

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



National University Rail Center - NURail
US DOT OST-R Tier 1 University Transportation Center

Submitted to
U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology

Grant Period:
30 September 2013 through 30 September 2018

Reporting Period:
1 April 2017 through 30 September 2017

Submitted:
07 November 2017

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Grant: DTRT13-G-UTC52

Duns: 04-154-4081

EIN: 37-6000511

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1. Accomplishments

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

a. What was accomplished under these goals? (major activities; specific objectives; significant results (positive and negative); key outcomes)

NURail Consortium

- Consortium partners wrote six final reports in the past six months and eight project proposals.
- The NURail Center Annual Meeting was held in August 2017 as part of the Midwest Rail Conference. It was held in Kalamazoo, MI and had over 220 attendees.
- Over 45 students from NURail partner schools attended the Railway Interchange conference on September 17 – 19, 2017 in Indianapolis, IN. In addition to competing in the student quiz bowl and attending the poster competition, students also had the opportunity to network with people and companies involved in the rail industry.
- NURail partner universities had a strong showing at the Joint Rail Conference (JRC) held on April 4-7, 2017 in Philadelphia, PA. NURail was responsible for eleven technical papers and two sessions chaired at the conference.
- The American Public Transportation Association (APTA) hosted its second biennial Passenger Railway Engineering Education Symposium (p-REES) on July 10-12, 2017 in Los Angeles, California at the Los Angeles Trade Technical College. P-REES' goal is to encourage engineering faculty to add rail and engineering content to their current courses and curricula. Fifteen to twenty new faculty "students" attended the symposium with several from NURail Center affiliates. Four NURail faculty members, three from the University of Illinois at Urbana-Champaign and one from Michigan Technological University, taught different modules at the symposium.

University of Illinois Urbana-Champaign

- One hundred and nineteen attendees participated in the first Rail Infrastructure and Vehicle Inspection Technology (RIVIT) Conference held on the UIUC campus on June 20 – 21, 2017. Twenty nine states, 7 countries and 29 rail companies were represented at the conference. Conference objectives included improving the effectiveness of existing technologies, development and implementation of new technologies, and presenting research on emerging technologies with the potential to be applied to rail transportation.

- UIUC hosted two William W. Hay Railroad Engineering Seminars. On April 21, Dr. Allan Zarembski from the University of Delaware spoke on “Fundamentals and Selected Technical Issues for High Speed and Heavy Axle Railroad Engineering”. Eric Gehringer from Union Pacific Railroad gave a presentation on “Seven Disciplines of Engineering at Union Pacific Railroad” on April 28.
- Six RailTEC faculty and students travelled to attend the 11th International Heavy Haul Association (IHHA) Conference in Cape Town, South Africa on September 2 – 6, 2017. RailTEC had a total of 11 faculty and student papers and presentations at the conference and some of this research was supported by NURail funding.
- UIUC hosted the NURail Center grant manager, LaChaundra Graham from the USDOT Office of the Assistant Secretary for Research & Technology, for a site visit on Tuesday, July 25, 2017. During the full day of meetings Ms. Graham listened to presentations on research, technology transfer, and education and workforce development projects as well as toured the Newmark Civil Engineering Laboratory and the Research and Innovation Laboratory (RAIL).
- For the fourth straight year, the UIUC AREMA Student Chapter won first place in the Railway Interchange (AREMA) conference quiz bowl. Chen-Yu Lin, a UIUC Ph.D. candidate, was the winner of the student poster competition. Over 25 UIUC students attended this conference in September.
- *Schedule Flexibility and Railway Line Capacity (Line Capacity)* - Results were presented as papers at the 2017 IAROR (April) and IHHA (September) conferences. Additional simulations were conducted to determine the relationship between schedule flexibility, train speed and the distribution of running times on a corridor. These results were developed into a draft paper submitted to TRB in August 2017.
- *Capacity of Hump Classification Yards (Yard Capacity)* - A proof-of-concept simulation model of a single pull-down lead was developed in SIGMA. Input data for the initial factorial experiment (Task 2) was developed and the corresponding scenarios are currently being simulated in YardSYM. Access was regained to the Belt Railway of Chicago hump yard model.
- *Railroad Grade Crossing Micro-Level Safety & Risk Analysis – Phase 2 (Grade Crossing)* - Developed a risk analysis concept and applied it to IL data. Various factors were considered individually and in combination using SAS statistical software and spreadsheet that was developed by the research team. Further analysis is underway to finalize the risk analysis model and prepare a report on the finding. The concept relies on finding accident frequency from the FRA Accident Prediction Model and applying adjustments to due to crossing characteristics to compute the risk.
- *Optimal Planning of Rail Grinding Activities in Large-scale Networks (Rail Grinding)* - Advanced mathematical models and customized solution techniques were developed to optimize scheduling of rail grinding activities in large scale railroad networks. Outcomes from this project have been incorporated into a decision-support system for a Class I railroad so as to help plan resources for its rail maintenance needs. The scientific contributions were documented into a draft paper submitted to the 2018 TRB Annual Meeting (also Transportation Research Record), and a presentation will be delivered at the 2017 INFORMS Annual Meeting.

