participate in 2014 TRB as well as other conferences.

Michigan Tech University

- Research - *The Upper Peninsula of Michigan Freight Rail Study* and *The Assessment in Michigan for High Speed Rail Ballast* will be completed, final reports issued.
 - Influences on Driver Behavior at Railroad Crossings - complete Phase 1; start Phase II.
 - Phase II of Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels project will be started.
 - Rail Embankment Stabilization Needs on the Hudson Bay project will perform literature search and develop a "Best Practices Guide" to diagnose, document, and perform corrective actions to railway conditions in permafrost affected areas.
 - Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies project will begin research and focus on algorithm development for autonomously detecting and scoring anomalous wheel conditions using thermal images provided by Union Pacific.
 - Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors will start collecting data and building track infrastructure for the simulation software.
- Student Projects – All current student projects will be completed within next reporting period. The outcomes will be presented at the 2014 Joint Rail Conference in Colorado Springs, CO.
- Tech Transfer - Planning underway for Summer Youth Programming, and the 2nd Annual Michigan Rail Conference. On February 17-18, 2014, rail industry companies and government agencies will gather at Michigan Tech for Rail Day and the 9th Annual Railroad Night. UTC projects will be showcased as part of the activities.

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.

University of Tennessee, Knoxville

- Collaborator in the TRB Workshop on Cost of Rail Congestion, several presentations at 2014 TRB Annual Meeting.
- Assisting with 2014 REES planned for June.
- Several faculty and students have papers accepted for the 2014 JRC and will attend.

Rose-Hulman Institute of Technology

- Student evaluations of CE490 Railroad Engineering were reviewed and updated as appropriate. Class promoted as viable technical elective for Civil/Mechanical/Electrical Engineering students.
- Soliciting rail sponsored Senior Design Projects for the 2014/2015 academic year.
- RHIT AREMA Student Chapter Outreach - Student chapter will continue to offer monthly program of meeting and field trips. Major effort was undertaken in December to expose students to rail related summer internships and permanent rail jobs. Chapter is developing an 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

- Van Dyk, B.J., C.T. Rapp, M.S. Dersch, J.R. Edwards, C.J. Ruppert, Jr. and C.P.L. Barkan. 2013. Evaluation of Existing Loading Environment in North America for Improved Concrete Sleepers and Fastening Systems. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Chadwick, S.G., C.T. Dick, M.R. Saat and C.P.L. Barkan. 2013. Statistical Modeling of Freight Train Derailments at Highway-Rail Level Crossings. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Lin, C-Y., M.R. Saat and C.P.L. Barkan. 2013. Causal Analysis of Passenger Train Accidents on Freight Rail Corridors. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Greve, M.J., C.T. Rapp, M.S. Dersch, J.R. Edwards, C.P.L. Barkan, J. Mediavilla and B. Wilson. 2013. Quantification of Concrete Sleeper and Elastic Fastening System Demands Utilizing Concrete Sleeper Rail Seat Contact Area. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Shin, M., Z. Chen, B.O. Andrawes, R.G. Kernes, M.S. Dersch and J.R. Edwards. 2013. Finite Element Models of Prestressed Concrete Sleepers and Fastening Systems in North America. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- do Carmo, T.B., J.R. Edwards, R.G. Kernes, B.O. Andrawes and C.P.L. Barkan. 2013. Analysis of the Shear Behavior of Rail Pad Assemblies as a Component of the Concrete Sleeper Fastening System. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Lovett, A.H., M.R. Saat, C.T. Dick, C. Ruppert and C.P.L. Barkan. 2013. Development of an integrated railroad track maintenance model. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. Integrated Risk Management Framework for Improving the Safety of Hazardous Materials Transportation by Rail. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Jacobini, F.B., E. Tutumler and M.R. Saat. 2013. Identification of High-Speed Rail Ballast Flight Risk Factors and Risk Mitigation Strategies. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.
- Liu, X., C.T. Dick, A.H. Lovett, M.R. Saat and C.P.L. Barkan. 2013. Seasonal Effect on the Optimization of Rail Defect Inspection Frequency. In: *Proceedings of the ASME 2013 Rail Transportation Division Fall Technical Conference*, Altoona, PA, October 2013.
- Liu, X., C.T. Dick, A.H. Lovett, M.R. Saat and C.P.L. Barkan. 2013. Optimization of Rail Defect Inspection Frequency. Presented at the 2013 INFORMS Conf, Minneapolis, MN, October 2013.
- Lin, C-Y., M.R. Saat and C.P.L. Barkan. 2013. Accident Analysis of Passenger Trains on Freight Rail Corridors. Presented at the 2013 INFORMS Conference, Minneapolis, MN, October 2013.
- Atanassov, I., C.T. Dick and C.P.L. Barkan. 2013. Incremental Capacity of Single to Double Track with Variable and Sparse Siding Spacing. Presented at the 2013 INFORMS Conference, Minneapolis, MN, October 2013.
- Shih, M.-C., C.T. Dick and C.P.L. Barkan. 2013. Optimal Siding Location Model. Presented at the 2013 INFORMS Conference, Minneapolis, MN, October 2013.
- Lovett, A.H., C.P.L. Barkan and C.T. Dick. 2013. An Integrated Model for the Evaluation and Planning of Railroad Track Maintenance. Presented at the 2013 INFORMS Conference, Minneapolis, MN, October 2013.
- Chadwick, S.G., M.R. Saat, C.T. Dick and C.P.L. Barkan. 2013. Decreasing Derailment Occurrence and Severity at Highway-Rail Grade Crossings. In: *Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference*, Indianapolis, Indiana, September 2013.
- Lovett, A.H., C.P.L. Barkan and C.T. Dick. 2013. An Integrated Model for the Evaluation and Planning of Railroad Track Maintenance. In: *Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference*, Indianapolis, IN, September 2013.

