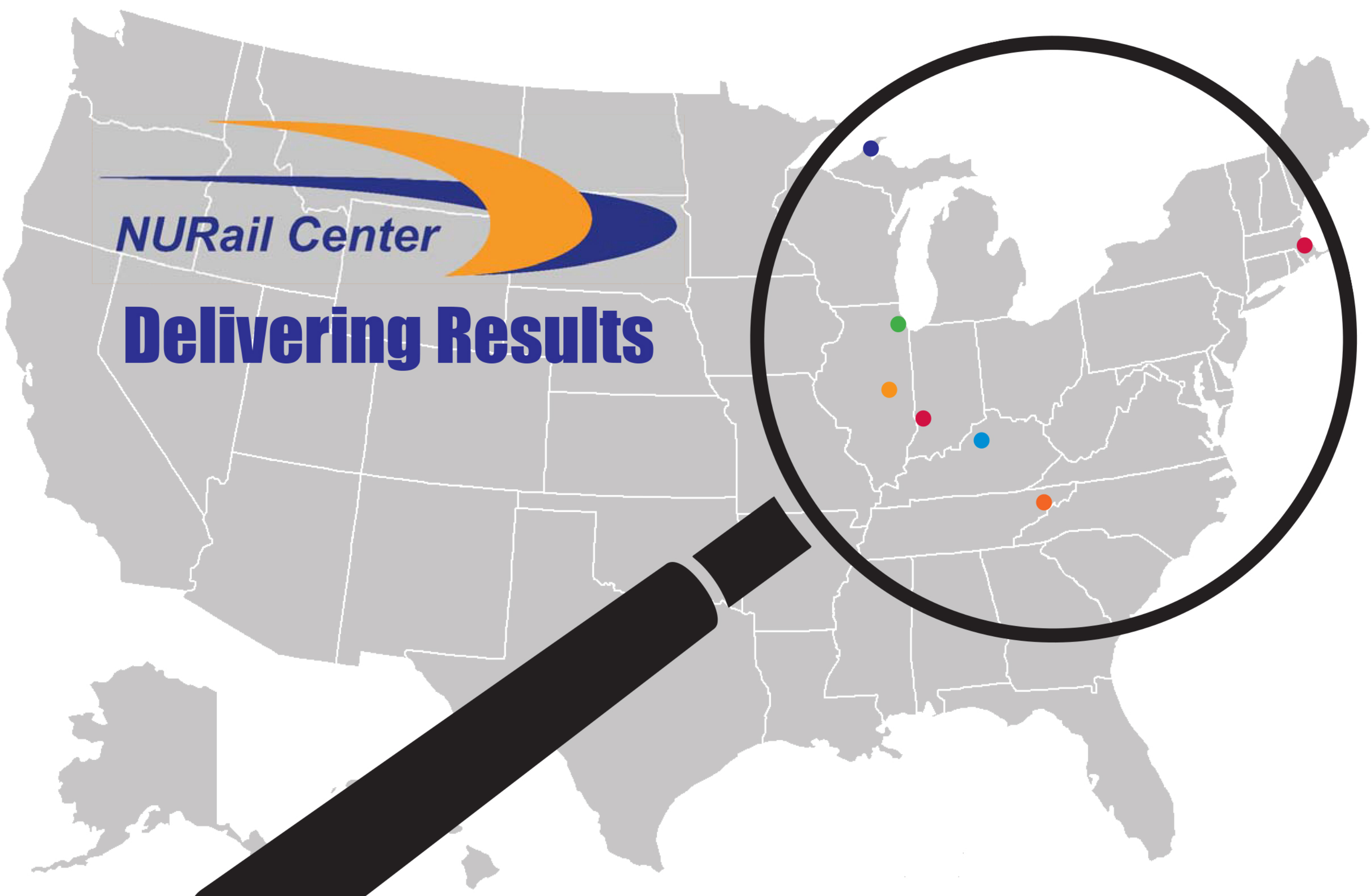
Presentation Booklet
National University Rail Center
2015 Annual Meeting



University of Illinois at Urbana-Champaign
University of Illinois at Chicago
Massachusetts Institute of Technology
Michigan Technological University
University of Kentucky
University of Tennessee, Knoxville
Rose-Hulman Institute of Technology

Rail Focused US DOT OST-R Tier 1 University Transportation Center

Theme: Delivering Results
Wednesday, June 3

8:30am	Tour of Metra/Amtrak Operations Center – Preregistration Required (Jody Plahm, UIC, and Greg Godfrey, Amtrak)	
9:30am	Tour of Metra/Amtrak Operations Center – Preregistration Required (Jody Plahm, UIC, and Greg Godfrey, Amtrak)	
11:00am - 7:00pm	Registration	
1:00pm - 1:30pm	Student Leadership Council meeting Tyler Dick, UIUC (Moderator)	
1:00pm – 1:30pm	NURail Affiliate Member Presentation Pasi Lautala, Michigan Tech (Moderator) Dimitris Rizos, University of South Carolina (Moderator)	5
1:30pm – 3:00pm	Technical Advisory Committee discussion Conrad Ruppert, UIUC (Moderator)	
3:00pm – 3:15pm	Break	
3:15pm – 4:30pm	Improving Student Placement in Rail Industry Discussion/Workshop David Clarke, UTK (Moderator)	21
4:30pm – 5:30pm	SDP breakouts/workshop 1. Vehicle - Track Interaction Conrad Ruppert, UIUC (Moderator) 2. Safety and Risk Rapik Saat, UIUC (Moderator) 3. Network Capacity Planning David Clarke, UTK (Moderator) 4. Urban, Regional and HSR Passenger & Funding and Economic Development Stephen Schlickman, UIC (Moderator) Joseph Sussman, MIT (Moderator) 5. Multimodal Freight Transport Reginald Souleyrette, UK (Moderator)	
5:30pm - 6:00pm	SDP Wrap-up Conrad Ruppert, UIUC (Moderator)	
6:00pm	Reception and Poster Session	

6:15pm	3-Minute Thesis Competition	
	Conrad Ruppert, UIUC (Moderator)	
	1. Sandeep Sasidharan	23
	"Infrastructure-less Indoor Navigation System"	
	2. Sam Levy	24
	"Capacity Challenges on the California High-Speed Rail Shared Corridors"	
	3. Hamed Pouryousef	25
	"Hybrid Optimization of Train Schedules (HOTS) Model"	
	4. Samantha Chadwick	26
	"Predicting Derailments at Highway-Rail Grade Crossings"	
7:00pm	Dinner and Keynote Address	
	Keynote Speaker:	
	Dr. Mitra Dutta	
	Vice Chancellor for Research, Distinguished Professor	
	Electrical and Computer Engineering Department, UIC	

Thursday, June 4

6:30am - 9:00am	Registration	
7:00am - 7:30am	Breakfast	
7:30am – 7:45am	Welcoming Remarks	
	Ahmed Shabana, UIC, and Steve Schlickman, UIC	
	Christopher Barkan, NURail Center Director, UIUC	
7:45am – 8:30am	Education Showcase: NURail Graduates in Action	
	Placement statistics (NURail and non-NURail students)	27
	Additional Student Testimonials	29
	Pasi Lautala, Michigan Tech (Moderator)	
	Student Testimonials and Panel Discussion	
	Michael McHenry, UK/TTC	
	Brandon Van Dyk, UIUC/Vossloh	
	Marcella Bondie, UIC-CUPPA	
	Joel Carlson, MIT/Consultant	
	Garrett Fullerton, UIUC/CN	
	Ahmed Aboubakr, UIC-COE/Gamma Technologies	
8:30am – 9:30am	Research Showcase – Part 1	
	Conrad Ruppert, UIUC (Moderator)	

	Vinaya "Vinny" Sharma, Sharma & Associates
	Michael Franke, Amtrak
1:45pm	Closing Remarks
	Christopher Barkan, NURail Center Director, UIUC
1:50pm	General Public Adjourn
2:00pm - 2:30pm	Executive Advisory Board Members – Closed Session
2:00pm - 2:30pm	NURail Principal Investigators Meeting
2:30pm - 4:00pm	Executive Advisory Board with NURail Partners – Closed Session

NURail Affiliate University Program

Presented by:

Dr. Dimitris C. Rizos
Chair of NURail Affiliate Universities 2014-2015
Director of Advanced Railway Technology Group, U. of South Carolina

NURail Annual Meeting 2015
Chicago IL
June 3-4, 2015

Outline

- Background
- Report on group activities/accomplishments
- Highlights of education activities at affiliate institutions
- Highlights of research activities at affiliate institutions
- Student impact

Background

"As part of our efforts to broaden the NURail Center's impact, we will create a NURail Affiliates program involving faculty from other colleges and universities."

- Recognition as university with railway related activities
- Networking
- Resource sharing opportunities
- Research and education collaborative opportunities
- Participation in Annual Meeting, workshops, seminars and conferences
- Visits to campuses,In-person meetings, teleconferences and webinars.

Slide 3

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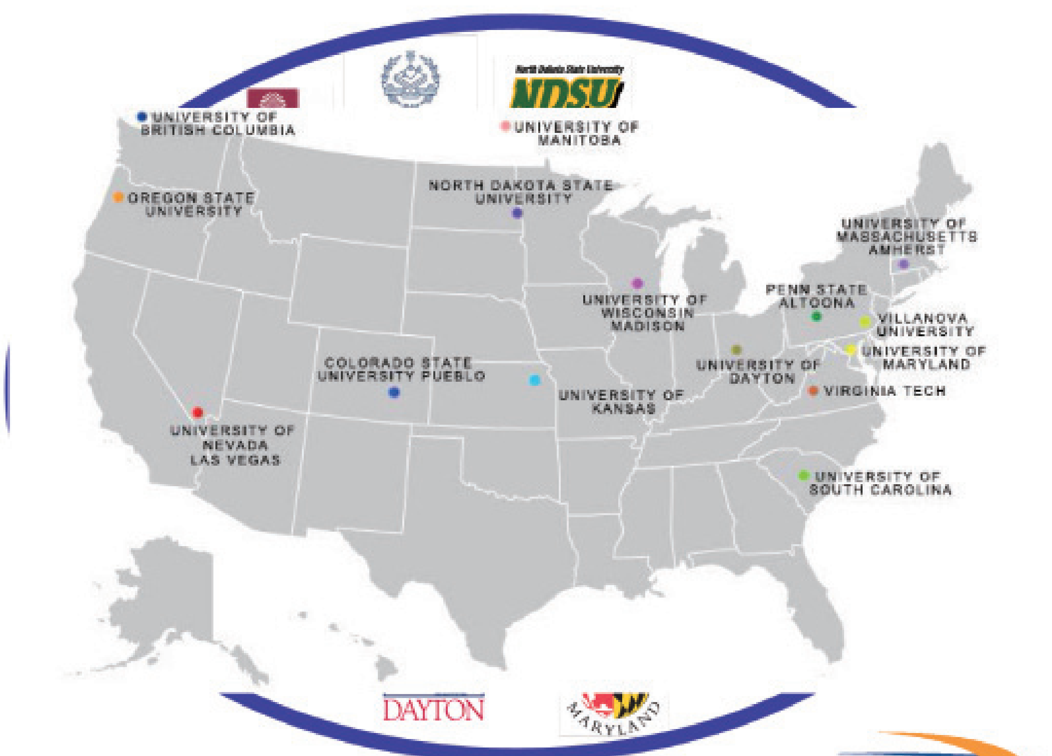

Slide 4

NURail Center

Outline

– Background
– Report on group activities/accomplishments during the first year
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Report on Activities

- **Bylaws**
- **Affiliates web page**
  http://www.nurailcenter.org/about/affiliate-members.php
- **Support letter to affiliates**
  - Recognition, support and statement of collaboration.
  - Signed by NURail EAB and Leadership
- **NURail affiliates meetings:**
  - The group met primarily via phone conferencing.

Report on Activities

- **Process to accept/decline new membership applications**
  - Simple process, encourages new members to join, and facilitates the growth of the group.
  - On-line application form https://docs.google.com/forms/d/1vnOUC0p17lOPOc8okaO1xjXbbGfhm7WXWw9Mku298CA/viewform
- **Annual reporting to maintain membership**
  - Report activities and efforts for the current year, and plans for the following year by June 30. Send three reminders of the report due date and suspend membership if report is not submitted.
- **Funding avenues for research and education activities:**
  - Form partnerships among affiliate members and NURail partners for any opportunities. Share education and research resources and facilities. Discussion to continue…

Slide 7

NURail Center

Report on Activities

- **Research and Education Database (under development)**
  - Course inventory (under development)
  - Inventory of graduates / resume book (under development)
  - Railway research resource inventory (specialized lab equipment, software and capability)
  - Inventory of research projects by the Universities
  - Participation in Strategic Development Plans (SDP).