- *Improving Track Substructure Designs and Settlement due to Complex Dynamic Loads from High-Speed Passenger and Freight Trains (Track Substructure)* - Analyses of rail displacements and forces on tie were conducted using the previously validated analytical track model for both ACELA high speed passenger and freight trains. Mathematical formulations of a 3-Dimensional subgrade soil representation was completed for the analytical track model and it is ready for implementation.
- *Numerical Investigation of Impact Load Effects on Railroad Track Systems (Load Effects)* - Additional field data was analyzed for both light rail and heavy rail transit systems, as well as a commuter rail passenger system. This data was compared to existing data from heavy haul freight systems and passenger data analyzed in previously. WILD data obtained on Amtrak's North East Corridor, for a variety of freight and passenger rolling stock types, was analyzed and included in a summary table.

University of Illinois Chicago

- College of Engineering (COE) - *Coupled Multibody and Finite Element Analysis of Rail Substructure Behavior (Substructure Behavior)* – Model has been applied to vibrations in nearby buildings. Basic model completed and performing mesh refinement studies and studies that the model dimensions are accurate.
- College of Urban Planning and Public Affairs (CUPPA) - There were two reports completed during the reporting period: *Connector Transitway* and *Off Peak Delivery Pilot Project*. The *Transit Value Capture Phase 2* report was completed, but needs final edits.

Massachusetts Institute of Technology

- *Competitive Strategy for the Proposed Texas High Speed Rail Project: A System Dynamics/ CLIOS Process Approach (Texas HSR)* – Thesis completed.
- *HSR Terminals* – Thesis completed.

Michigan Tech University

- *Sawyer International Airport Transportation Improvements* – Completed this undergraduate project.
- *Manistique, MI – Transportation Improvements* - Started a new undergraduate project.
- Presented four papers at the Joint Rail Conference 2017, one at Railway Interchange 2017 and two at the SHRP2 Data Conference.
- Made presentations at RIVIT Conference and at FRA Grade Crossing Workshop.
- Started an undergraduate fellowships for grade crossing research; Darian Reed (CEE) – *Summer Undergraduate Research Fellowship; Valuation of Methods to Record Head Orientation in Driving Simulator and In-Vehicle Study Environments*
- Submitted (and accepted) two papers to TRB Annual Meeting.
- Conducted 2017 Summer Youth Program in Rail and Intermodal Transportation.
- Organized the Inaugural Midwest Rail Conference in Kalamazoo, MI.
- Completed *Life Cycle Assessment (LCA) of Ore Transportation Route/Mode Alternatives for Eagle Mine* research project.

- Supported the organization of Passenger Railway Engineering Education Symposium (pREES).

University of Kentucky

- Developed laboratory test method that serves as a means to calibrate pressure cells that are to be placed in trackbed support layers and developed the test procedure, under controlled loadings similar to in-track loadings using a simulated trackbed, technique to install the cells in an active trackbed.
- Finished and submitted final reports parts one and two (of four) on the *Pressure distributions and magnitudes tie/ballast* project:
 - Asphalt Underlayment Highway/Railway At-Grade Crossings: Designs, Applications, and Long-Term Performance Evaluations. NURail2017-UKY-R12a. 25 pages.
 - Asphalt Underlayment Railway Trackbeds: Designs, Applications, and Long-Term Performance Evaluations. NURail2017-UKY-R12b. 37 pages.