- Caughron, B.M., C. T. Dick and C.P.L. Barkan. 2013. A Project Selection Model for Improving Running Time on Passenger Rail Corridors. In: *Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference*, Indianapolis, Indiana, September 2013.
- Grasse, J.S., S. Wei, J.R. Edwards, D.A. Kuchma, M. Dersch and D.A. Lange. 2013. Investigating the Concrete Crosstie and Fastening System Load Path Through Field Instrumentation. In: *Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference*, Indianapolis, Indiana, September 2013.
- Sogin, S., C.T. Dick, Y-C. Lai and C.P.L. Barkan. 2013. Analyzing the Incremental Transition from Single to Double Track Railway Lines. In: *Proceedings of the International Association of Railway Operations Research (IAROR) 5th International Seminar on Railway Operations Modelling and Analysis*, Copenhagen, Denmark, May 2013.
- Van Dyk, B.J., M.S. Dersch, J.R. Edwards, C.J. Ruppert Jr. and C.P.L. Barkan. 2013. Quantifying Shared Corridor Wheel Loading Variation Using Wheel Impact Load Detectors. In: *Proceedings of the ASME Joint Rail Conference*, Knoxville, TN, April 2013.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. Safety Effectiveness of Integrated Accident Prevention Strategies. In: *Proceedings of the ASME Joint Rail Conference*, Knoxville, TN, April 2013.
- Lovett, A.H., C.T. Dick, C.J. Ruppert Jr., M.R. Saat and C.P.L. Barkan. 2013. Development of an integrated model for the evaluation and planning of railroad track maintenance. In: *Proceedings of the ASME Joint Rail Conference*, Knoxville, TN, April 2013.
- Lautala, P.T., C.T. Dick, J.L. McKinney and D.B. Clarke. 2013. Railway Engineering Education Symposium (REES) - Universities and Industry Collaborate to Develop Railway Education. In: *Proceedings of the ASME Joint Rail Conference*, Knoxville, TN, April 2013.
- Sogin, S., C.T. Dick, Y-C. Lai and C.P.L. Barkan. 2013. Analyzing the Progression from Single to Double Track Networks. In: *Proceedings of the ASME Joint Rail Conference*, Knoxville, TN, April 2013.
- Chadwick, S.G., M.R. Saat, C.T. Dick and C.P.L. Barkan. 2013. Decreasing Derailment Occurrence and Severity at Highway-Rail Grade Crossings. Presented at the ASME Joint Rail Conference, Knoxville, TN, April 2013.
- Caughron, B.M., C. T. Dick and C.P.L. Barkan. 2013. A Project Selection Model for Improving Running Time on Passenger Rail Corridors. Presented at the ASME Joint Rail Conference, Knoxville, TN, April 2013.
- Lin, C-Y., M.R. Saat and C.P.L. Barkan. 2013. Causal Analysis of Passenger Train Accidents on Freight Rail Corridors. Presented at the ASME Joint Rail Conference, Knoxville, TN, April 2013.
- Shurpali, A.A., R.G. Kernes, J.R. Edwards, M.S. Dersch, D.A. Lange and C.P.L. Barkan. 2013. Investigation of the Mechanics of Rail Seat Deterioration (RSD) and Methods to Improve the Abrasion Resistance of Concrete Sleeper Rail Seats. In: *Proceedings of the 10th International Heavy Haul Association Conference*, New Delhi, India, February 2013.
- Van Dyk, B.J., J.R. Edwards, C.J. Ruppert Jr. and C.P.L. Barkan. 2013. Considerations for Mechanistic Design of Concrete Sleepers and Elastic Fastening Systems in North America. In: *Proceedings of the 10th International Heavy Haul Association Conference*, New Delhi, India, February 2013.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. Analysis of Major Derailment Causes on Heavy Haul Railways in the United States. In: *Proceedings of the 10th International Heavy Haul Association Conference*, New Delhi, India, February 2013.
- Sogin, S., Y-C. Lai, C.T. Dick and C.P.L. Barkan. 2013. Comparison of the capacity of single and double track rail lines using simulation analyses. Presented at the 2013 Transportation Research Board Annual Meeting, Washington D.C., January 2013.