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Challenges

- Rail industry is perceived as a low-tech industry by higher administration at academic institutions and does not necessarily align with the strategic plans. Consequently, there are limited institutional resources and low awareness/interest in investing in the development of rail programs.
- Marketing/advertising of academic programs in rail engineering
- Availability of teaching material (textbooks etc)
- Lack of coordinated/standard curriculum in railroad engineering
- Set of skills a graduate should possess to be competitive in the pursue of employment (Differences between Rail companies and other companies catering to the rail industry)

NURail Center

Outline

– Background

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NURail Center

Education by Numbers

Institution	Faculty	Courses	Empl	Degrees	AREMA	Rsrch
Colorado State – Pueblo						
North Dakota State	3	1 (35-40)	(n/a)	in plan	in plan	Y
Oregon State	2	2 (40)	1+	-	10	Y
Penn State – Altoona	4	8 (n/a)	9	BS	30	Y
U British Columbia	1	1 (6)		-	Y	Y
U Dayton						
U Kansas						
U Manitoba	1	1+	3+	-	~25	Y
U Maryland	4	2 (44)	5+	-	N	Y
UMass – Amherst						
U Nevada – Las Vegas	10+	6 (60+)	(n/a)	in plan	Y	Y
U South Carolina	4+	7 (70+)	14+	MS/ME/PhD	~38	Y
U Wisconsin – Madison	3	11* (40)	(n/a)	-	~5	Y
Villanova University						
Virginia Tech						

*Continuing Education Courses – No credit

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Education by Numbers

Institution	Intro to RR Eng/ Planning	Track	Opera-tions	Signals	Capstone Project	Other
Colorado St. Pueblo						
North Dakota State	O					
Oregon State	O					O
Penn State Altoona	O	O	O	O	O	O
U British Columbia	O					
U Dayton						
U Kansas						
U Manitoba	O		O			O
U Maryland	O					O
UMass Amherst						
U Nevada LV	O	O	O			O
U South Carolina	O	O	O	O	O	O
U Wisc. Madison	O	O	O	O		O
Villanova University						
Virginia Tech						

Slide 12

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Outline

– Background
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Research

- Funding Sources
  – Federal Railroad Administration
  – USDOT – RITA
  – State DOTs
  – National Science Foundation
  – Private Industry
  – etc

NDSU Rail Projects: 2014

Regional railroad infrastructure needs

- Requested by Legislature; funded by NDDOT
- 1,210 miles of regional rail line in ND (35%)
- 82% of miles with rails < 100 lb/yd
- $471 million to rehabilitate
- Legislature appropriated $7 million

CE456/656 student projects

- Detailed rehabilitation plan for 18-mile line
- NPR contributed resource time/data/field work

NDSU Rail Projects 2015

Grade crossing traffic hazard forecasting model

- 20-year forecasts of traffic at crossings
- Enhanced hazard forecasting model
- Optimization/selection programming

ITS approach to railroad infrastructure performance evaluation

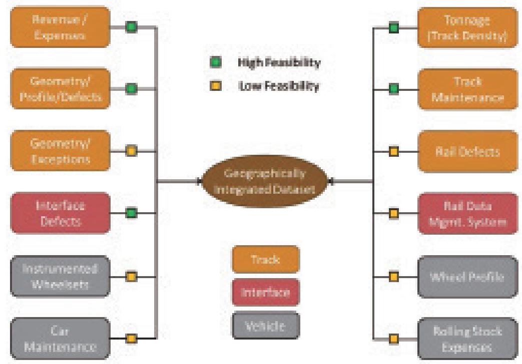
- Inertial sensing with smart phone applications

U Manitoba

University of Manitoba

A Conceptual Framework for Geographic Linking of Wheel-Rail Interaction Data

Linking existing wheel-rail interaction data to support proactive maintenance planning, asset management, productivity, and safety



Research generously supported by:

ARM ADVANCED RAIL MANAGEMENT (CANADA) INC

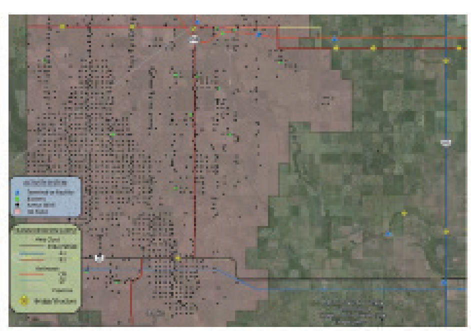
NSERC CRSNG

U Manitoba

University of Manitoba

Characterizing Freight Traffic Related to Southwest Manitoba's Petroleum Sector

Providing an interactive, map-based information system about petroleum-related freight traffic to support engineering design, planning, and management decisions



Research generously supported by:

Manitoba Infrastructure and Transportation

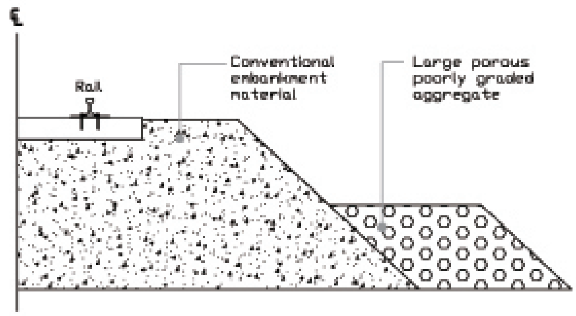
NSERC CRSNG

U Manitoba

University of Manitoba

Roadbed Stability in Areas of Permafrost and Discontinuous Permafrost

Synthesizing international best practices in the mitigation of rail roadbed stability problems in permafrost regions



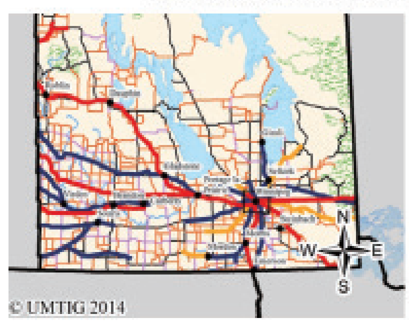
Research generously supported by:
Transport Canada – Surface – Prairie and Northern Region

U Manitoba

University of Manitoba

Atlas of Manitoba's Freight Rail Network and Operations

Compiling publicly available data on Manitoba's freight rail operations to create a resource for the physical features, rail user demand, and flow characteristics of the network



Research generously supported by:

NSERC CRSNG

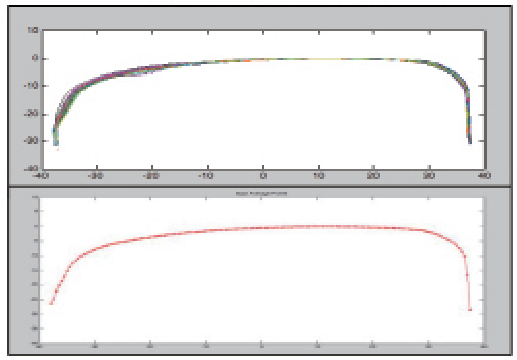
University of Manitoba

U Manitoba

UNIVERSITY OF MANITOBA

A Repeatable Procedure to Determine a Representative Average Rail Profile

Developing a method for calculating a representative average rail profile for a track segment to support infrastructure maintenance programs and planning



Research generously supported by:

ADVANCED RAIL MANAGEMENT (CANADA) INC

NSERC CRSNG

Penn State - Altoona

PENNSTATE Altoona

Field Investigation & Modeling of Track Substructure Performance under Trains Moving at Critical Speeds

sponsored by the Federal Railroad Administration.

An Automated System for Rail Transit Infrastructure Inspection

sponsored by the U.S. Department of Transportation/Research and Innovative Technology Administration

U of British Columbia

EMISSION ZERO - HYBRID ELECTRIC LOCOMOTIVE POWER (EZ-HELP)

- Innovative alternative technologies and practices to power locomotives that will reduce (eliminate) air emissions in the rail sec-tor, investigating:
  - 1. Zero emission, all-electric power, Locomotive systems technology that in-cludes different on/off-board energy sources, on-board storage elements, and hybrid power drive optimization configurations.
  - 2. Systems monitoring and control, including Data management to optimize the use of these different energy source and storage, and power drive tech-nologies, and maximize train range and productivity.
- Evaluation of different infrastructure interfaces between all-electric locomotives and off-board to on-board electric power transmission technologies to Optimize Railway Operations, including double-stacked trains

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U. of Maryland

- **Phased Development of Transportation Facilities,** Mid-Atlantic University Transportation Center, Dec. 2012 – Aug. 2015.
- **Estimating the Economic Impacts of Multimodal Transportation Improvements,** Maryland State Highway Administration, Oct. 2013 – Dec. 2015.
- **Efficiency and Reliability in Freight Transportation Systems,** USDOT through the National University Transportation Center for Economic Competitiveness, Oct. 2013 – Sep. 2017.
- **Market Opportunity Assessment for the Eastern Shore Short-Line Rail in Maryland,** Maryland Department of Transportation, April –Sept. 2015.

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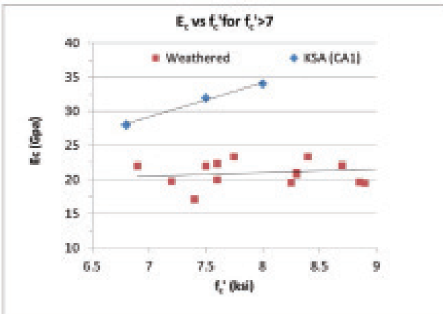
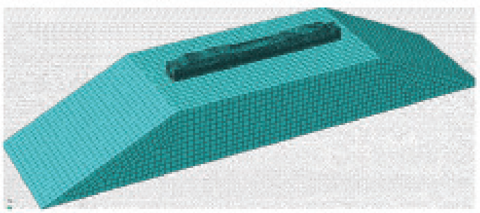
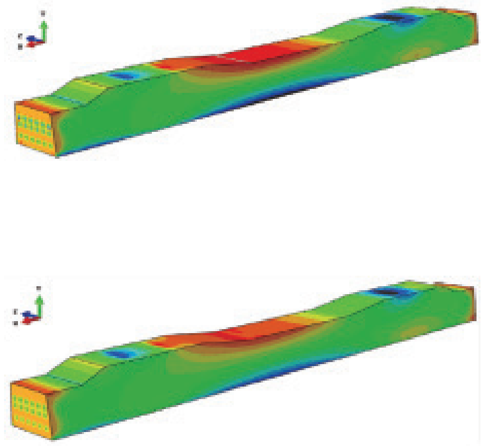
NURail Center

U of South Carolina

Prestressed Concrete Tie Technology: High Strength Reduced Modulus HPC
Federal Railroad Administration

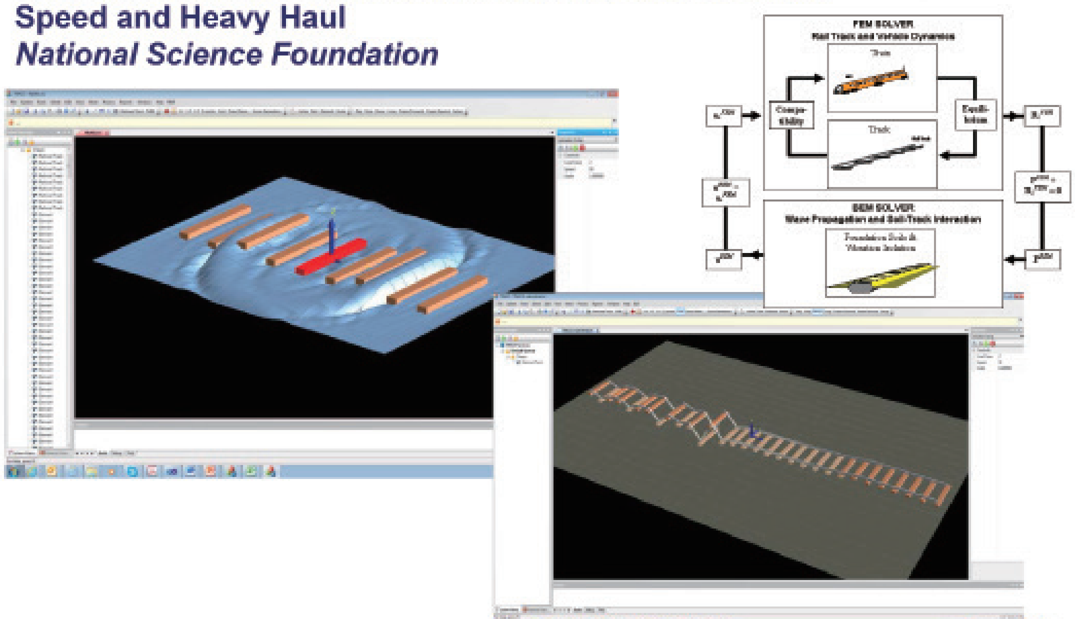






U of South Carolina

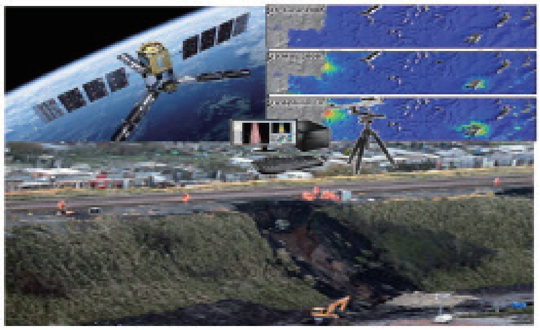
Railway Dynamics: Train-Track-Soil Interaction for High Speed and Heavy Haul
National Science Foundation



U of South Carolina

Digital Image Correlation Techniques for Railroad Applications: Railroad Infrastructure Failure Identification through Satellite Imaging

Advanced Railroad Technology Group & USC



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U of Wisconsin - Madison

Increasing rail freight loads with strategic injections of polyurethane into ballast layers.

Sponsored by National Center for Freight & Infrastructure Research and Education.

TRB NCRRP 06-01Building and Retaining Workforce Capacity for the Railroad Industry.