University of Tennessee, Knoxville

- *Laboratory Investigation of Steel Tie Performance (Steel Tie)* - Nearing completion. Prepared papers describing results and one paper was published.
- *Seismic Performance of Stone Masonry and Unreinforced Concrete Railroad Bridge Substructures (Bridge Substructures)* - Team conducting theoretical modeling analysis based on the data from previous experiments. This analysis focuses on the constraint effect of the rail track structure on the displacement behavior of railroad bridge pier top. The purpose of this analytical study is to prepare critical parameters for the following lab testing.

b. How have the results been disseminated?

NURail Consortium

- Between April 1, 2017 and September 30, 2017 the NURail website had over 3,100 unique visits and 7,750 page loads.
- The NURail Center grant manager, LaChaundra Graham from the USDOT Office of the Assistant Secretary for Research & Technology, came for a site visit on Tuesday, July 25, 2017. During the full day of meetings Ms. Graham listened to presentations on research, technology transfer, and education and workforce development projects as well as toured the Newmark Civil Engineering Laboratory and the Research and Innovation Laboratory (RAIL). Presentations were given by both Illinois students and researchers, as well as NURail partners from Michigan Technological University, the University of Illinois at Chicago and the University of Kentucky.

University of Illinois Urbana-Champaign

- Three NURail faculty members from the UIUC taught different modules at the American Public Transportation Association's (APTA) second biennial Passenger Railway Engineering Education Symposium (p-REES), July 10-12, 2017, in Los Angeles, California at the Los Angeles Trade Technical College.

- Six RailTEC faculty and students travelled to the 11th International Heavy Haul Association (IHHA) Conference in Cape Town South Africa on September 2 – 6, 2017. A total of 11 faculty and student papers and presentations at the conference and some of this research was supported by NURail funding.
- *Line Capacity*. A paper describing this research was presented at the International Association of Railway Operations Research conference in April 2017. A second paper describing this research was presented at the International Heavy Haul Association conference in September 2017.
- *Rail Grinding*. A draft paper has been submitted to the 2018 TRB Annual Meeting for presentation (and also to Transportation Research Record for publication), and it will be presented at the 2017 INFORMS Annual Meeting in Houston, TX.
- *Track Substructure*. A paper validating the developed analytical track model was presented at ASCE T&DI ICRT Chengdu 2017 conference event and published in the conference proceedings. A poster presentation describing the NURail2013-UIUC-R10 project was displayed at the Midwest Rail Conference, which took place in Kalamazoo, MI in August 2017.
- *Load Effects*. Results shared with at least three Class I railroads (UPRR, BNSF, and Amtrak) and four transit agencies (St. Louis Metrolink, New York City Transit, Chicago Metra and SEPTA). Presentation given at 2017 Joint Rail Conference in Philadelphia. Journal paper developed and submitted for review focusing on the development of new impact factors prediction equations.
- Webinar given by Dr. Christopher Barkan, NURAIL Director on “Shared Railroad Passenger and Freight Operations: The Challenge of Combining High-Efficiency Freight and Reliable Passenger Rail” on September 21, 2017.

University of Illinois Chicago

- *Substructure Behavior*. One paper in review, results presented at the NURail Annual meeting.
- *Off Peak Delivery*. A news story (with a link to the complete report) was written and shared with a wide range of transportation media, bloggers, MPOs and other relevant audiences. An abstract was posted on UIC’s University Transportation Center (UTC) website.
- *Connector Transitway*. A white paper and an abstract were posted on the UTC website. Short news items were posted on the UTC website News section, and both reports were promoted via social media platforms.

University of Kentucky

- Three technical papers are under review. Two NURail reports under final review.
- JRC 2017 – April 4 - 6 in Philadelphia: *Pressure Measurements at the Tie-Ballast Interface in Railroad Tracks using Granular Material Pressure Cells* – Presentation and Paper in Proceedings of 2017 Joint Rail Conference.
- AREMA – 2017 – September 17-20 in Indianapolis: 1) *Asphalt Railway Trackbed Designs, Applications, and Long-Term Performances* – Presentation and Paper in Proceedings of 2017 AREMA Annual Meeting and 2) *Highway-Railway At-Grade Crossings Designs Containing Asphalt Underlayments* – Presentation and Paper in Proceedings of 2017 AREMA Annual Meeting.

c. What do you plan to do during the next reporting period to accomplish the goals and objectives?