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.

- 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)
- 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.” 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.

University of Illinois Chicago – CUPPA

- Jane Wilberding, Stephen Schlickman, Janet Smith, Tom Bothen, Yittayih Zelalem, Jordan Snow. “Value Capture Coordination: Analysis and Best Practices,” American Public Transportation Association Annual Conference. Chicago, IL, 9/30/13.
- Ning Ai, Anthony Grande and Marcella Bondie. "Environmental Impact Assessment Of Rail Infrastructure In Illinois," American Public Transportation Association Annual Conference. Chicago, IL, 9/30/13.
- Paul Metaxatos, P.S. Sriraj. “Nonmotorist Safety Attitudes and Revealed Behavior at Rail Grade Crossings,” The Rail Summit: Economic Impacts of Short Lines. Chicago, IL, 10/25/13.

Massachusetts Institute of Technology

- The impact of high-speed rail and low-cost carriers on European air passenger traffic. Clewlow, Sussman and Balakrishnan, in press, Transportation Policy.
- Uncertainty and Inter-Jurisdictional High-Speed Rail Planning: Insights from Portugal and the United Kingdom, Stein and Sussman, in review, Journal of the TRB.
- Productivity of Passenger Rail Transportation Services in the Northeast Corridor, Archila, Sakamoto, Fearing and Sussman, in review, Journal of the TRB.
- Pagliara, Abreu, Stein and Sussman, “Megacities and High-Speed Rail Systems: Transportation Demand Management. Insights from the mobil.TUM 2012 International Scientific Conference on Mobility and Transport.”
- 2013 Oct. “Big Ideas, Innovative Research in Portugal” MPP Visiting Rectors and Deans, MIT.
- 2013 Jul. “A Review of Recent Regional/High-Speed Rail Research”, IST/Portugal.

Michigan Tech University

- Myoungsoon Jeon and Pasi Lautala presented a conference paper, “Necessity of Vehicle to Rail Infrastructure Communication for Grade Crossing Warning & Safety” at the Adjunct Proceedings of the 5th International Conference on Automotive User Interfaces and Vehicular Applications (AutomotiveUI’13), in Eindhoven, The Netherlands, October 27 – 30 , 2013.
- Karl Warsinski, Pasi Lautala, and Paul Sanders (paper is accepted), “Austempered Ductile Iron Performance at Rail Wheel Applications”, for the Proceedings of the 2014 IEEE/ASME Joint Rail Conference to be held in Colorado Springs, CO, April 2-4, 2014.

University of Kentucky

- Rose, Jerry G., “Highway-Railway At-Grade Crossing Rehabilitation Practices to Enhance Long-Term Performances: Criteria and Evaluations”, National Highway-Rail Grade Crossing Safety Conference, Fort Worth, November 3-6, 2013, (publication and presentation).
- Souleyrette, R., “NHI Highway Rail Grade Crossing Improvement Program,” Short Course, St. Louis, MO, Sept 10-11, 2013.

