

3rd 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

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

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1. Accomplishments

Efforts within the NURail Center have been focused on appropriately and responsibly spending any remaining funds from NURail's original grant (number DTRT12-G-UTC18) that expire on January 31, 2016 before dipping into NURail's second grant (number DTRT13-G-UTC52) which expires on September 30, 2017. While some professors and researchers are beginning to use funding from the second grant, it is in the early stages of projects and there are few accomplishments, publications or other products that can be attributed to these expenditures.

a. What was accomplished under these goals?

University of Illinois Urbana-Champaign

- New full-semester graduate-level course on Railway Terminal Design and Operations was developed and delivered to 23 students in Fall 2014. Creation of the course required development of: twenty-five 90-minute lectures, ten homework assignments, two design assignments using MicroStation and a large integrated group classification yard design project spanning the entire semester.
- During winter 2014-15, simulation work continued to investigate the interaction between mainline and terminal capacity. This work is still in progress.

University of Illinois Chicago

Improving Track-Bridge Interaction Using Recycled Plastic Crossties –

- Tested mechanical performance of recycled plastic cross-ties in the lab and with computer simulations.
- Beginning to simulate their performance in various bridge designs.

Computational Ballast and Soil Models to Improve Track Transition Design –

- Updated coupled rail/substructure simulations to fully capture deformation of soil for postprocessing.
- Adapted nonlinear viscoplasticity model for modeling ballast and subgrade materials.

3D Visualization of Rail Vehicle-Track Interaction –

- Created a PC implementation of 3D visualization procedures for rail vehicle and infrastructure dynamics and their interactions.
- Adapted for the PC platform a program originally engineered to run on the Electronic Visualization Laboratory's CAVE2 virtual reality environment.

Vehicle/Track Interaction –

- Continued work on enhancing vehicle/track interaction simulation models based on multibody system algorithms.
- Worked with other UIC co-PI's on developing new models for rail vehicles interacting with finite element tracks and visualizing the numerical results.

Michigan Tech University

- Completed negotiations with MI Department of Transportation for matching funds and projects to be completed under the grant. Secured a contract and started first project and coordination for 3rd Michigan Rail Conference.

University of Kentucky

3D methodology for evaluating rail crossing roughness - continuation:

- Kinect Sensor is developed and ready for testing, but not yet validated.
- Mounted structured light sensor on a high-rail vehicle and collected data.
- Developed software to merge individual 3D images captured by the sensors.
- Software now available for testing.
- Acquired database of field inspection data from the KYTC.

Educational Materials Development:

- Multimodal class notes and PowerPoints developed.
- REES modules prepared and delivered in 2014.
- Kentrack 2014 software updated.
- Selected class PPT voice overs completed.
- Tech brief prepared.

Evaluate changes in track behavior at transition zones:

- Constructed test bed in conjunction with the University of Tennessee (UTK) in the John D Tickle Structures Lab.
- Acquired track panel section and railroad car truck from Norfolk Southern.
- UTK installed a load frame, UKY installed pressure sensors, and UIUC began to analyze the test bed with accelerometers and high speed cameras.
- UKY acquired permission and conducted tests on an operating railroad, TTI in Paris, KY. For that test, a locomotive was used to introduce dynamic loads while UK and UIUC researchers made measurements in situ.

Pressure distributions and magnitudes at the tie/ballast interface:

- Conducted preliminary tests on trackage of TTI, a shortline railroad.

Implementation of a rail crossing condition index:

- Collected ten 3D profiles of Kentucky rail highway grade crossings using LiDAR.
- Made acceleration measurements for a variety of vehicles, crossings and speeds in preparation for development of a crossing performance index.

University of Tennessee, Knoxville

- Full-scale impact testing of HCB was conducted at the end of PPPR reporting period. Results were outstanding and fully met expectations of research team and assembled guests.

b. How have the results been disseminated?

University of Illinois Urbana-Champaign

- Lectures and assignments in the Railway Terminal Design and Operations course have been delivered to the students enrolled.

University of Illinois Chicago

- Close to reporting that software for rail wheel-track-infrastructure 3D visualization has been transferred to UK.

University of Kentucky

3D methodology for evaluating rail crossing roughness - continuation:

- One refereed conference paper produced. (See below.)