University of Illinois Urbana-Champaign

- *Line Capacity*. Consolidate previous conference papers into a journal paper for submission in Fall 2017.
- *Yard Capacity*. Complete simulations for the initial factorial experiment (Task 2). A presentation on this research will be made at the INFORMS annual meeting in October 2017.
- *Grade Crossing*. Analyze the outcome of the risk analyses concept applied, fine tune it if needed, and prepare a write up about the procedure.
- *Rail Grinding*. Continue efforts on developing new mathematical models and solution techniques for the rail grinding scheduling problem, and continue to collaborate with industry partner to facilitate field implementation. Prepare final report and additional publications from this project.
- *Track Substructure*. Research team will work on improving the current analytical track model by fully implementing the 3-D soil representation, which will consider wave propagation in track substructure due to dynamic train loading. Will prepare a journal paper to include all recent research findings related to analytical track model simulations for submission in spring/summer 2018.
- *Load Effects*. Continue to analyze and disseminate data from transit field and Amtrak WILD sites. Compare data to static design loads of railcars and previously developed metrics for predicting dynamic and impact loads. Ultimately, propose new mode-specific equations for predicting load environment.

University of Illinois Chicago

- *Substructure Behavior*. Will complete the vibrations study and begin studies of settlement at transition zones using a nonlinear model.
- *Transit Value Capture*. Complete Phase 2 of research and develop a communications plan to disseminate the results.

Michigan Tech University

- Continue the research project “*Evaluation of Driver Behavior at Railroad-Highway Grade Crossings Using Naturalistic Driving Study Data*”, co-funded with the Federal Railroad Administration.
- Secure co-funding and initiate two new research projects on “*Remote Rail Temperature Monitoring*” and “*Log Movement in the Superior Region – Rate and Capacity Based Analysis of Modal Share*”.
- Initiate planning for 2018 Michigan Rail Conference and the 2018 Summer Youth Program in Rail and Intermodal Transportation.
- Support planning for the 2018 Railway Engineering Education Symposium (REES).

University of Kentucky

- Further perfecting and checking the procedure and determining the effects of various variables on the pressure magnitudes and distributions in trackbeds.
- JRC – 2018 -- April 18-21, 2018 in Pittsburgh (accepted)
 - “Relationships between Wheel/Rail Surface Impact Pressures and Correspondingly Transmitted Tie/Ballast Impact Pressures for Revenue Train Operations” -- Abstract Accepted , Paper in Preparation.
- TRB 2018 – January 7-11 in Washington (submitted two abstracts)
 - “Development of a Laboratory Test Method for Measuring Trackbed Pressures at the Tie/Ballast Interface” – Accepted as Proceedings Paper TRB Paper 18-00592.
 - “Application of Granular Material Pressure Cells to Measure Railroad Track Tie/Ballast Interfacial Pressures” – Submitted to TRB for Presentation at the 2018 Meeting and Publication.
- NURail Reports
 - “A Laboratory Test Method for Measuring Realistic Trackbed Pressures at the Tie/Ballast Interface”. 2017-UKY-R12c. 20 pages. Nearly finished, anticipate November.
 - “In-Track Railway Track Tie/Ballast Interfacial Pressure Measurements Using Granular Material Pressure Cells”. 2017-UKY-R12d. 26 pages. Nearly finished, anticipate November.

University of Tennessee, Knoxville

- *Bridge Substructures*. Team plans to conduct small shaking table testing and large-scale pseudo-static loading test.
- *Steel Tie*. Team will prepare the project report.

2. Products

a. Journal publications:

University of Illinois Urbana-Champaign

- Xie, S., Lei, C. and Ouyang, Y. “Optimal routing and scheduling of maintenance vehicles in railroad networks.” *Transportation Research Record*. Under review.

University of Kentucky

- TRB 2018 Paper "Application of Granular Material Pressure Cells to Measure Railroad Track Tie/Ballast Interfacial Pressures" has been accepted as Journal Paper. TRB Paper 18-00593.