University of Tennessee, Knoxville

- M. Jin, H. Li, and R. Song, “Formulation and Solution Approach of Railcar Classification and Connection in Hump Yards,” INFORMS Annual Meeting, Minneapolis, MN, Oct 2013.
- Al-Khaled, M. Jin, and X. Li, “Evaluating Criticality of Intermodal Network Infrastructures Using Flow Optimization,” INFORMS Annual Meeting, Minneapolis, MN, and Oct 2013.
- Clarke, D.B., “An Introduction to Track Mechanics,” Invited Lecture, CE 521, Department of Civil and Environmental Engineering, University of Tennessee, Knoxville, TN, July 18, 2013.
- Clarke, D.B., “Railway Transportation,” Invited Presentation, STEM Workshop for Teachers, Knoxville, TN, July 19, 2013.
- Clarke, D.B., “China’s Railways,” Invited Presentation, AREMA Student Chapter, Department of Civil and Environmental Eng., University of South Carolina, Columbia, SC, October 23, 2013.

b. Journal publications:

University of Illinois Urbana-Champaign

- Liu, X., M.R. Saat, X. Qin and C.P.L. Barkan. 2013. Analysis of U.S. freight-train derailment severity using zero-truncated negative binomial regression and quantile regression. *Accident Analysis and Prevention*. 59: 87-93.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. Integrated risk reduction framework to improve railway hazardous materials transportation safety. *Journal of Hazardous Materials*. 260: 131-140.
- Rapp, C.T., M.S. Dersch, J.R. Edwards, C.P.L. Barkan, B. Wilson and J. Mediavilla. 2013. Measuring concrete cross-tie rail seat pressure distribution with matrix based tactile surface sensors. In Press, *Transportation Research Record: Journal of the Transportation Research Board*.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. Safety effectiveness of integrated risk reduction strategies for rail transport of hazardous materials. *Transportation Research Record: Journal of the Transportation Research Board* 2374: 102-110.
- Liu, X., M.R. Saat and C.P.L. Barkan. 2013. A framework for evaluating cost-effectiveness of accident prevention strategies under uncertainty. In Press, *Transportation Research Record: Journal of the Transportation Research Board*.
- Sogin, S., Y-C. Lai, C.T. Dick and C.P.L. Barkan. 2013. Comparison of the capacity of single and double track rail lines using simulation analyses. In Press, *Transportation Research Record: Journal of the Transportation Research Board*.
- Chadwick, S.G., N. Zhou and M.R. Saat. 2013. 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*.
- Rapp, C.T, R.G. Kernes and M.R. Saat. 2013. Overview of issues and research related to special trackwork for shared high-speed-rail passenger and heavy-axle-load freight operations. In Press, *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*.

University of Illinois Chicago – COE

- José L. Escalona, Hiroyuki Sugiyama, and Ahmed A. Shabana, “Modelling 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.
- 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.

Massachusetts Institute of Technology

- The impact of high-speed rail and low-cost carriers on European air passenger traffic. Clewlow, Sussman and Balakrishnan, in press, Transportation Policy.
- Uncertainty and Inter-Jurisdictional High-Speed Rail Planning: Insights from Portugal and the United Kingdom, Stein and Sussman, in review, Journal of the TRB.
- Productivity of Passenger Rail Transportation Services in the Northeast Corridor, Archila, Sakamoto, Fearing and Sussman, in review, Journal of the TRB.
- Pagliara, Abreu, Stein and Sussman, “Megacities and High-Speed Rail Systems: Transportation Demand Management. Insights from the mobil.TUM 2012 International Scientific Conference on Mobility and Transport”.

University of Kentucky

- Two papers submitted to Transportation Research Record

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

Massachusetts Institute of Technology

- Annotated Bibliography of Papers Relevant to High-Speed Rail, Regional Economic Development and Related Areas (.pdf ESD-WP-2013-23).

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

PhD students presented posters at the NURail annual meeting at Urbana-Champaign

- James J. O’Shea (with Prof. Ahmed A. Shabana), “Large Angle of Attack Wheel Climb”.
- Ahmed El-Ghandour (with Prof. Craig Foster), “Railroad Substructure/ Foundation Model for Integrated Simulation of Vehicle-Track Interaction”.
- Ibrahim Lotfy, Maen Farhat, (with Prof. Mohsen Issa), “Flexural behavior of High Density Polyethylene Railroad Crossties.”
- Ibrahim Lotfy, Maen Farhat, (with Prof. Mohsen Issa), “Testing and Simulation of Fastening System for HDPE Crossties.”