Educational Materials Development

- REES 2014 Modules were presented.
- Liu, S., R. Souleyrette and J. Rose, “Kentrack 4.0: A Revised Railway Structural Design Program,” *Proceedings of the 93rd Annual Meeting of TRB*, Washington, DC, Jan. 2014.
- Rose, J. S. Liu, and R. Souleyrette, “Kentrack 4.0: A Railway Trackbed Structural Design Program,” *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, CO, April 2-4, 2014.

Pressure distributions and magnitudes at the tie/ballast interface:

- One journal paper produced. (See below.)

Implementation of a rail crossing condition index:

- Brett Malloy produced a Masters report on the subjects.
- Malloy, B., J. Rose and R. Souleyrette, “Rehabilitation, Assessment and Management Practices to Ensure Long-Life, High Performance Highway-Railway At-Grade Crossings,” *Proceedings of the 2014 Joint Rail Conference*, Colorado Springs, CO, April 2-4, 2014.
- Professor Jerry Rose produced four KYTC crossing reports published by KTC.

University of Tennessee, Knoxville

- Despite the early stage of the projects, several conference papers addressing interim results were prepared and presented.

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

University of Illinois Urbana-Champaign

- Pending railroad data availability, work will continue on mainline and terminal capacity interaction project over the summer. Project team aims to complete a journal/conference paper on this project during summer 2015.

University of Illinois Chicago

Dynamic Modeling of Railroad Vehicles and Vehicle-Track Interaction.

- Mechanical Engineering Department will begin to spend NURail 2013 funds to pay research assistants for further work on the above goals, previously pursued under earlier NURail funding.

Improving Track-Bridge Interaction Using Recycled Plastic Crossties.

- Continue to use laboratory results for recycled plastic crossties as inputs into various computer simulations, including use of plastic ties in high-speed rail bridge design.

Computational Ballast and Soil Models to Improve Track Transition Design.

- Couple the new nonlinear viscoplasticity model for the rail track and substructure with Mechanical Engineering's vehicle dynamics model. This should help model the dynamics of train transitions from ballasted track to bridges in order to understand issues of ride quality and possible derailments.

3D Visualization of Rail Vehicle and Track and Infrastructure Dynamic Simulations.

- Complete PC adaptation of the EVL CAVE2 visualization of rail vehicle and infrastructure dynamic data so it is ready to be shared with other NURail partners for both research and teaching. Plan to attempt to transfer this to partners.

University of Kentucky

3D methodology for evaluating rail crossing roughness – continuation:

- Complete collection of 3D surfaces for comparison to LiDAR, write report and publish paper from student's dissertation.

Educational Materials Development

- Continue to refine and add to class notes and slides.
- Present at upcoming Passenger Rail Education and Engineering Symposium.

Evaluate changes in track behavior at transition zones:

- Continue work with UIUC and UTK on full scale test bed and in field on operating railroads to collect and analyze data.
- AREMA and TRB papers are planned.

Pressure distributions and magnitudes at the tie/ballast interface:

- Continue work with UIUC and UTK in the lab on full scale test bed and in field on operating railroads to collect and analyze data.
- Additional AREMA and TRB papers are planned.

Implementation of a rail crossing condition index:

- Develop the crossing index.
- Compare the index with existing ratings from the KYTC.
- Work with the KYTC to implement it for this year's crossing survey.

University of Tennessee, Knoxville –

- Work on all projects will proceed as scheduled.

2. Products

a. Journal publications:

University of Kentucky

- McHenry, M., M. Brown, J. LoPresti, J. Rose, and R. Souleyrette, "The Use of Matrix Based Tactile Surface Sensors to Assess the Fine Scale Ballast-Tie 1 Interface Pressure Distribution in Railroad Track," Accepted for Publication in *Transportation Research Record (TRR), Journal of the Transportation Research Board*.