University of Tennessee, Knoxville

- Song, W., Shu, X., Huang, B., Sun, Y., Gong, H. and Clarke, D. (2017). “Pressure Distribution under Steel and Timber Crossties in Railway Tracks.” *Journal of Transportation Engineering, Part A: Systems*, 143(9), 04017046: 1-10.

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

NURail Consortium

NURail partners completed six final reports. They are:

- Burton, M.L. and D.B. Clarke. “The Impact of Reduced Coal Consumption on the Southeastern Railroad Network”, NURail 2013-UTK-R08, final report.
- Edwards, J.R. and M.S. Dersch, “Mechanistic Design of Concrete Crossties and Fastening Systems – Phase 1”, NURail 2014-UIUC-R11, final report.
- Andrawes, B. “Modeling the Lateral Load Distribution for Multiple Concrete Crossties and Fastening Systems”, NURail2014-UIUC-R09, final report.
- Hidema, T. and J.M. Sussman, “Competitive Strategy for the Proposed Texas High Speed Rail Project: A System Dynamics/ CLIOS Process Approach”, NURail2017-MIT-R05, final report.
- Saat, M.R. “Development and Teaching of a Graduate Course in Multimodal Transportation Safety and Risk”, NURail2013-UIUC-E03, final report.
- Oommen, T. and P. Lautala. “Rail Embankment Stabilization Needs on the Hudson Bay Railway”, NURail2013-MTU-R08, final report.

c. Other publications, conference papers and presentations:

University of Illinois Urbana-Champaign

- Edwards, J.R., A. Cook, M. Dersch, M. Csenge, Y. Qian, and A. Canga. 2017. Quantification of Impact Factors: Results from Rail Transit Systems. Presented at the 2017 Joint Rail Conference (JRC), Philadelphia PA, April 2017.
- Mussanov, D., N. Nishio and C.T. Dick. 2017. Delay Performance of Different Train Types Under Combinations of Structured and Flexible Operations on Single-Track Railway Lines in North America. In: Proceedings of the International Association of Railway Operations Research (IAROR) 7th International Conference on Railway Operations Modeling and Analysis, Lille, France, April 2017.
- Mussanov, D., N. Nishio and C.T. Dick. 2017. Building Capacity Through Structured Heavy Haul Operations on Single-track Shared Corridors in North America. In: Proceedings of the 11th International Heavy Haul Association (IHHA) Conference, Cape Town, South Africa, September 2017.
- Hou, W., Tutumluer, E., Huang, H., Boler, H. and D. Mishra. 2017. Analytical Model of Ballasted Track Bridge Approach Validated with Field Measurements. Presented and Published in the Proceedings of the ASCE T&DI International Conference on Rail Transportation (ICRT), Southwest Jiaotong University, Chengdu, China, July 10-12 2017.
- Hou, W. and E. Tutumluer. 2017. Analytical Model of Ballasted Track under Complex Dynamic Loads. Poster presentation at the Midwest Rail Conference, Kalamazoo, MI. August 15-17, 2017.
- Xie, S., Lei, C. and Ouyang, Y. Optimal Routing and Scheduling of Maintenance Vehicles in Railroad Networks. To be presented at the 2018 INFORMS Annual Meeting, Houston, TX.

- Xie, S., Lei, C. and Ouyang, Y. Optimal Routing and Scheduling of Maintenance Vehicles in Railroad Networks. Submitted for presentation at the 2018 Transportation Research Board Annual Meeting, Washington DC.
- Webinar given by Dr. Christopher Barkan, NURAIL Director, on “Shared Railroad Passenger and Freight Operations: The Challenge of Combining High-Efficiency Freight and Reliable Passenger Rail” on September 21, 2017.

University of Illinois Chicago

- Masurekar, S., C.D. Foster and A.I. El-Ghandour. “3D FEM and MBS Coupling of Railroad Dynamics with Vibration of Surrounding Building Structures” Midwest Rail Conference. August 15-17, 2017. Kalamazoo, MI.