Responsible for developing a Competency Model for railroad professionals in the engineering and operations disciplines.

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Outline

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Student Impact

Institution	Faculty	Courses	Empl	Degrees	AREMA	Rsrc h
Colorado State – Pueblo						
North Dakota State	3	2 (35-40)	n/a	in plan	in plan	Y
Oregon State	2	2 (40)	1+	-	Y (10)	Y
Penn State – Altoona	4	8	9	BS	Y(30)	Y
U British Columbia	1	1 (6)		-	Y	Y
U Dayton						
U Kansas						
U Manitoba	1	1+	3+	-	Y (~25)	Y
U Maryland	4	2 (44)	5+	-	N	Y
UMass – Amherst						
U Nevada – Las Vegas	10+	6 (60+)	(n/a)	in plan	Y(n/a)	Y
U South Carolina	4+	7 (70+)	14+	MS/ME/PhD	Y (~38)	Y
U Wisconsin – Madison	3	11* (40)	(n/a)	-	Y (~5)	Y
Villanova University						
Virginia Tech						

*Continuing Education Courses – No credit

Slide 30

NURail Center

Student Impact

- AREMA Scholarships
  - *Relative low number compared to available scholarships*
- Undergraduate student involvement in rail related research
- AREMA Student Chapters
  - *Volunteer work*
  - *Invited Speakers*
  - *Field Trips*

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National University Rail Center

THANK YOU!

"This project was supported by the National University Rail (NURail) Center - a US DOT RITA University Transportation Center"

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

Slide 32

Workshop: Improving Student Placement in Rail Industry

June 3, 2015, Moderated by:

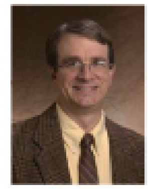
Dave Clarke – University of Tennessee, Knoxville

Pasi Lautala

Michigan Tech

David Clarke

The University of Tennessee Knoxville



Tyler Dick

Illinois Railroad Engineering Program

James McKinney

Rose-Hulman Institute of Technology

Dimitris Rizos

Advanced Railroad Technology Group
Civil & Environmental Engineering

1

NURail Center

Workshop Format

- Six groups (check your group number)
- One discussion topic per workshop round
- Each topic has three questions
- 8-minute internal discussion at each table
- Reconvene: 15-minute breakdown per topic
  - 2 minutes per table to report results
  - Wrap-up

2

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Discussion Questions

- Recruiting and Interacting with Students
  - How can the industry make the most of **on-campus career fairs/special events**?
  - What are other **recruitment approaches/tools/resources/activities** to consider beyond career fairs?
  - What are the best channels and strategies for effective and timely **communication** with candidates?
- Making Railroad Industry the Preferred Destination
  - How to **improve visibility** before education and career choices are made?
  - What are the positives of industry and **how are they (should be) promoted**?
  - What can the rail industry realistically do to **compete for talented students** with Google, airlines, automotive manufacturers, international design-build firms etc.?
- Retaining the Next Generation
  - How can universities **help find students** and direct to correct subfield in industry (railroad, consultant, manufacturer, DOT, etc.) that fits their goals and lifestyle?
  - How can we **take advantage of technology** to help with work-life balance and job satisfaction while in the rail industry?
  - What makes people stay/leave their job...and **what can we do to keep them**?

3

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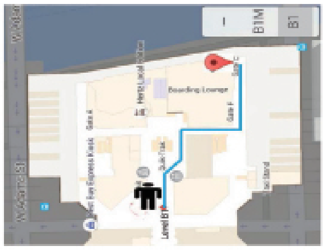
National University Rail Center

INFRASTRUCTURE-LESS INDOOR NAVIGATION SYSTEM

Sandeep Sasidharan, Ouri Wolfson, Primary grant support: NURail Center



WALKING DIRECTIONS

- Walk straight 5m and turn slightly right
- In 5 m, turn right
- In 8 m, turn left
- Walk 10 m straight and your destination will be on the right

Problem Statement and Motivation

- GPS does not work indoors
- Valuable services like navigation, indoor parking assistance, location based services are not feasible
- High deployment and maintenance cost of infrastructure based indoor positioning systems
- Low accuracy of popular Wi-Fi based infrastructure-less systems

Technical Approach

- Generating the digital map from building floor plan blueprint
- Constructing the user trajectory by computing rotation and translation vectors from the basic smartphone motion sensors
- Estimating the user location and providing voice guidance to the destination by matching the trajectory of the user with geometry of the building floor plan using Machine Learning techniques

Key Achievements and Future Goals

- A fully digitized indoor map was created from the floor plan of an indoor parking garage (test location)
- An android based smartphone application for indoor location identification and navigation was developed integrating the digital map and motion sensor outputs
- Future goal is to enhance the accuracy of the localization employing map matching and machine learning techniques

UIC COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS AT CHICAGO

National University Rail Center

Capacity Challenges on the California High-Speed Rail Shared Corridors

How Today's Local Decisions have Statewide Impacts

Sam Levy, Graduate Research Assistant, MIT

MIT Regional Transportation and HSR Group
Research Advisor: Professor Joseph M. Sussman

NURail Annual Meeting 2015
Three Minute Thesis Competition
Chicago, IL
June 2, 2015

Slide 1

Implementation of the future California Rail Network

Challenges

- CHSR is a tenant railroad on three key sections (~100 miles) of corridor
- CHSR will be competing with spatially and temporally with commuter and freight rail
- Integration with commuter rail is a critical component of the CHSRA's business plan

Conclusions

- The ... d ... nds
- Local ... sio ... ss
- A private ope ... a ri ... s rules

Slide 2

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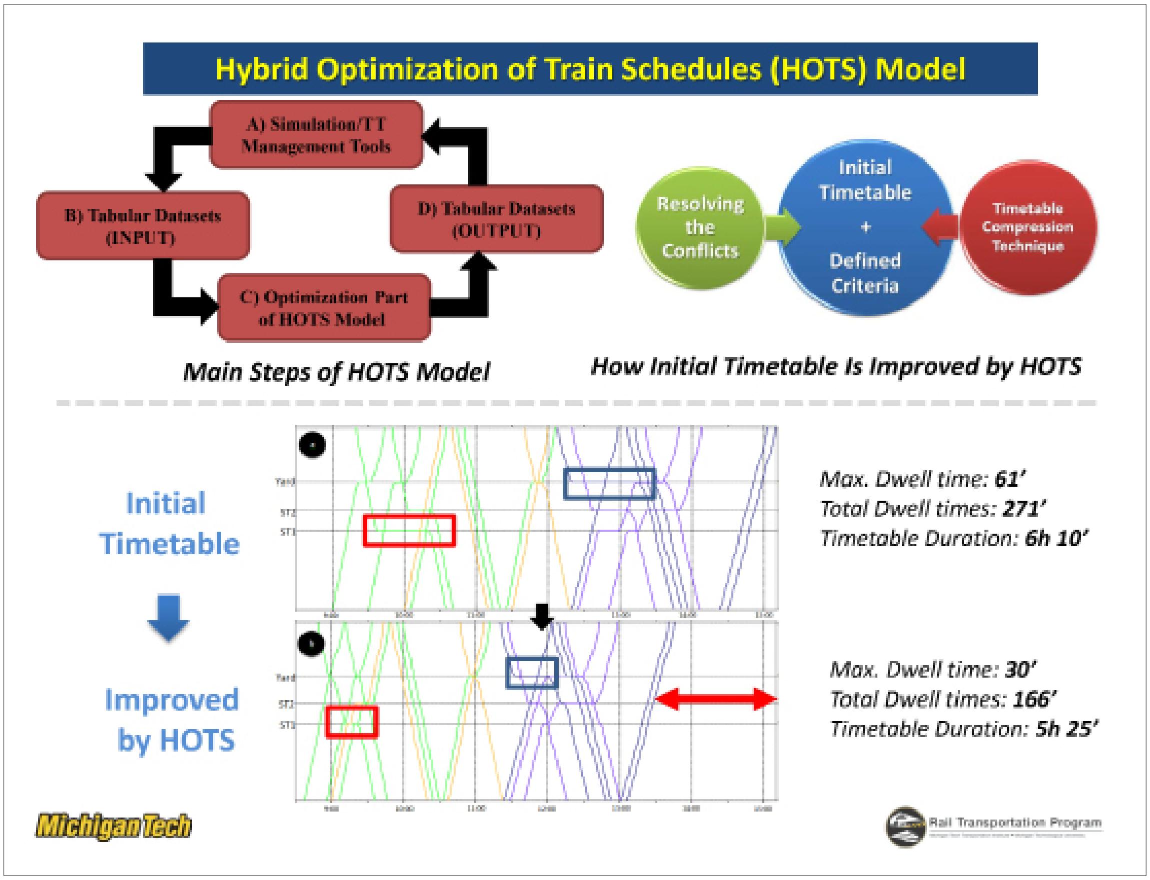
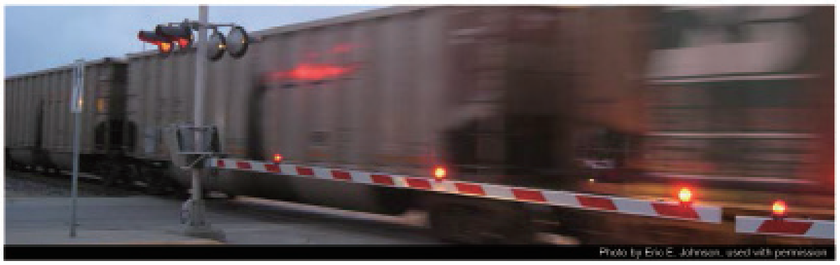


Hybrid Optimization of Train Schedules (HOTS) Model
A) Simulation/TT Management Tools
B) Tabular Datasets (INPUT)
C) Optimization Part of HOTS Model
D) Tabular Datasets (OUTPUT)
Main Steps of HOTS Model
Resolving the Conflicts
Initial Timetable + Defined Criteria
Timetable Compression Technique
How Initial Timetable Is Improved by HOTS
Initial Timetable
Improved by HOTS
Yard
ST2
ST1
Max. Dwell time: 61'
Total Dwell times: 271'
Timetable Duration: 6h 10'
Max. Dwell time: 30'
Total Dwell times: 166'
Timetable Duration: 5h 25'
Michigan Tech
Rail Transportation Program

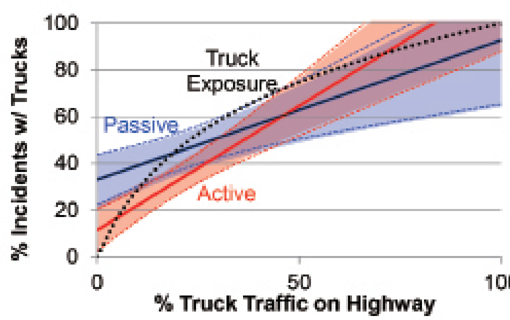
Predicting Derailments at Highway-Rail Grade Crossings



Samantha G. Chadwick, M. Rapik Saat & Christopher P. L. Barkan
Rail Transportation and Engineering Center (RailTEC)
University of Illinois at Urbana-Champaign

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Predicting Derailments at Highway-Rail Grade Crossings



P(D|I) Calculator

Enter Crossing Factors

Posted Highway Speed Limit*	35	mph
Timetable Speed*	45	mph
* values must be greater than 0		
Grade Crossing Type	Other Active	
Percent Truck Traffic	8	(0-100)

Results

Probability of Derailment	0.000380

Derailment likelihood: a new way to quantify and rank risk at highway-rail grade crossings

Education Showcase – NURail Graduates in Action

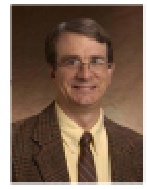
June 4, 2015, Moderated by:
Pasi Lautala, Michigan Tech