Massachusetts Institute of Technology

- 2013 Oct. “Big Ideas, Innovative Research in Portugal” MPP Visiting Rectors and Deans, MIT.
- 2013 Jul. “A Review of Recent Regional/High-Speed Rail Research”, IST/Portugal.

Michigan Tech University

Hardy, A., Hill, J., Jeon, M & Lautala, P. (submitted). Driver Response to Various Railroad Grade Crossings and Hazard Detection. 2014 Global level crossing safety & trespass prevention symposium (GLXS2014), Urbana, IL, August 3 – 8, 2014.

Rose-Hulman Institute of Technology

Building a Railroad Engineering Program at a Primarily Undergraduate Institution, James L. McKinney PhD PE, at the 2013 NURail Annual Meeting.

RHIT AREMA Student Chapter: Formation /Presentations/Field Trips, Greg Frech, President, and Zach Ehlers, Secretary/Treasurer, at the 2013 NURail Annual Meeting.

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

University of Illinois Urbana-Champaign

The 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: <http://www.nurail.uic.edu> –Information on the project and an interactive mapping tool.

Massachusetts Institute of Technology

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

Michigan Tech University

The High Speed Rail Learning System (HSRLS) website provides access and links to presentations, recordings and photos of the Michigan Rail Conference at <http://rail-learning.mtu.edu>. The Rail Transportation Program Website includes NURail project research, project synopses, and other information at www.rail.mtu.edu.

f. Technologies or techniques:

University of Kentucky

3D structured light scanner application at the large scale to scan railroad and railroad highway crossing at relative low cost and high precision (0.1inch/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.

Michigan Tech University

Rail Transportation Promotional Video available for viewing on website www.rail.mtu.edu as well as YouTube at <http://www.youtube.com/watch?v=DgRhL81Ui5M>.

University of Kentucky

3D structured light scanner has been built with 10ft by 5ft scanning area with 1 MP resolution.

3. Participants and Other Collaborating Organizations

a. Partners

Organization Name:	Location of the Organization:	Partner's Contribution to the Project:	Name (First and Last)	University
Indiana Rail Road	Indianapolis, IN	In-Kind, Collaborative Support, Tech. Asst., Student Mentorship	Thomas Hoback Peter Ray	Rose-Hulman
IST (University)	Lisbon, Portugal	Joint proposal to FCT in Portugal		MIT
East Japan Railway Company	Tokyo, Japan	Research sponsor		MIT
CSX	Jacksonville, FL	In kind, facilities	Sam Carter	Kentucky
TTCI	Pueblo, CO	In kind, facilities	Mike Brown	Kentucky

NS	Norfolk, VA	Funding	NS Corporate Partnership	Kentucky
NS	Norfolk, VA	Funding	NS Foundation	Kentucky
Nichols Foundation	Jacksonville, FL		Gerald Nichols	Kentucky
KY Transportation Cabinet	Frankfort, KY	Funding	Jennifer McCleave	Kentucky
Union Pacific Railroad	Omaha, NE	Financial and collaborative support	Tom Bartlett	Michigan Tech
Michigan Dept of Transportation	Lansing, MI	Financial and collaborative support	Tim Hoeffner, Nikkie Johnson	Michigan Tech
Tech Expert Network	-	Financial	Carl Shade	Michigan Tech
Norfolk Southern Railroad	Norfolk, VA	Financial and collaborative support	Brian Sykes	Michigan Tech
CN	Montreal, Quebec	Financial Support	Stephen Schlickman	UI Chicago
Tangent Technologies	Aurora, IL	In-kind support	Mohsen Issa	UI Chicago
Chicago Transit Authority (CTA)	Chicago, IL	In-kind support	Mohsen Issa	UI Chicago
Norfolk Southern Corp.	Atlanta, GA	Data	Clark Cheng	UTK
Beijing Jiaotong University	Beijing, PRC	Exchange personnel	Haodong Li, Minshu Ma, Hua Kiu	UTK
CSX	Jacksonville, FL	Data and Problem	Yu Wang, Dharma Acharya	UTK
Tennessee Dept 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. Development Agency	Bangkok, Thailand	Collaborative Support	Nakon Chantasom	UIUC
KTH (Royal Institute of Tech.	Stockholm, Sweden	Collaborative Support, Joint Class Develop.	Sebastian Stichel	UIUC

b. Additional collaborators

University of Illinois Chicago – CUPPA

VC: Engaged transit and city officials and developers from Washington, DC, Chicago, New York and San Francisco during the case study portion. Freight: Interviewed John Trowbridge and Rhonda Novak, both with the Tax Assessor’s Office of Will County. Met staff from Will County Center for Econ Development.