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

University of Tennessee, Knoxville

- Mitchell, C.A., "Design and Construction of a Full-scale Lateral Impact Testing Facility," MS Thesis, University of Tennessee Knoxville, Dec. 2014.

c. Other publications, conference papers and presentations:

Massachusetts Institute of Technology

- HSR as Transit: The Continuing Transportation-driven Evolution of Metropolitan Form Westrom, R., Sussman, J.M. Presentation: Transportation Research Forum, Atlanta GA (March 11-14, 2015).
- Analysis of Capacity Pricing and Allocation Mechanisms in Shared Railway Systems: Lessons for the Northeast Corridor Peña-Alcaraz, M., Sussman, J.M. Presentation: Transportation Research Forum, Atlanta GA (March 11-14, 2015).
- Analyzing the Financial Relationship between Railway Industry Players in Shared Railway Systems: The Train Operator's Perspective. Levy, S., Peña-Alcaraz, M., Prodan, A., Sussman, J.M. Presentation: Transportation Research Board 94th Annual Meeting, Session 362 Intercity Passenger Rail Transportation Research (January 12, 2015) Paper: Included in conference compendium as TRB 15-1697; Accepted for publication in Transportation Research Record (issue pending).
- Capacity Challenges on the San Francisco Peninsula Corridor Levy, S. NURail Shared Rail Corridor, UIUC Hay Seminar (April 17, 2015).
- Impact of institutional relationships on hub stations: A case study of Penn Station,

NYC Heywood, R. Joint Rail Conference, San Jose (March 2015).

- Capacity Challenges on the San Francisco Peninsula Corridor – How Local Decisions have Statewide Impacts Levy, S. Joint Rail Conference, San Jose (March 2015).

University of Kentucky

- Wang, T., R.R. Souleyrette, D. Lau, A. Aboubakr and E Randerson. “Quantifying Rail-Highway Grade Crossing Roughness: Accelerations and Dynamic Modeling.” *Proceedings of the 94th Annual Meeting of TRB*, Washington, DC, Jan. 2015. 11 pages.
- Rose, J. G., Stark, T.D., Wilk, S. T., and M. Purcell, “Design and Monitoring of Well-Performing Bridge Transitions”, *Proceedings of the 2015 Joint Rail Conference*, Colorado Spring, CO, March 23-26, 2015.

University of Tennessee, Knoxville

- H. Li, M. Jin, and S. He, “Sequencing and Scheduling in Railway Classification Yards,” 94nd Annual Meeting of the Transportation Research Board, Washington, DC, January 2015.
- Wang, Xin, Khattak, A.J., Liu, Jun, and Clarke, D.B., “Non-crossing Rail-Trespassing Crashes in the Past Decade: A Spatial Approach to Analyzing Injury Severity”, 94nd Annual Meeting of the Transportation Research Board, Washington, DC, January 2015.

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

Massachusetts Institute of Technology –

- Continue to update and maintain the MIT HSR website: <http://web.mit.edu/hsr-group/index.html>

Michigan Tech University –

- Launched website for 3rd Michigan Rail Conference.

e. Technologies or techniques:

University of Kentucky –

- Kentrack 4.0 software update

f. Inventions, patent applications and/or licenses:

None

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

University of Illinois Urbana-Champaign

- CEE 598 RTD Railway Terminal Design and Operations course materials.

University of Kentucky –

- Several class presentations with voice-over and some recorded technical presentations

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)
Michigan Dept. of Transp.	Lansing, MI	Matching funds	Nikkie Johnson
Highland Copper	White Pine, MI	Research Data	Carlos Bertoni
JR East	Tokyo	Financial Support	
ICA Engineering	Brentwood, TN	Technical assistance	Carter Bearden
UIUC	Kentucky, Alabama and Tennessee	Video and accelerometer analysis	Prof Tim Stark and students
Univ. of Kentucky	Lexington, KY	Collaborator	Dr. Jerry Rose
Norfolk Southern	Atlanta, GA	Materials donation	
HC Beam, Inc.	Chicago, IL	Test specimen, technical support	John Hillman, Mike Zicko, Robert Kuhlke
Southern Shores Development	Knoxville, TN	Test site	Chris Burkhart, JD Wallace
Britton Bridge, LLC	Knoxville, TN	Test assistance	Jerry Britton
TTCI	Pueblo, CO	Technical assistance	Duane Otter
Mega Machinery, Inc.	Knoxville, TN	Test assistance	Megan Dyer
Narstco	Midlothian, TX	Technical assistance	
UIUC	Kentucky, Alabama and Tennessee	Video and accelerometer analysis	Prof Tim Stark and students
UTK	Tennessee	Full scale test facility development and use	Prof Baoshan Huang, Prof David Clarke, and students

b. Additional collaborators:

Name (First and Last)	Company, University, Organization Name	Location	Contribution to the Project
Dean Hollingsworth	Self (FRA ret.)	Ten Mile, TN	Education support

Shingli Xia	Beijing Jiaotong Univ.	Beijing, PRC	Collaborator
Sam Carter	CSX RR	Jacksonville, FL	Advisor
Jeremiah Dirnberger	CSX Transportation	Jacksonville FL	CEE 598 RTD semester design proj. development, in-kind support
Rupy Sawhney	UTK, Ind. Engr.	Knoxville	Collaborator
Richard Bennett	UTK, Civil Engr.	Knoxville	Collaborator
Asad Khattak	UTK, Civil Engr.	Knoxville	Collaborator
Xin Wang	UTK, Civil Engr.	Knoxville	Collaborator

4. Impact

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

University of Illinois Urbana-Champaign

- Railway Terminal Design & Operations course fills the demand for graduates with skills in developing new intermodal, port and hump yard facilities. This is a unique course not taught elsewhere in North America.

University of Kentucky

- Impacts include expansion of knowledge about the relationship between loads and subsurface stresses as well as applications of 3D and acceleration measurement technologies.

University of Tennessee, Knoxville

- Research being conducted on steel crosstie/ballast interaction and the innovative HC Beam can directly translate into the expanded use of these materials in the industry.

b. What is the impact on other disciplines?

University of Kentucky

- Use of 3D sensing technology is an electrical engineering innovation and has applications in many fields including engineering, medicine, agriculture and energy production to name a few.

University of Tennessee, Knoxville

- Unclear at present.

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

University of Illinois Urbana-Champaign

- Railway Terminal Design & Operations course helps fill the demand for young transportation professionals with a breadth of knowledge that spans all facets of rail industry engineering and operations, and not just the infrastructure design of mainline tracks. The course compliments other advanced track and rail vehicles courses being developed or recently taught for the first time at UIUC.

University of Kentucky

- Producing BS, MS and PhD students who are ready for the workforce, additional education, or academia.

University of Tennessee, Knoxville

- Held continuing education classes addressing topics in railroad track inspection, bridge inspection, and track maintenance that produced nearly 5,000 contact hours of instruction.
- University classes in railroad operations and railroad simulation modeling were in progress during Spring 2015.

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

University of Kentucky–

- Development of the full scale testing lab at UTK enhances the physical infrastructure of that university.

University of Tennessee, Knoxville

- Research is making active use of new state-of-the-art research labs in the John D. Tickle Engineering Building.
- Facilities are also being used by our collaborators at the University of Kentucky.

e. What is the impact on technology transfer?

University of Kentucky

- Several reports, tech briefs, conference papers and journal papers have been cited and used by others in academia and in the practice.

University of Tennessee, Knoxville

- Significant findings from the research activities are incorporated into the UTC education products and activities.
- Presented in conference presentations and papers.

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

University of Illinois Urbana-Champaign

- Properly designed rail yards and terminals operate more efficiently, lowering supply chain costs and improving reliability of the transportation system, to the economic benefit of society.

University of Kentucky

- More efficient and safer transportation facilities.

University of Tennessee, Knoxville

- Difficult to state with any certainty at this point.

5. Changes/Problems

a. Changes in approach and reasons for change

None

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

Michigan Tech University

- Contract with MDOT slightly delayed, but should be now on schedule.

University of Kentucky

- Has been much more difficult than originally anticipated to calibrate the dynamic simulation model and develop merged images from the 3D scanners.

University of Tennessee, Knoxville

- Railroads have been reluctant to provide information on specific bridges due to security concerns.
- Research team has resorted to published information in various sources to gather information on typical pier designs.

c. Changes that have a significant impact on expenditures

None

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

None

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

University of Kentucky

- Use of TTI and other operating railroads and UTK's full-scale test facility was not originally anticipated. However, this has been fortuitous for the projects.