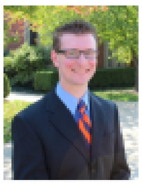
Pasi Lautala

Michigan Tech
Create the Future

David Clarke

The University of Tennessee UT Knoxville



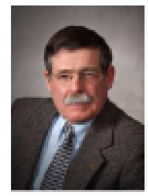


Tyler Dick

Illinois Railroad Engineering Program

James McKinney

Rose-Hulman Institute of Technology



Dimitris Rizos

Advanced Railroad Technology Group
Civil & Environmental Engineering

Slide 1

NURail Center

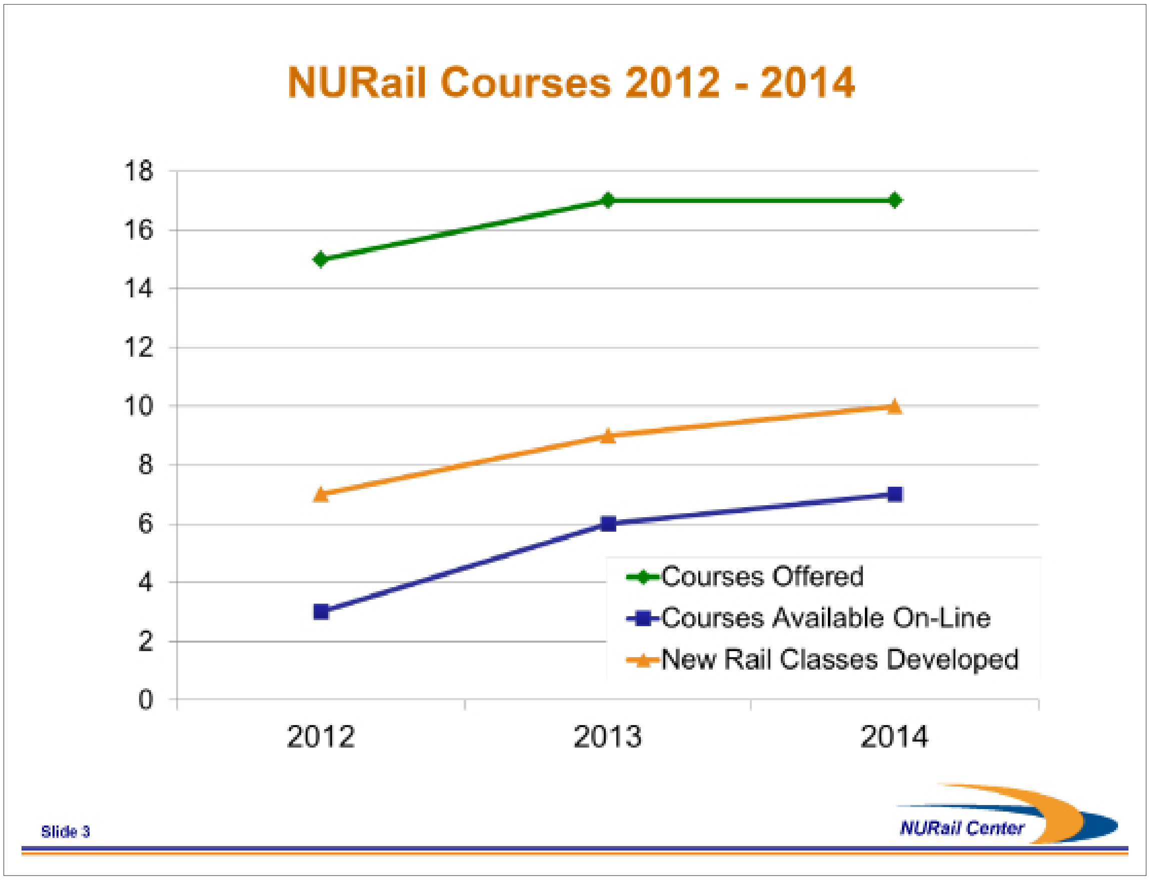
NURail Objectives

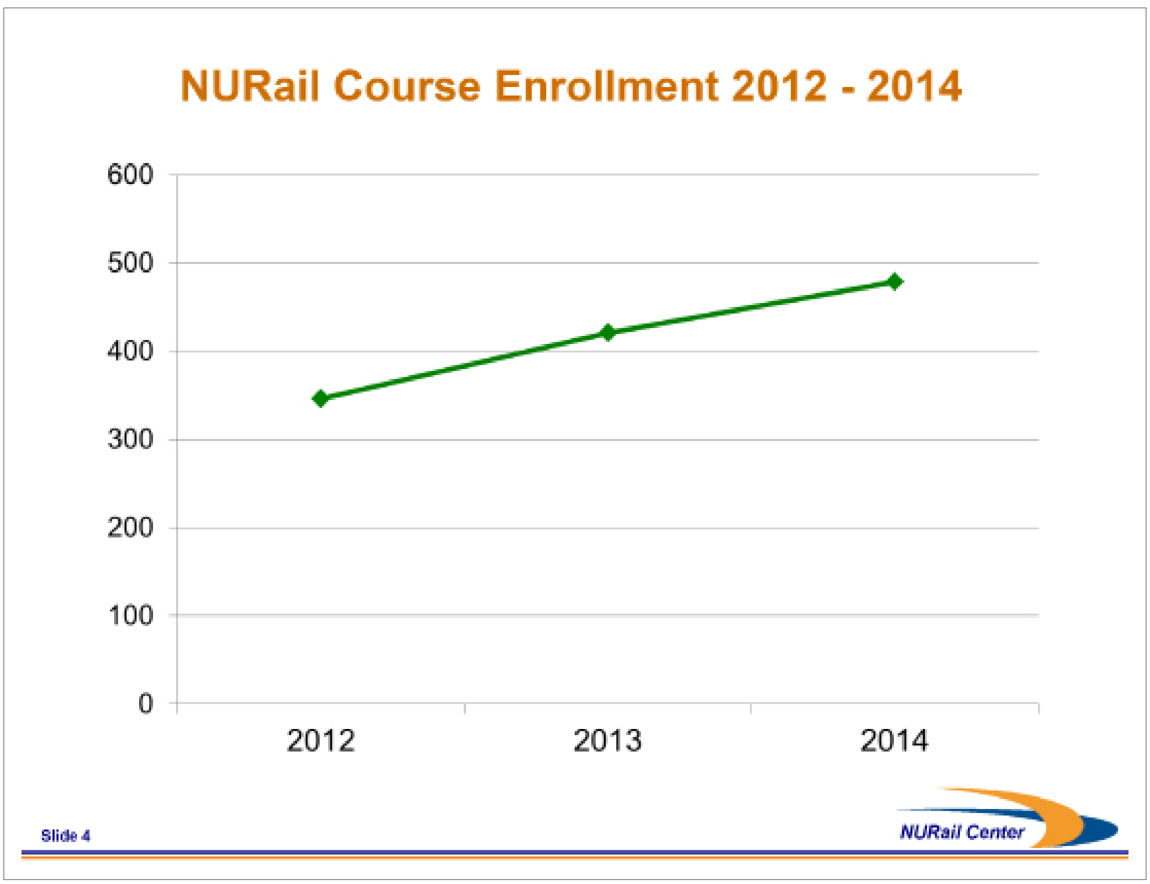
"The NURail Center mission includes outreach to a wide range stakeholders with the goal of developing the railway workforce of the future"

- Education
  - Expand and improve railway engineering and transport education in North America
  - Engaging and encouraging new faculty interest
  - Inspiring student interest

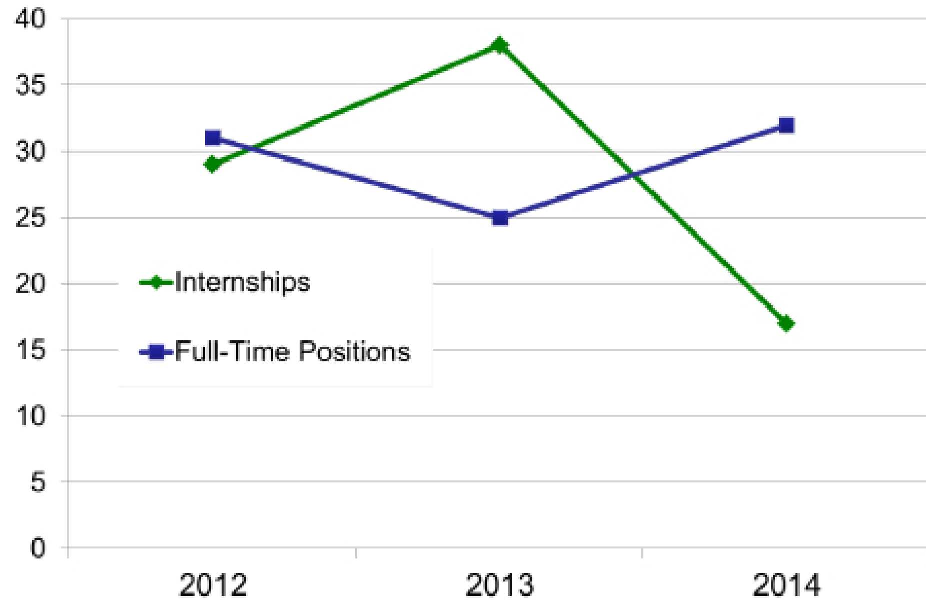
Slide 2

NURail Center


NURail Courses 2012 - 2014
18
16
14
12
10
8
6
4
2
0
2012
2013
2014
Courses Offered
Courses Available On-Line
New Rail Classes Developed
Slide 3
NURail Center


NURail Course Enrollment 2012 - 2014
600
500
400
300
200
100
0
2012
2013
2014
Slide 4
NURail Center

NURail Students Hired 2012 – 2014*



*** Includes only partial data through self-reporting**

Slide 5

NURail Center

National University Rail Center

UIC

AHMED ABOUBAKR
University of Illinois at Chicago
Dynamic Simulation Laboratory

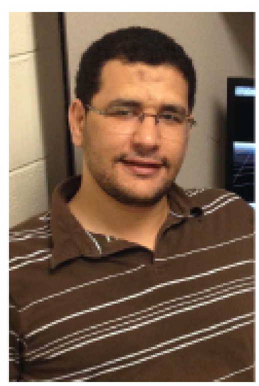
GT Gamma Technologies

- **Ph.D. - Mechanical Engineering (2014)**

Conducted research on computational dynamics for rigid and deformable bodies with applications in longitudinal train dynamics, vehicle dynamics, in addition to numerical integration and computational algorithms for complex and large systems

- **Professional experience in the field of structural dynamics and machine condition monitoring**
- **Contributed with fifteen publications in top-tier journals and conferences**
- **Current : Senior Mechanical Engineer for GT**

With development responsibilities in the area multibody dynamics modeling , with applications to engine , power train and vehicle systems and beyond



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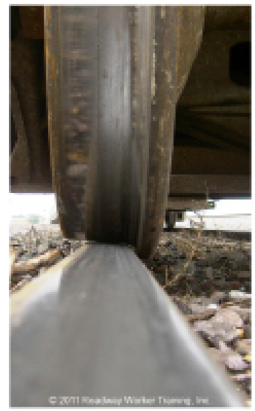
Slide 6

UIC **AHMED ABOUBAKR** **GT Gamma Technologies**

- **Involvement in Rail Activities:**
  - Longitudinal Train Dynamics
    - ✓ Analysis of train longitudinal forces for long trains
    - ✓ Development of three dimensional coupler model
    - ✓ Development of air brake system (ECP) model
    - ✓ Development of train tractive effort, and resistance force models
    - ✓ Development of a graphical user Interface (ATTIF) for real time applications
  - Train /Track Interaction
    - ✓ Development of a computation algorithms for stiff DAE (contact problems)
    - ✓ Building long train models for the analysis of train/track interaction and longitudinal train dynamics together



- **Involvement in NURail Projects:**
  - Quantifying Rail-Highway Grade Crossing Roughness: Accelerations and Dynamic Modeling

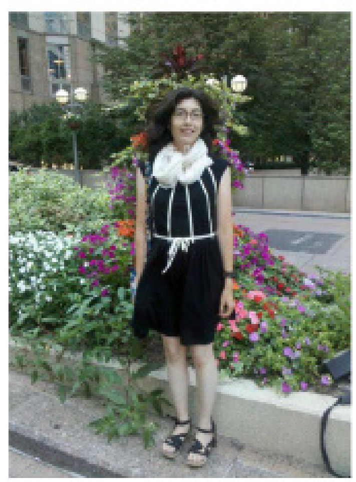
"Exposure to DSL / NURail not only leads me to knowledge , but also makes me to think"

Slide 7 NURail Center

National University Rail Center

MARCELLA BONDIE KEENAN
University of Illinois at Chicago

MUPP
College of Urban Planning & Policy
2014



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MARCELLA BONDIE KEENAN

- Community-Specific Environmental Impact Assessment of Rail Infrastructure
- Urban Transportation Center Student of the Year
- Chicago Consular Corps Scholarship
- American Association of University Women Career Development Grant

"I was challenged to move out of my comfort zone - environmental planning - and find deep connections with other planning specialties."

Slide 9

NURail Center

National University Rail Center

JOEL CARLSON
Massachusetts Institute of Technology
CPCS

MIT (Cambridge)
Master of Science in Transportation and Engineering Systems, 2014
Railroad Strategy for Energy Resource Transportation

CPCS Transcom Limited (Toronto)
Consultant, 2014-present
Ongoing work on rail/multimodal freight feasibility studies, research projects

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Slide 10

JOEL CARLSON

- **Pre-MIT:**
  - BSc (Civil)
  - internships with CN
- **MIT**
  - Transportation Club; Internship at the SNCF
  - Winner, UIC Highspeed Student Essay Competition and Best Paper, Canadian TRF Conference

exposed me to the latest trends/broader issues facing the railway industry and its impacts on society

experience developing a systematic approach to problem solving

GARRETT FULLERTON–

University of Illinois at Urbana-Champaign/ Canadian National Railway

M.S. Civil Engineering 2015

GARRETT FULLERTON

- AREMA Student member since 2011- Undergrad and Graduate School
  - Treasurer for Student Chapter in 2014
  - Student member of Committee 16- Railway Economics
- Project- “Transitioning to a Near-Zero Emission Line-Haul Freight Rail System in California: Operational and Economic Considerations”
  - Papers presented at JRC, TRB, IHHA, and IAROR
  - Published in the 2015 TRR
- Position with CN- Engineering Management Trainee
  - Asst. Manager in projects in all engineering departments
  - Will find permanent role after trainee period (4-6 months)

Mike McHenry

Transportation Technology Center, Inc. (TTCI)
Pueblo, CO
Engineering Services
Senior Engineer

University of Kentucky
BS (’11) - Civil Engineering
MS (’13) - Civil Engineering

Thesis Topic: Ballast-tie interface pressure measurement

Mike McHenry

RAIL ACTIVITIES AND RESEARCH

- UK AREMA Student Chapter Pres.
- Undergraduate Research
- NURail supported graduate research
- Internship at TTCI - 2012

AWARDS/FUNDING

- USDOT Eisenhower Graduate Fellowship
- UK Wethington Graduate Fellowship
- AREMA and AARS Scholarships ('11)

CURRENT POSITION AT TTCI

- Senior Engineer
- Railway research and testing for
  - AAR, Railroads, FRA, Commercial
- Currently managing tie/fastener projects
- Supporting other track research

"The railway engineering exposure, education and networking afforded to me during school allowed me to choose an exciting and meaningful career path. Working at TTCI puts my skills to use everyday for the railway industry."