Michigan Tech University

- Lautala P., Nelson, D., Dean, A. and M. Muhire. Evaluating Driver Compliance at Highway-Rail Grade Crossings, Railway Interchange, Indianapolis, IN, September 17-20, 2017.
- Dean, A., Lautala, P. and D. Nelson. Effectiveness of Using SHRP2 Naturalistic Driving Study Data to Analyze Driver Behavior at Highway-Rail Grade Crossings, ASME/ASCE/IEEE 2017 Joint Rail Conference, Philadelphia, PA, April 4-7, 2017.
- Oduru, S. and P. Lautala. Incorporating Life Cycle Assessment (LCA) in Freight Transportation Infrastructure Project Evaluation, ASME/ASCE/IEEE 2017 Joint Rail Conference, Philadelphia, PA, April 4-7, 2017.
- Muhire, M., Lautala P., Nelson, D. and A. Dean. Selection of Representative Crossings Database for the Evaluation of Driver Behavior Over Highway-Rail Grade Crossings, ASME/ASCE/IEEE 2017 Joint Rail Conference, Philadelphia, PA, April 4-7, 2017.
- Deilamsalehy, H. Havens, T. and P. Lautala. Sensor Fusion of Wayside Visible and Thermal Imagery for Rail Car Wheel and Bearing Damage Detection, ASME/ASCE/IEEE 2017 Joint Rail Conference, Philadelphia, PA, April 4-7, 2017.

University of Kentucky

- TRB 2018 Paper "Development of a Laboratory Test Method for Measuring Trackbed Pressures at the Tie/Ballast Interface" has been accepted as Proceedings Paper. TRB Paper 18-00592.
- JRC 2018 Paper "Relationships between Wheel/Rail Surface Impact Pressures and Correspondingly Transmitted Tie/Ballast Impact Pressures for Revenue Train Operations" has been accepted as Conference Proceedings Paper. JRC 2018-6184.

University of Tennessee, Knoxville

- Rose, J.G., Clarke, D.B., Liu, Q. and Watts, T.J., “Development of a Laboratory Test Method for Measuring Trackbed Pressures at the Tie/Ballast Interface”, submitted to the 2018 Transportation Research Board Annual Meeting, July 31, 2017.
- Rose, J.G., Clarke, D.B., Liu, Q. and Watts, T.J., “Application of Granular Material Pressure Cells to Measure Railroad Track Tie/Ballast Interfacial Pressures”, submitted to the 2018 Transportation Research Board Annual Meeting, July 31, 2017.

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

University of Illinois Urbana-Champaign

- NURail Center website:
<http://www.nurailcenter.org/index.php>

University of Illinois Chicago

- *Connector Transitway* report featured on Chicago Central Area Committee website:
<http://ccac.org/wp-content/uploads/2016/10/Consolidated-Connector-PDF.pdf>

Massachusetts Institute of Technology

- Regional Transportation Planning and High Speed Rail Research Group:
<http://web.mit.edu/hsr-group/index.html>

Michigan Tech University

- Midwest Rail Conference:
<http://www.rail.mtu.edu/event/mrc2017>
- 2017 Summer Youth Program Web site:
<http://rail.mtu.edu/event/rail-and-intermodal-transportation-2017>

e. Technologies or techniques:

Michigan Tech University

- Developed automated processing methodology to extract data from SHRP2 Naturalistic Driving Study database and to use it for creation of “compliance score” at grade crossings.

f. Inventions, patent applications and/or licenses:

Nothing to report.

g. Other products (i.e. databases, audio/video products):

Michigan Tech University

- Database of 10,000+ grade crossing traversal parameters from the SHRP2 data.

3. Participants and Other Collaborating Organizations

a. What other organizations have been involved as partners?