University of Kentucky

Dan Lau, Dept. of Electrical Engineering, and Visualization Center, Univ. of Kentucky has contributed his time, technology and resources to the 3D rail crossing project.

University of Tennessee, Knoxville

University 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.

Dr. Mike Moorhead PhD PE – Associate Professor of Mechanical 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: Project could assist transit and rail capital planners in making more effective decisions concerning the use and development of value capture strategies for funding. GIS: Project is expected to advance the existing environmental impact assessment of rail infrastructure and services by providing a system view of sustainability and one-stop database, so that life cycle impacts and the interactions among environmental, economic, social, and infrastructure systems can be incorporated in rail planning and management. Freight: Widely recognized that freight activities and economic outputs are intimately connected. Project will strive to develop a tool based on broad assumptions of General Equilibrium of the Economy.

Massachusetts Institute of Technology

Issues researched are inherently interdisciplinary in content and approach. While the field of transportation is advanced, it is done in a context of a deeper understanding of regional economics, land use planning, and other related fields.

Michigan Tech University

Michigan Tech's program has no single discipline, but reaches quite evenly across multiple departments.

University of Tennessee, Knoxville

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

Rose-Hulman Institute of Technology

CE 490 Railroad Eng. is a technical elective and the RHIT AREMA Student Chapter is an opportunity for Civil Eng. 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: The recycled plastic railroad crossties 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. 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.

University of Kentucky

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

Rose-Hulman Institute of Technology

CE 490 RR Engineering is an elective for Mechanical and Electrical Engineering students and the RHIT AREMA Student Chapter is open to all students to learn about the rail industry and careers opportunities.

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

University of Illinois Urbana-Champaign

UIUC taught 4 rail courses in Fall 2013, one of which was a new class, Transportation Safety and Risk. The total enrollment was 129 undergraduate and graduate students including 13 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 of our major research thrusts. Students have access to the 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.

University of Illinois Chicago – CUPPA

The Metra management training project will focus on developing current transportation employees into more effective managers. VC: Graduate students have been and will continue to assist with research and case studies for this project. Rail Safety: Educational tools that provide a better understanding about the risks and impacts of safety at rail crossings will likely be developed and be of use in the training of rail operators, and other stakeholders.

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 presently supports several grad students focusing on transportation careers.

Program also supports the UTK AREMA student chapter, continuing education to improve skills of railway industry workers, and provides railway content to undergrad and grad civil engineering classes.

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

A new laboratory facility is being equipped to support railway research activities involving both civil and mechanical engineering. It will include a full-scale track loading test bed that will allow experimentation and testing of the complete track system (rail, ties and ballast). Operational by Spring 2014.

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 crossies and a collection of different analytical models addressing different aspects of the rail system.

University of Illinois Chicago – CUPPA

Program will 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 Tennessee, Knoxville

The new building housing the Civil/Environmental and Industrial/Systems Engineering Departments opened Fall 2013. A hybrid composite beam has already been moved to the lab for testing. UTK and UK are exploring collaborative geotechnical and materials projects for these new labs.

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.

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 new recycled plastic railroad crossies 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

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

Massachusetts Institute of Technology

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

Michigan Tech University

The first annual Michigan Rail Conference impacts the growth and use of rail transportation in Michigan corridors. This first conference centered on themes in passenger and freight that impact residents in many areas of Michigan. The second conference planning 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

a. Changes in approach and reasons for change

University of Kentucky

Structured light was discovered as a promising technique for the 3D rail crossing sensor, so this was investigated first (not in original plan). This coming year, low cost commercially available sensors (Kinect; Structure Sensor) will be investigated (this was in the original plan).

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

University of Illinois Chicago – CUPPA

VC: Original estimate for finishing final report was the end of January 2014. This will not mark the completion of the report, but will not cause any sort of cost overage.

c. Changes that have a significant impact on expenditures

Nothing to report.

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

Nothing to report.

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

Nothing to report.