Slide 15

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National University Rail Center

BRANDON VAN DYK
University of Illinois at Urbana-Champaign
Vossloh Fastening Systems America

Master of Science in Civil Engineering
Characterization of the Loading Environment for Shared-Use Railway Superstructure in North America
2014

vossloh

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BRANDON VAN DYK

- Graduate Research Assistant for the FRA Tie and Fastener BAA
  - Performed research on concrete ties and fastening systems
  - Worked in field at TTC and attended several other field trips
  - Participated in conferences and committee meetings, becoming exposed to industry issues and meeting industry members
- AREMA Student Chapter member (served as Treasurer in 2012)
- Enrolled in six railway-specific courses at UIUC
- Contributed to discussions/presentations related to peers' NURail projects
- Current role: Technical Engineer at VFSA

"***The importance of industry exposure while attending UIUC was immeasurable; such exposure introduced me to real-world railway engineering concepts and my current employer.***"

Slide 17

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KYLE BARDO
UIC / GATX Corporation

MUPP, December 2013

Thesis:
Relationship Building with Freight Railroads Critical to Support Intercity Passenger Rail Development

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KYLE BARDO

- **Involvement in rail activities (while in university)**
  - Was employed at Permian Basin Railways in marketing function
  - Consulted on RRIF/state rail loans and rail spur development
- **Involvement in NURail projects**
  - Presented at JRC 2013 Conference
- **Awards**
  - CN Railway Fellow, George Krambles Transportation Scholarship
- **Current job title**
  - Fleet Manager, Canada

"UIC and NuRail helped me to become a greater thinker and planner by providing me the resources to analyze, evaluate and synthesize topics in railroading that were tailored to my career and interests. The faculty and staff were immensely supportive in my work and encouraged me to take on new challenges to expand my transportation worldview."

SAM BECK

BNSF
Mechanical Department
Foreman I
Argentine Yard

BNSF RAILWAY

Rose-Hulman Institute of Technology
BS - Mechanical Engineering 2014

Founding VP RHIT AREMA
AREMA Scholarship 2013 & 2014

Summer 2012 & 2013
Norfolk Southern
Mechanical Intern
Portsmouth, Ohio

SAM BECK

JOB TITLE/DUTIES:

June 2014

- **Yard Foreman – Management Trainee**
  - **Argentine Yard, KS**
  - team of 13-15 carmen
  - derailments & service interruptions
  - 2-state, 6-subdivsion territory

November 2014

- **Mechanical Foreman I**
  - providing blue signal protection
  - bad ordering defective cars
  - go-between Mechanical & Transportation

THOUGHTS/COMMENTS:

"Awesome industry - each day is different"

"Some days are unbelievably smooth and others throw many challenges and obstacles at you. I have to constantly be thinking on my feet"

"It is pretty interesting being 23 years old and coordinating derailment clean-ups or handling distributed power issues on our Transcon"

GREG FRECH

BNSF
Track Geometry Car 87
Technician

BNSF RAILWAY

Rose-Hulman Institute of Technology
BS – Civil Engineering 2014

Founding President RHIT AREMA
AREMA Scholarship 2013

Summer 2012
REU - Undergrad Research Assistant
UIUC RAILTECH
Concrete Tie Project

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GREG FRECH

JOB TITLE/DUTIES:

September 2014
- **Track/MOW Management Trainee**
  - **Galesburg, IL**

April 2015
- **Track Geometry Car 87 Technician**
  - Chicago to Wisconsin & Minnesota
  - Great Plains, Northern Rockies
  - Pacific Northwest

THOUGHTS/COMMENTS:

"I cannot stress enough the positive role AREMA and the NURail organization played in getting me to where I am today."

"The opportunity for growth both personally and professionally is tremendous."

"One of the great things about the railroads is their size. If you don't like your position, rather than quitting they're great about providing chances to try another job to see if it's a better fit."

SAM LEVY –
Massachusetts Institute of Technology

Master of Science in Transportation

Capacity Challenges on the California High-Speed Rail Shared Corridors: How Local Decisions Have Statewide Impacts

Class of 2015

Michigan Tech | MIT Massachusetts Institute of Technology | UIC University of Illinois at Chicago | Illinois | Rose-Hulman Institute of Technology | UK University of Kentucky | The University of Tennessee Knoxville

SAM LEVY

- Member of NURail Student Leadership Committee
- Schottler Fellowship and Two-Time AREMA Scholarship Winner
- Graduate Research Assistant at MIT (Class of 2015); Revenue Analytics and Planning Analyst at Hawaiian Airlines (Starting June 2015)

"NURail has provided a great community to gain critical feedback and advice on my research, seek help from my peers, and grow my professional network"

TOLU OGUNBEKUN –
Massachusetts Institute of Technology

Master of Engineering in Transportation

The Impact of Amtrak Performance in the Northeast Corridor

Class of 2015

MichiganTech | MIT Massachusetts Institute of Technology | UIC University of Illinois at Chicago | ILLINOIS | ROSE-HULMAN Institute of Technology | UK University of Kentucky | The University of Tennessee UT Knoxville

TOLU OGUNBEKUN

- Graduate Research Assistant at MIT (Class of 2015);
- Senior Consultant at Steer Davies Gleave, Boston (Starting July 2015)

"NURail has expanded my knowledge on innovative research strategies being applied to enhance the performance of freight and passenger rail systems in the U.S."

MAITE PENA-ALCARAZ –
Massachusetts Institute of Technology

PhD, Engineering Systems & Policy

Analysis of Capacity Pricing and Allocation Mechanisms in Shared Railway Systems

Class of 2015

Michigan Tech | MIT Massachusetts Institute of Technology | UIC University of Illinois at Chicago | Illinois | Rose-Hulman Institute of Technology | University of Kentucky | The University of Tennessee Knoxville

MAITE PENA-ALCARAZ

- Graduate Research Assistant at MIT (Class of 2015); Associate at McKinsey Boston (Starting July 2015)

"I really appreciate NURail's support for my research and the opportunity to connect with other people working on capacity planning in the railway industry through NURail's network"

LAUREN PLOUFF

BNSF
Intern

Rose-Hulman Institute of Technology
BS – Civil Engineering 2016

Vice President RHIT AREMA 2014-2015
President Elect RHIT AREMA 2015-2016

Summer 2015
BNSF – INTERNSHIP
Chicago, IL

LAUREN PLOUFF

JOB TITLE/DUTIES:

May - August 2015

- **BNSF Track Intern**
  - **Chicago, IL**
  - **Track construction & renovation**
  - **BNSF system travel**

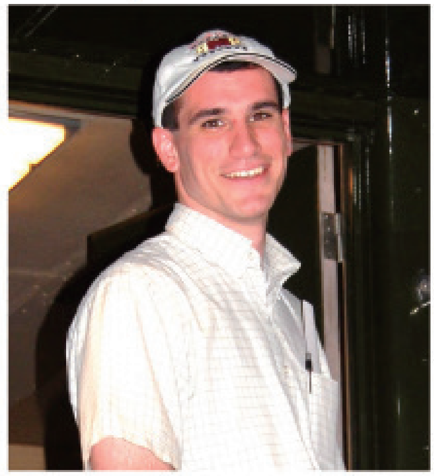
THOUGHTS/COMMENTS:

"AREMA, especially the conference, has helped me get an internship and hopefully a full time job with a company I have wanted to work for since sophomore year. AREMA has also helped me make new connections and advance my career opportunities."

JEREMIAH PARUNAK

The University of Tennessee
Norfolk Southern Corp.

Bachelor of Science,
Civil Engineering - 2013



JEREMIAH PARUNAK

- AREMA Student Chapter, TRB Summer Rail
- Assist in HSR and RISA 2008 research
- AREMA Foundation Scholarships
- Railroad engineering drew a lot of interest from various places. As a result, Jeremiah developed a lot of unique relationships around campus.

"***AREMA, TRB and NuRail provided me with great networking opportunities in addition to a firm knowledge base of railroad infrastructure that is not widely available in academia today.***"

IRFAN RASUL

Michigan Technological University
AECOM

MS in Civil Engineering

Thesis Title: "Evaluation of Potential Transload Facility Locations in the Upper Peninsula (UP) of Michigan"

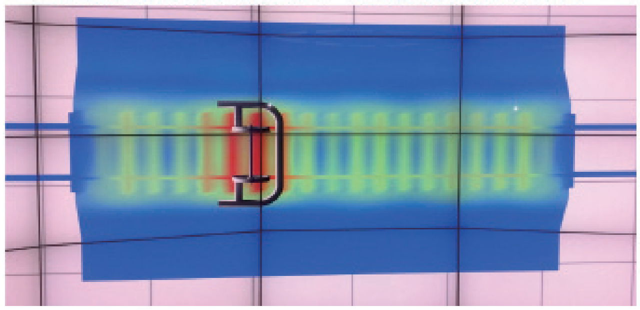
2014

IRFAN RASUL

- Actively participated in Railroad Engineering and Activities Club (REAC) at MTU.
- Demonstrated how railroad can exhibit better performance than trucks in the STEM festival to teach grade 3-4 students.
- Analyzed Commodity Flows and worked on interactive GIS rail map/inventory for the NURail/MDOT funded project; "Upper Peninsula Freight Rail Study".
- Recipient of AREMA (2013) and CN Railroad (2013 and 2014) scholarships.
- Currently working as "Track Design Engineer" for the Southwest Light Rail Transit Project at Minneapolis (AECOM is the Project Consultant).

"***The Rail Transportation Program (RTP) at MTU provided me with the critical exposure to the railroad industry through networking and hands-on experience in design. This was instrumental in obtaining my current position and provided me with the tools to succeed***"

Coupled Multibody and Finite Element Modeling for Simulating Vehicle-Track-Substructure Interaction



Craig Foster, Ahmed El-Ghandour, Mohammad Hosein Motamedi, Martin Hamper

University of Illinois at Chicago

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Acknowledgements

Collaborators:

Andrew Johnson, Jason Leigh, UIC Electronic Visualization Laboratory

Ahmed Shabana, Antonio Recuero, Liang Wang, UIC Computational Dynamics Laboratory

Funding:

NURail, National Science Foundation CMMI-1030398, UIC

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Rail substructure is essential for performance

Ballast, subballast, and subgrade:

- Support track structure
- Provide drainage
- Damp track vibrations

Some potential issues

- Differential settlement, especially at transitions
- Increased maintenance
- Passenger comfort
- Vibrations in nearby structures

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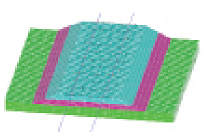
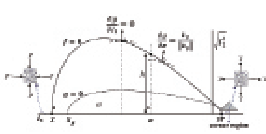
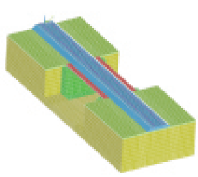
Outline



Elastic soil coupling with Rail Multibody Simulation



Elasto-viscoplastic soil model



Ongoing work

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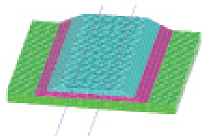
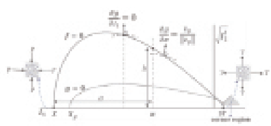
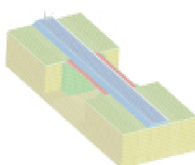
Outline



Elastic soil coupling with Rail Multibody Simulation



Elasto-viscoplastic soil model

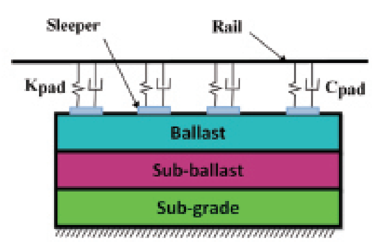


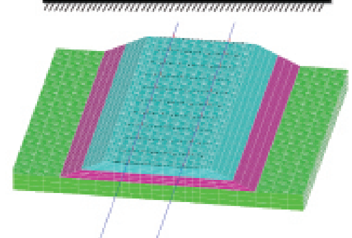
Ongoing work

Elastic modeling of soil can simulate dynamic response of track substructure

Coupling procedure

- Construct geometric model of track and substructure
- Create finite element discretization to find mass and stiffness matrices
- Extract relevant mode shapes, modal mass and stiffness
- Use mass and stiffness values to run multibody simulation of train
- Reconstruct total deformation and other quantities of interest