Organization or University Name	Location	Contribution to the Project	Name (First and Last)
Amtrak	Philadelphia, PA	In-Kind support, provision of WILD data	Steven Melniczuk
MetroLink	St. Louis, MO	In kind Support, access to infrastructure f/ experimentation	Chuck Clemins
MTA New York City Transit Authority	New York, NY	In kind support, access to infrastructure for experimentation	Antonio Cabrera
Union Pacific Railroad	Chicago, Metra	In Kind Support, Access to infrastructure f/ experimentation	Antonio Buelna
Univ. of Kentucky	Lexington, KY	Collaboration	Dr. Jerry Rose
Norfolk Southern Corporation	Knoxville, TN	Test site and field support	Mr. Les Hall
Federal Railroad Administration	Washington, DC	Co-funded project	Starr Kidda
Michigan Dept. of Transportation	Lansing, MI	Co-organizer of Midwest Rail Conf.	Nikkie Johnson
Sawyer International Airport	Marquette, MI	Senior Design sponsor	Steve Shanton
Marquette County	Marquette, MI	Senior design advisor	Eric Anderson
Eagle Mine	Marquette, MI	Graduate Research project support	Matt Johnson
University of Wisconsin-Superior	Superior, WI	Co-organizer of Summer Youth Program	Richard Stewart
Norfolk Southern Corp.	Mascot, TN	Provide Test Site and In-Kind assistance	Philip Merilli
CSX Transportation	Jacksonville, FL	Cost-match, expert knowledge, data support, field implement	Kamalesh Somani
Masdar Institute of Science and Technology	Abu Dhabi, UAE	Complementary Funding for related research on HSR	Prof. Rita Sousa
JR East	Tokyo, Japan	Complementary Funding for related research on HSR	Masaki Ogata, Vice Chairman
Belt Railway of Chicago	Chicago IL	In-kind support of base case for yard simulations	Nick Chodorow
Dr. Hai Huang	Penn State Altoona		
Chicago Central Area Committee	Chicago	Let Connector Transitway research	Ed Zotti
Supply Chain Innovation Network, CDOT, IDOT, CMAP and others	Chicago	Support to Off Peak Delivery research	

b. Additional collaborators:

Name (First and Last)	Company, University, Organization Name	Location	Contribution to the Project
Dr. Quinglie Liu	East China Jiaotong University	Nanchang, PRC	Collaborator on tie project
David B. Clarke	Center for Transportation Research	University of Tennessee, Knoxville	Funding
Ed Zotti	Chicago Central Area Committee	Chicago	Led research and drafted final report

4. Impact

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

University of Illinois Urbana-Champaign

- *Yard Capacity.* Terminal capacity constraints are a major issue for the railroads. With major investments in new hump yard projects underway, design and sizing of new yards and terminals is a growing need for the rail industry. Research on interaction between yard and mainline capacity will allow railroad practitioners to make better capital investment decisions to maximize the overall capacity of the rail network through properly balanced investments in mainline and yard projects.
- *Grade crossing.* Project study directly supports USDOT Strategic Goals on safety. Findings will help improve safety at highway-railroad crossings. Indirectly supports USDOT Strategic Goals of Economic Competitiveness and Livable Communities by improving safety and reducing delay for motor vehicles and trains, as well as making grade crossing areas safer for the people living in the area.
- *Load Effects.* Project supports DOT goals for safety and state of good repair by providing a better understanding of how railroad track components may deteriorate and from that identifying areas where designs can be improved to mitigate high impacts loads entering the track structure.
- *Rail Grinding.* Field implementation of the project outcome at our partnering Class 1 railroad showed significant efficiency improvements and cost reductions. In a recent year, we were able to help the company save 40% of the resource waste (e.g., grinder deadheading), and improve the amount of productivity (i.e., total rail miles grinded) by over 20%.

University of Illinois Chicago

- *Substructure Behavior.* Vibration analysis will help determine whether buildings in different situations could be subject to significant vibrations from passing trains. In the case that they are, the models could be used in the design and evaluation of techniques to reduce vibrations in nearby buildings, improving occupant comfort and potentially the life of the system.

- *Connector Transitway*. Whitepaper addressed the fundamental planning components required to advance the proposed central area transit connector line: Identifying the challenge, citing the service area of the proposed transit line, proposing funding sources, and stating the next steps required – approval from the public and land owners.
- *Off Peak Delivery*. Study presented research and implementation options to consider and adopt strategies and methods to shift more deliveries to off-peak times. Benefits include: reduced congestion, greater efficiency, and lower emissions.

Michigan Tech University

- Student projects continue to change the principles how we educate our students.
- Summer Youth Program has had a positive effect on student recruitment.

University of Kentucky

- Final reports (parts 1 and 2 of 4) represent Consensuses of Practices for the Developments and Applications of the two Asphalt Trackbed Technologies which are immediately useful to the RR industry.
- Forthcoming final reports (parts 3 and 4 of 4) will represent Developments of New Technologies, one for laboratory tests and the other for in-track tests – also immediately useful to the RR industry, but also available for additional studies determining effects of various factors influencing trackbed pressures. Additional NURail reports for this study will be forthcoming until the end of NURail. These will include information on the trackbed pressures in excess of that in the research plan.

b. What is the impact on other disciplines?