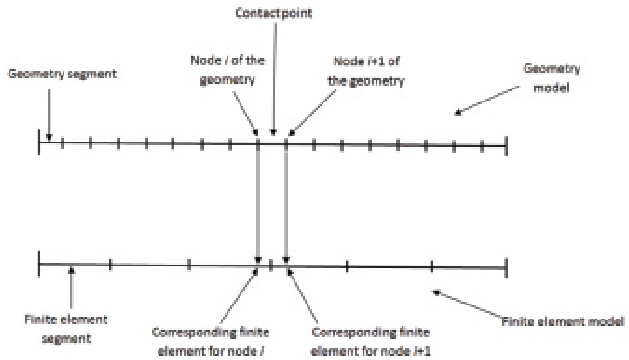




Run time depends on number of modes and rail nodes, not substructure geometry

Wheel-rail contacted calculated in SAMS/rail

- Multibody dynamics code calculates dynamic interaction or rigid and flexible bodies coupled by algebraic constraints
- SAMS/rail includes sophisticated calculation of wheel-rail contact points and forces



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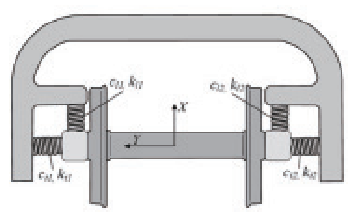
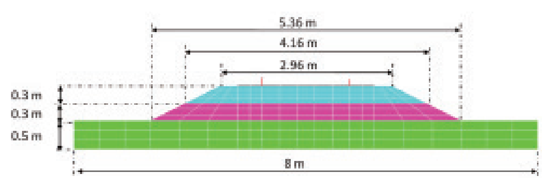
Example - suspended wheelset on elastic soil

Wheelset:

Mass	1568 kg
I_{xx}	656 kgm^2
I_{yy}	168 kgm^2
I_{zz}	656 kgm^2
$k_{l1} = k_{l2}$	13,500 N/m
$k_{t1} = k_{t2}$	25,000 N/m
$c_{l1} = c_{l2}$	1000 Ns/m
$c_{t1} = c_{t2}$	0 Ns/m



Substructure Geometry:



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Example - suspended wheelset on elastic soil

Rail and substructure parameters

Rigid rail length	40 (on both sides)	m	Poisson's ratio of a sleeper (ε_s)	0.25	
Gage length	1.5113	m	Cross-sectional area of a sleeper (A_s)	513.8×10^{-4}	m^2
Flexible rail length	6.5	m	Second moment of inertia of a sleeper, I_{yy}	$25{,}735 \times 10^{-8}$	m^4
Stiffness of the rail (E_r)	210×10^9	N/m^2	Second moment of inertia of a sleeper, I_{yy}	$18{,}907 \times 10^{-8}$	m^4
Density of the (ρ_r)	7700	kg/m^3	Timoshenko shear coefficient of a sleeper	0.83	
Poisson's ratio of the rail (ε_r)	0.3		Stiffness of the ballast (E_b)	260×10^6	N/m^2
Cross-sectional area of the rail (A_r)	64.5×10^{-4}	m^2	Density of the ballast (ρ_b)	1300	kg/m^3
Second moment of inertia of the rail, I_{yy}	2010×10^{-8}	m^4	Poisson's ratio of the ballast (ε_b)	0.3	
Second moment of inertia of the rail, I_{zz}	326×10^{-8}	m^4	Stiffness of the sub-ballast (E_{sb})	200×10^6	N/m^2
Timoshenko shear coefficient for the rail	0.34		Density of the sub-ballast (ρ_{sb})	1850	kg/m^3
Length of a sleeper	2.36	m	Poisson's ratio of the sub-ballast (ε_{sb})	0.35	
Gap between sleepers	0.65	m	Stiffness of the sub-grade (E_{sg})	200×10^6	N/m^2
Stiffness of a sleeper (E_s)	64×10^9	N/m^2	Density of the sub-grade (ρ_{sg})	1850	kg/m^3
Density of a sleeeper (ρ_s)	2750	kg/m^3	Poisson's ratio of the sub-grade (ε_{sg})	0.3	
Stiffness coefficient of a pad (K_{pad})	26.5×10^7	N/m	Damping coefficient of the pad (C_{pad})	4.6×10^4	Ns/m

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Results can be visualized with help from Electronic Visualization Laboratory

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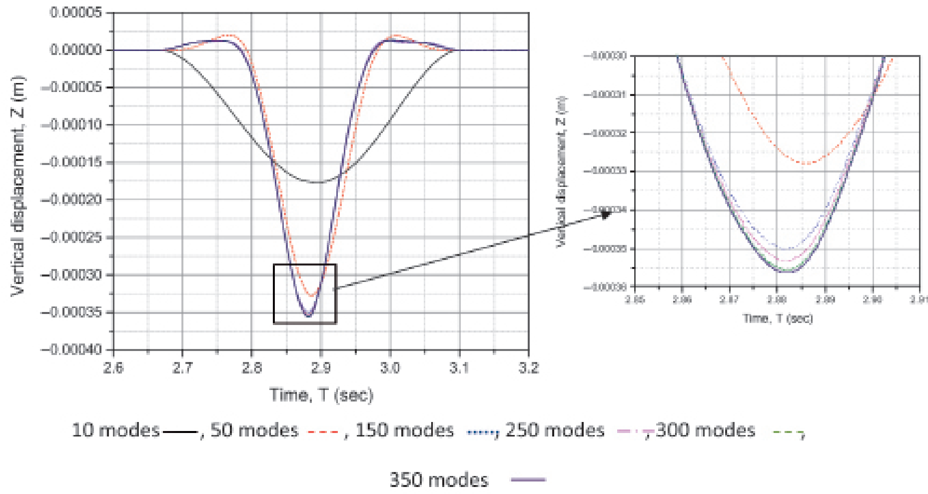
Displacement of rail can be calculated



Many modes are necessary for accurate solution of a concentrated, moving load.

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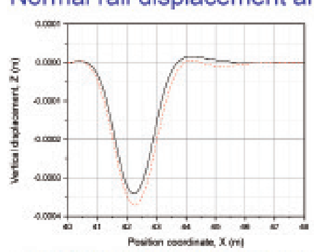
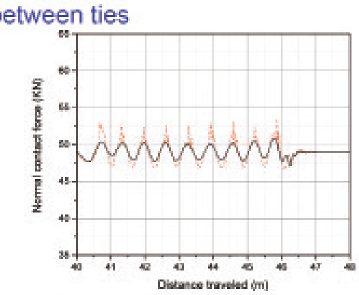
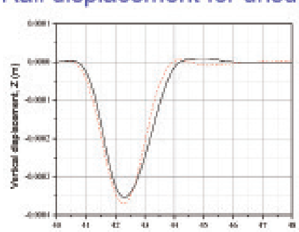
Results can be compared for "normal" track and unsupported tie

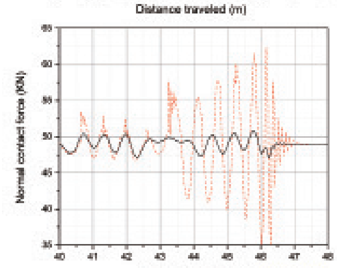
Normal rail displacement and contact force between ties





Rail displacement for unsupported tie





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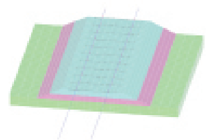
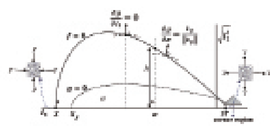
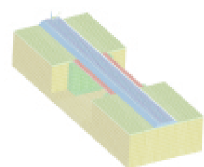
Outline



Elastic soil coupling with Rail Multibody Simulation



Elasto-viscoplastic soil model

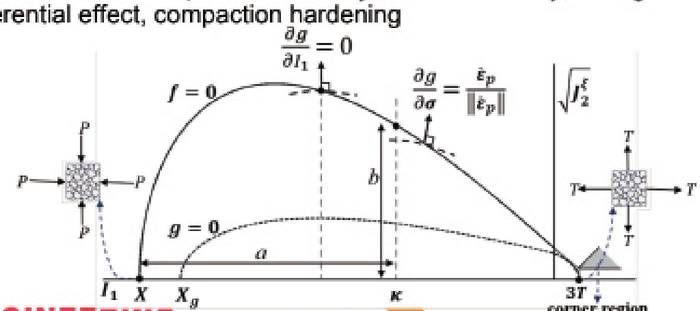


Ongoing work

Permanent deformation requires inelastic modeling

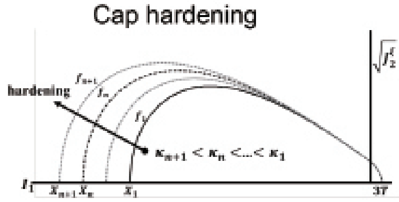
Important features for ballast, subballast and subgrade settlement:

- Dilation at low pressure, compaction higher
- Rate dependence
- Kinematic hardening to capture Bauschinger effect in cyclic loading
- Other features for improved accuracy: nonassociativity, strength differential effect, compaction hardening

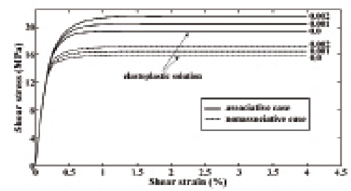


We have adapted the Sandia GeoModel, a cap palsticity model, to captures these features.

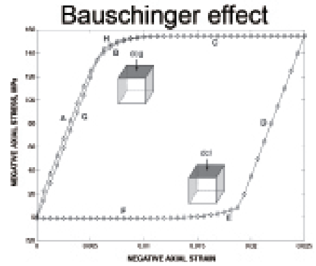
Cap hardening



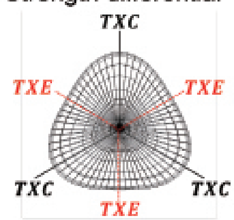
Rate dependence



Bauschinger effect



Strength differential



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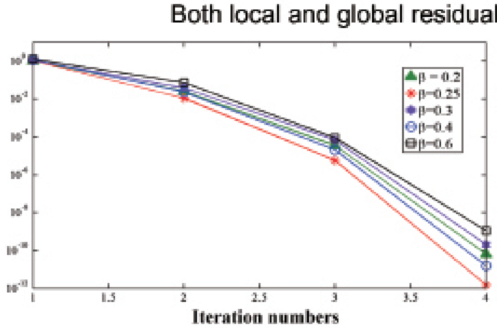
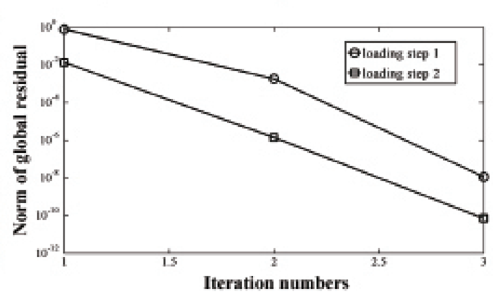
Recent modifications have improved robustness and efficiency

- Reparameterized yield function
- Normalized units of local residual

Both local and global residuals show quadratic convergence





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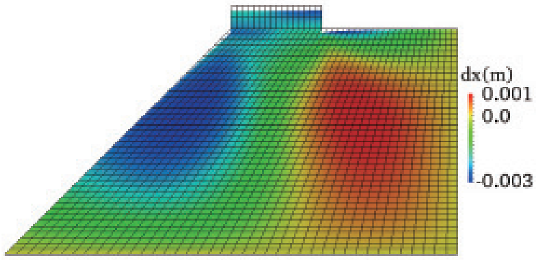
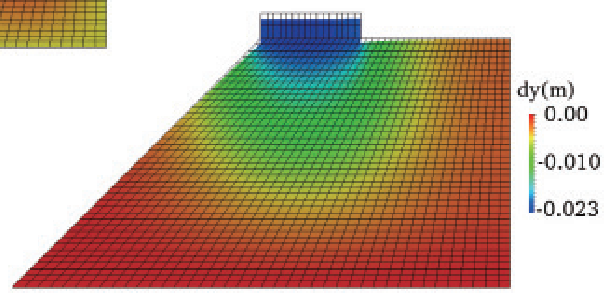
The model can be used in large-scale finite element problems





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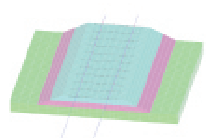
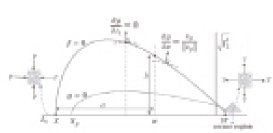
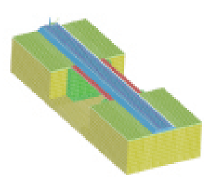
Outline



Elastic soil coupling with Rail Multibody Simulation



Elasto-viscoplastic soil model



Ongoing work

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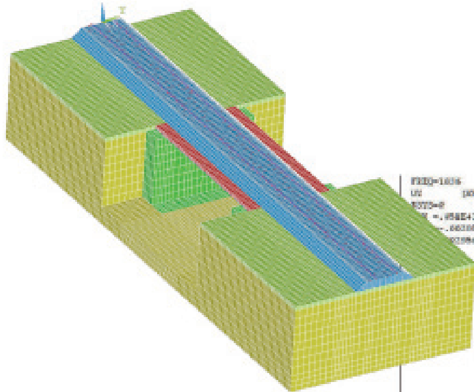
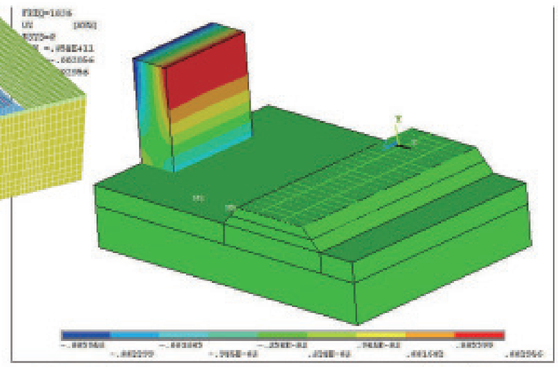
This linear elastic model is now being applied to bridge approaches and building vibrations





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This viscoplastic model will be coupled to the multibody model by a linear approximation

- Use linear stiffness to calculate displacements
- Use the displacement to calculate full stress and plastic strain
- Since inelastic deformation is small over a given event, rerun loads
- Periodically update geometry to account for settlement

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Conclusions

- Continuum modeling of track substructure lead to more accurate modeling of train dynamics
- Can be applied to a variety of problems related to rail geotechnics, including building vibration and transitions
- More advanced soil modeling necessary to capture permanent settlement (ballast fouling and degradation needs further modification)

References

[1] Motamedi, M. H., Foster, C. D., (2015), "An improved implicit numerical integration of a non-associated, three-invariant cap plasticity model with mixed isotropic/kinematic hardening for geomaterials" *IJNAMG*, In Press.

[2] El-Ghandour, Ahmed I., Martin B. Hamper, and Craig D. Foster. "Coupled finite element and multibody system dynamics modeling of a three-dimensional railroad system." *JRRT* (2014): 0954409714539942.

[3] Recuero, A. M., J. L. Escalona, and A. A. Shabana. "Finite-element analysis of unsupported sleepers using three-dimensional wheel–rail contact formulation." *JMD* 225.2 (2011): 153-165.

[4] C.D. Foster, R.A. Regueiro, A.F. Fossum, and R.I. Borja. (2005), "Implicit numerical integration of a three-invariant, isotropic/kinematic hardening cap plasticity model for geomaterials" *CMAME*, Vol. 194, Nos. 50-52, 5109-5138.

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Hazards Associated with High-Speed Rail (HSR) Operation Adjacent to Conventional Tracks

Chen-Yu Lin
Dr. M. Rapik Saat
Dr. Christopher P.L. Barkan

4th June 2015
NURail Annual Meeting, Chicago, IL

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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Outline

- Approaches to developing high-speed rail (HSR) and shared-use rail corridor (SRC)
- Hazards associated with operating high-speed rail on shared-use corridor
- Hazard assessment
  - High-risk locations
  - Influencing factors
  - Potential risk mitigation strategies
- Fault-tree analysis of hazards
- Ongoing work

Slide 3

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Two Key Decisions in High(er)-Speed Rail Development

- Approach to HSR
  - Incremental upgrade of existing line
  - New dedicated line
- Track and right-of-way (ROW) usage
  - Shared track
  - Shared right of way
  - Shared corridor
- Each has different implications regarding speed, performance, cost, operational, institutional, regulatory and safety considerations

Slide 4

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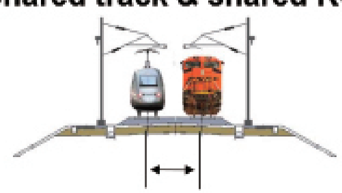
Shared-Use Rail Corridor (SRC)

- **Shared track:** tracks shared between passenger and freight or other service
- **Shared right of way (ROW):** dedicated high-speed passenger tracks separated from freight or other service tracks up to 25 ft
- **Shared corridor:** dedicated high-speed passenger tracks separated from freight or other service tracks by 25 – 200 ft

Shared track & shared ROW

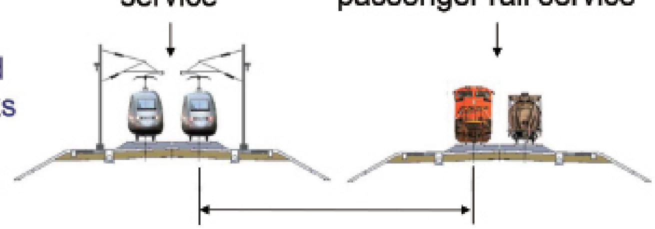


Adjacent track centers ≤ 25’

Shared corridor

High-speed rail service

Freight or conventional passenger rail service



Adjacent track centers >25’ and ≤ 200’

Shared-Use Implementation Challenges

Safety
- Adjacent track accident (ATA)
- Loss of shunt problem
- Pedestrian risk
- Highway/rail grade crossings

Infrastructure and Rolling Stock
- Wheel-load characteristics
- Track structure and components
- Special trackwork
- Track geometry
- Vehicle-track interaction (VTI)
- Stations
- Signaling systems and train control technology

Planning and Operation
- Host railroad negotiation
- Train scheduling
- Capacity planning
- Train control and operations

Economic
- Capital cost sharing
- Passenger operation sustainability
- Freight level of service preservation

Institutional
- Regulatory compliance
- Performance incentives/penalties
- Grant agreement structure
- Liability

Saat, M.R., and Barkan, C.P.L. *Investigating Technical Challenges and Research Needs Related to Shared Corridors for High-Speed Passenger and Railroad Freight Operations:* http://www.fra.dot.gov/eLib/details/L04578

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Safety Issues of Operating High-Speed Rail (HSR) Adjacent to Conventional Tracks

- The Federal Railroad Administration (FRA) set out to develop a guidance document for SRC
- The document combines existing and proposed research to aid in the proposal, design, and evaluation of planned HSR alignments
- The document provide risk assessment capabilities for potential hazards of HSR operations on SRC as well as potential risk mitigation strategies

Slide 7

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Safety Issues of Operating HSR Adjacent to Conventional Tracks

Development of the document and its final contents consider the following issues:

- Minimum track and Right-of-Way (ROW) spacing from adjacent railroad tracks without the use of additional protection
- Use of intrusion detection or protection devices and proper system characteristics and installation locations
- Use of physical barriers or crash walls; what conditions warrant use and basic design characteristics
- Other relevant considerations such as aerodynamics, effects of grading and track heights, and protection from activities along ROW access roads, etc

Slide 8

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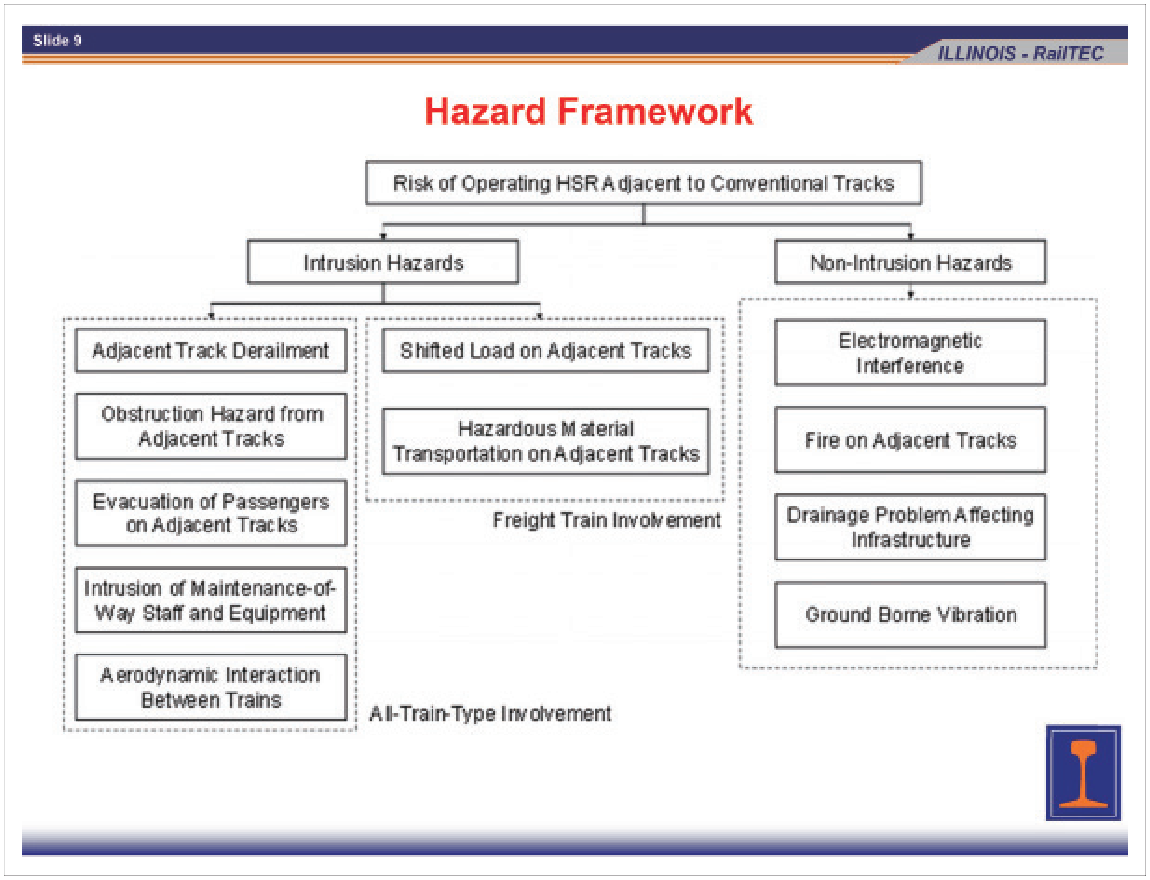
List of Hazards Associated with Operating HSR Adjacent to Conventional Tracks

- Derailment on adjacent tracks
- Shifted load on an adjacent track
- Aerodynamic interaction between trains on adjacent tracks
- Ground borne vibration and its effect on HSR track geometry
- Intrusion of maintenance of way staff and equipment working on the adjacent track
- Obstruction hazard resulting from an adjacent track (non-derailment and grade-crossing collisions)
- Drainage problem affecting either the HSR track or the adjacent track
- Evacuation of passengers from trains on the adjacent track
- Hazardous materials on the adjacent track
- Fire on the adjacent track
- Electromagnetic interference between trains and wayside equipment on adjacent tracks


Slide 9
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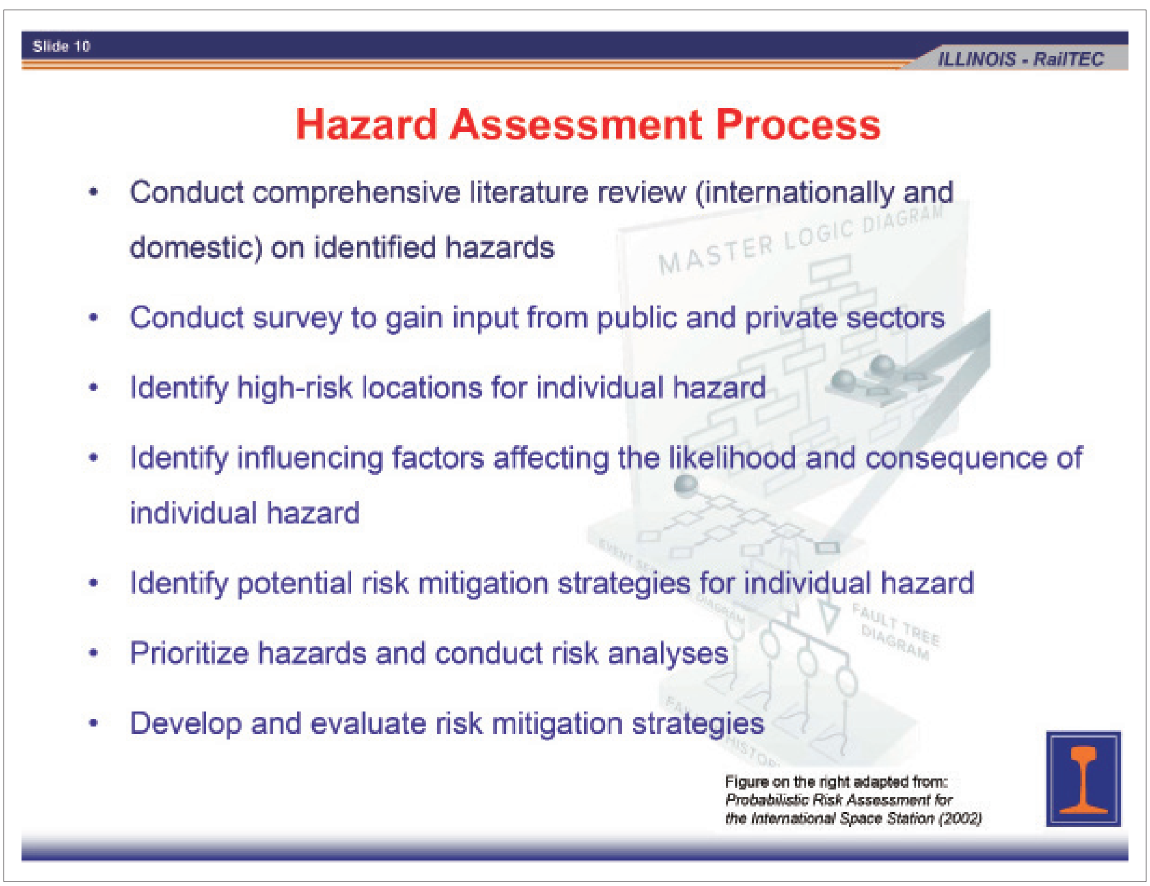
Hazard Framework
Risk of Operating HSR Adjacent to Conventional Tracks
Intrusion Hazards
Non-Intrusion Hazards
Adjacent Track Derailment
Obstruction Hazard from Adjacent Tracks
Evacuation of Passengers on Adjacent Tracks
Intrusion of Maintenance-of-Way Staff and Equipment
Aerodynamic Interaction Between Trains
All-Train-Type Involvement
Shifted Load on Adjacent Tracks
Hazardous Material Transportation on Adjacent Tracks
Freight Train Involvement
Electromagnetic Interference
Fire on Adjacent Tracks
Drainage Problem Affecting Infrastructure
Ground Borne Vibration