University of Illinois Chicago

- *Substructure Behavior*. Developing numerical models that can be applied to a variety of dynamic systems including coupled finite element and multibody problems. Other applications specifically include vehicle/soil interaction and geotechnical modeling for soil structure interaction.
- *Connector Transitway*. The Connector would help Chicago’s central area continue to meet transit demands of the growing downtown employment and permanent residential populations.
- *Off Peak Delivery*. Study serves as a foundation for future efforts by interested Chicago organizations.

Michigan Tech University

- Most activities (student projects, rail conference, summer youth program) are designed for multiple disciplines.

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

University of Illinois Chicago

- *Substructure Behavior*. Project is working with one research student.
- *Connector Transitway*. Connector would help Chicago's central area continue to meet transit demands of the growing downtown employment and permanent residential populations.
- *Off-Peak Delivery*. New positions could be created for carriers, receivers, shippers, customers and within the community to launch and maintain an off-peak delivery (OPD) program.

Michigan Tech University

- Total of 30 civil engineering and surveying students are involved in the completed and on-going undergraduate student projects.

University of Tennessee, Knoxville

- *Steel Tie*. Part of a Ph.D. dissertation in Dr. Baoshan Huang's group is based on the results from this study.

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

University of Illinois Chicago

- *Substructure Behavior*. Developing modeling techniques that can be used with other partner institutions or others to evaluate vibration-damping options.
- *Connector Transitway*. Whitepaper provided the initial "first step" in the planning process for the proposed 14-mile grade separated rail line.
- *Off-Peak Delivery*. Organizations in metropolitan Chicago now have a resource that can lead to development of an OPD pilot and perhaps more encompassing program.

e. What is the impact on technology transfer?

University of Illinois Chicago

- All research completed on the Connector Transitway and Off-Peak Delivery projects will remain in the public domain through the news story and abstract/complete reports posted on the UTC website. Any inquiries related to these reports will be followed up promptly.

Michigan Tech University

- Midwest Rail Conference had over 30 technical presentations and panel discussants.

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

University of Illinois Urbana-Champaign

- Proper investments in mainline and yard capacity allow railroads to operate more efficiently, lowering supply chain costs and improving reliability of the transportation system, to the economic benefit of society.
- *Grade Crossing*. Indirectly supports the USDOT Strategic Goals of Economic Competitiveness and Livable Communities by improving the safety and reducing delay for motor vehicles and train, as well as making the grade crossing areas safer for the people living in the area.
- *Rail Grinding*. Directly supports the USDOT Strategic Goals of Economic Competitiveness and Safety; enhanced grinding efficiency improves the safety and efficiency of railroad operations that are important for our society and economy.

University of Illinois Chicago

- *Substructure Behavior*. Vibration analysis will increase occupant comfort in buildings near railways. Ultimately, can evaluate the most efficient and economical tools for mitigating vibrations.
- *Connector Transitway*. This paper could be the catalyst to initiate a new public transit system to help Chicago manage growth in the central area and enhance mobility.
- *Off-Peak Delivery*. Study may build awareness among business and civic leaders for the potential value of an OPD program in terms of improved efficiency and reduced congestion. These stakeholders will need to encourage OPD and lobby city officials to make it a priority.

Michigan Tech University

- Midwest Rail Conference is an avenue for larger understanding of rail transportation and attracts participants from outside industry.

5. Changes/Problems

a. Changes in approach and reasons for change

University of Tennessee, Knoxville

- *Steel Tie*. Team has experienced difficulty in instrumenting the steel crossties in a manner that permits accurate in-service pressure measurements. The tie configuration and size do not permit installation of the pressure cells in a manner that permits field tamping of the ballast. These problems were examined in the laboratory and successfully solved for timber crossties, as verified by in-service testing. It is unlikely that the original objective of examining field performance of steel crossties can be achieved given budget and time constraints, but the findings from timber crosstie measurements are extremely useful.

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

Nothing to report.

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.