Slide 10
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Hazard Assessment Process
• Conduct comprehensive literature review (internationally and domestic) on identified hazards
• Conduct survey to gain input from public and private sectors
• Identify high-risk locations for individual hazard
• Identify influencing factors affecting the likelihood and consequence of individual hazard
• Identify potential risk mitigation strategies for individual hazard
• Prioritize hazards and conduct risk analyses
• Develop and evaluate risk mitigation strategies
MASTER LOGIC DIAGRAM
FAULT TREE DIAGRAM
Figure on the right adapted from:
Probabilistic Risk Assessment for the International Space Station (2002)

Slide 11

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High-Risk Locations of Hazards

	Hazard	Locations
1	Derailment on adjacent tracks	Along a shared-use rail corridor with multiple tracks
2	Shifted load on adjacent tracks	Along a shared-use rail corridor with freight train services
3	Aerodynamic interaction between trains on adjacent tracks	Along a shared-use rail corridor with multiple tracks, tunnels and stations where trains operate at high speed
4	Ground borne vibration and its effect on HSR track geometry	Along a shared-use rail corridor where trains operating at high speed especially at locations with subgrade and track infrastructure conditions susceptible to vibrations, and at special track locations (e.g. switches and turnouts)
5	Intrusion of maintenance of way staff and equipment working the adjacent tracks	Along a shared-use rail corridor where track maintenance activities are frequently taken place and locations with limited clearances (e.g. bridges, tunnels)
8	Evacuation of passengers from trains on adjacent tracks	Along a shared-use rail corridor with multiple tracks
9	Hazardous material transportation on adjacent tracks	Along a shared-use rail corridor with freight trains transporting hazardous materials
10	Fire on adjacent tracks	Along a shared-use rail corridor with freight trains transporting flammable liquids and/or gases, and other locations near fuel-based activities (e.g. power stations, gas stations)
11	Electromagnetic interference between trains and wayside equipment on adjacent tracks	Along a shared-use rail corridor where the high-voltage overhead catenary wires present

Slide 12

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Key Influencing Factors of Hazards

	Hazard	Key Influencing Factors
1	Derailment on adjacent tracks	Track center spacing, train speed, human factor, track geometry, type of rail infrastructure, train control systems
2	Shifted load on adjacent tracks	Track center spacing, train speed, human factor, track geometry, train control systems
3	Aerodynamic interaction … adjacent tracks	…ment design, wind
4	Ground borne vibration a… geometry	…etry, type of rail …cteristics
5	Intrusion of maintenance … equipment working the ad…	…tor
6	Obstruction hazard result… tracks (non-derailment co…	…tor, track geometry,
7	Drainage problem affecti… adjacent tracks	…e characteristics, track
8	Evacuation of passengers … tracks	… human factor
9	Hazardous material transportation on adjacent tracks	Track center spacing, train equipment design, hazardous materials traffic volume
10	Fire on adjacent tracks	Track center spacing, train equipment design, human factor, flammable product traffic volume
11	Electromagnetic interference between trains and wayside equipment on adjacent tracks	Train equipment design, type of rail infrastructure, train control systems

Major common influencing factors:

- Track center spacing
- Train speed
- Human factor
- Track geometry
- Train equipment design

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Proposed Risk Mitigation of Hazards

	Hazard	Potential Risk Mitigation Strategies
1	Derailment on adjacent tracks	Proper track center spacing, installation of intrusion detection systems, building physical barriers, improved employee training
2	Shifted load on adjacent tracks	Proper track center spacing, installation of intrusion detection systems, building physical barriers, improved employee training on cargo securement
3	Aerodynamic interaction between trains on adjacent tra	Proper track center spacing, installation of intrusion detection eed
4	Ground bor geometry	
5	Intrusion of equipment	detection ee training,
6	Obstruction tracks (non-	detection ee training,
7	Drainage pr adjacent tra	ved drainage
8	Evacuation tracks	detection systems, building physical barriers, improved employee training on safe passenger evacuation, enhanced rail equipment design
9	Hazardous material transportation on adjacent tracks	Proper track center spacing, building physical barriers, temporal separation, enhanced rail car design to prevent hazardous material release
10	Fire on adjacent tracks	Proper track center spacing, building physical barriers, temporal separation, enhanced rail equipment design
11	Electromagnetic interference between trains and wayside equipment on adjacent tracks	Improved employee training, better rail equipment design to prevent or reduce electromagnetic field effect

Major potential risk mitigation strategies:

- Proper track center spacing
- Installation of intrusion detection
- Physical barriers
- Improved employee training
- Enhanced rail equipment design

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Shared-Use Rail Corridor Risk Management

- Risk management planning
- Risk identification
- Risk assessment
  - Qualitative and quantitative
- Development and evaluation of risk mitigation strategies
- Risk monitoring

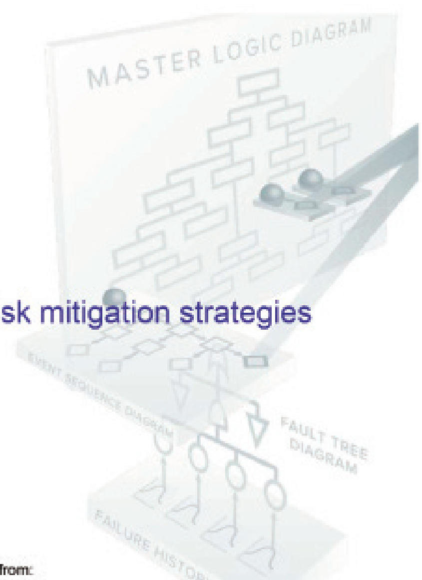

Figure on the right adapted from:
Probabilistic Risk Assessment for the International Space Station (2002)

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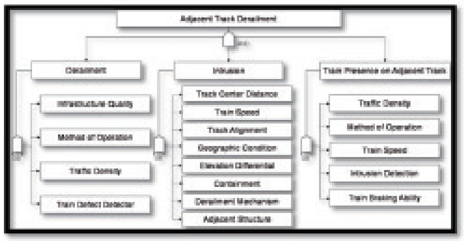
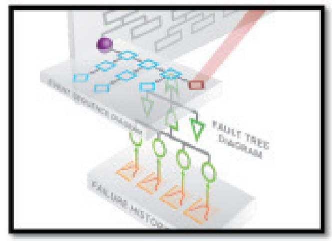
Fault-Tree Analysis

- A deductive process to break down a top event into basic events and all possible paths and elements for this event to occur are systematically deduced
- A graphical representation of the various contributors of failures that lead to the occurrence of the top event (SRC hazard)
- The probability of the top event can be calculated by calculating the probabilities of basic events





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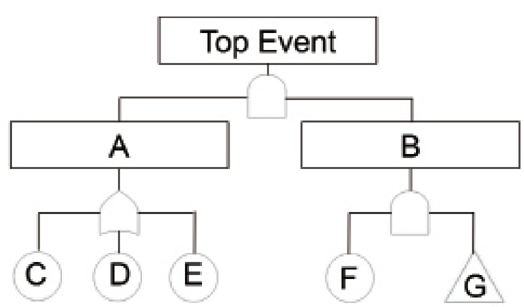
Fault-Tree Analysis Configuration

- Event symbols
  - Basic event
  - Conditioning event
  - Undeveloped event
  - Intermediate event
  - External event
- Gate (Logic) Symbols
  - And
  - Or
  - Exclusive or
  - Priority and
  - Inhibit
- Transfer Symbols



Slide 17

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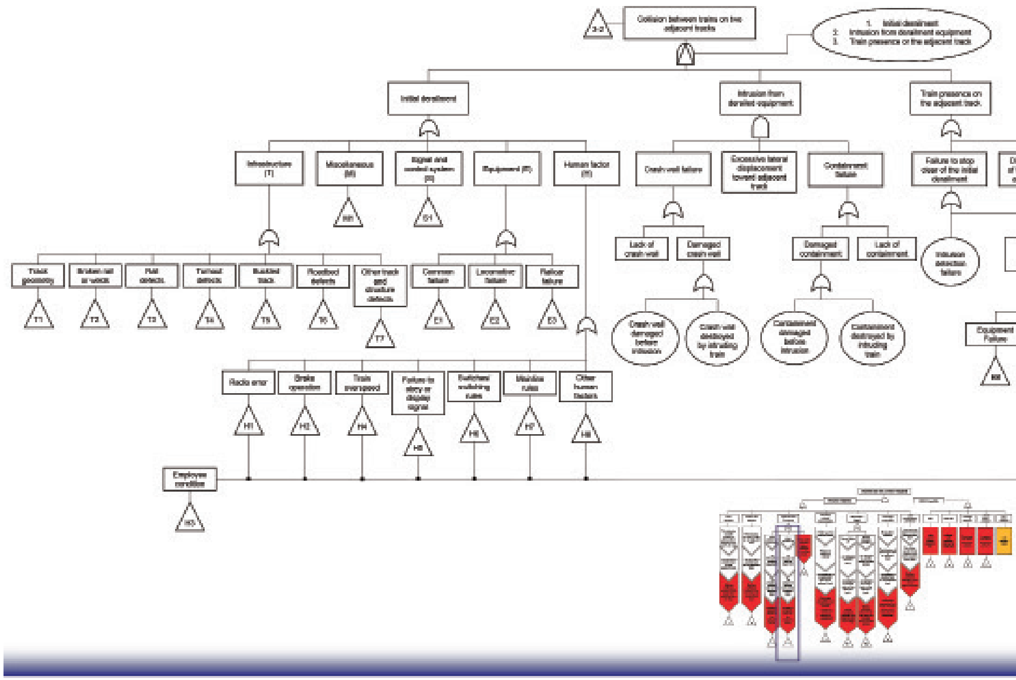
Fault Tree Analysis for Adjacent Track Collision



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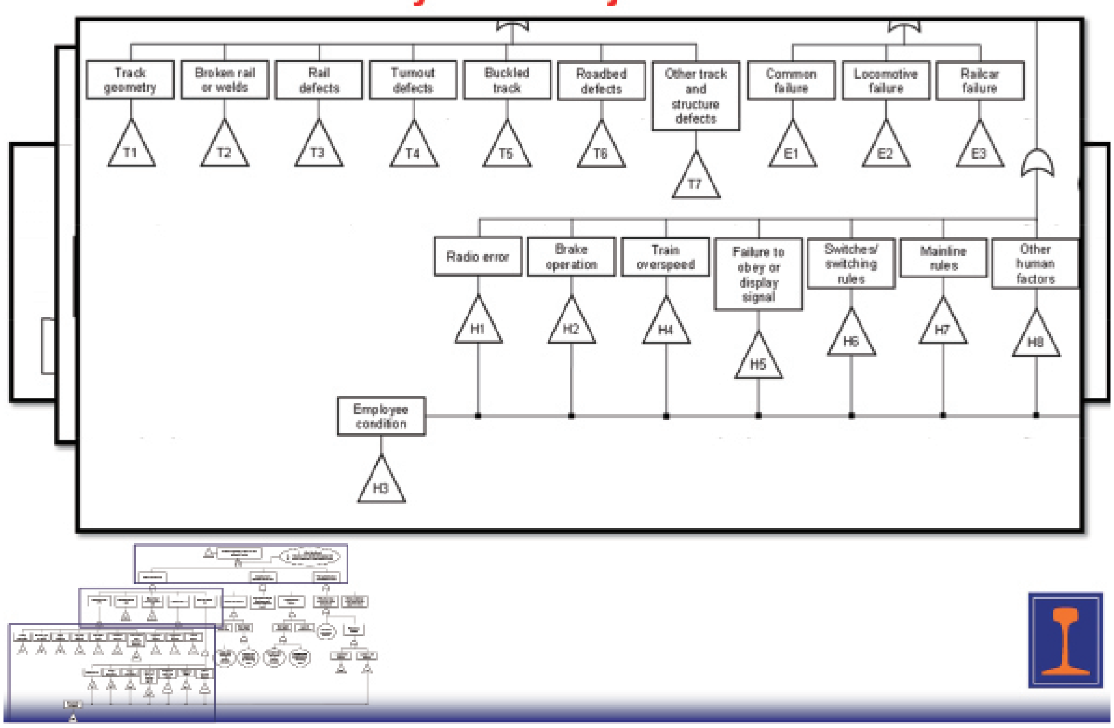
Fault Tree Analysis for Adjacent Track Collision



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Conclusion and Future Work

- Holistic risk assessment is able to identify the potential hazards for the shared-use rail corridors operations, including their eminent locations, influencing factors, and potential risk mitigation strategies
- Fault tree analysis is an essential method in both qualitative identification and characterization and quantification of SRC hazards
- The risk model developed can provide the industry both quantitative result from fault-tree analysis and risk assessment procedure
- Future work includes complete fault-tree analysis on hazards and quantitative risk model development as well as the development of an integrated risk assessment framework

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Acknowledgement

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National University Rail Center (NURail Center)

A Tier-1 University Transportation Center (UTC) under the US Department of Transportation (DOT) Office of the Assistant Secretary for Research & Technology (OST) program.

U.S. Department of Transportation
Federal Railroad Administration

Thank you!
Questions and comments are Welcomed!
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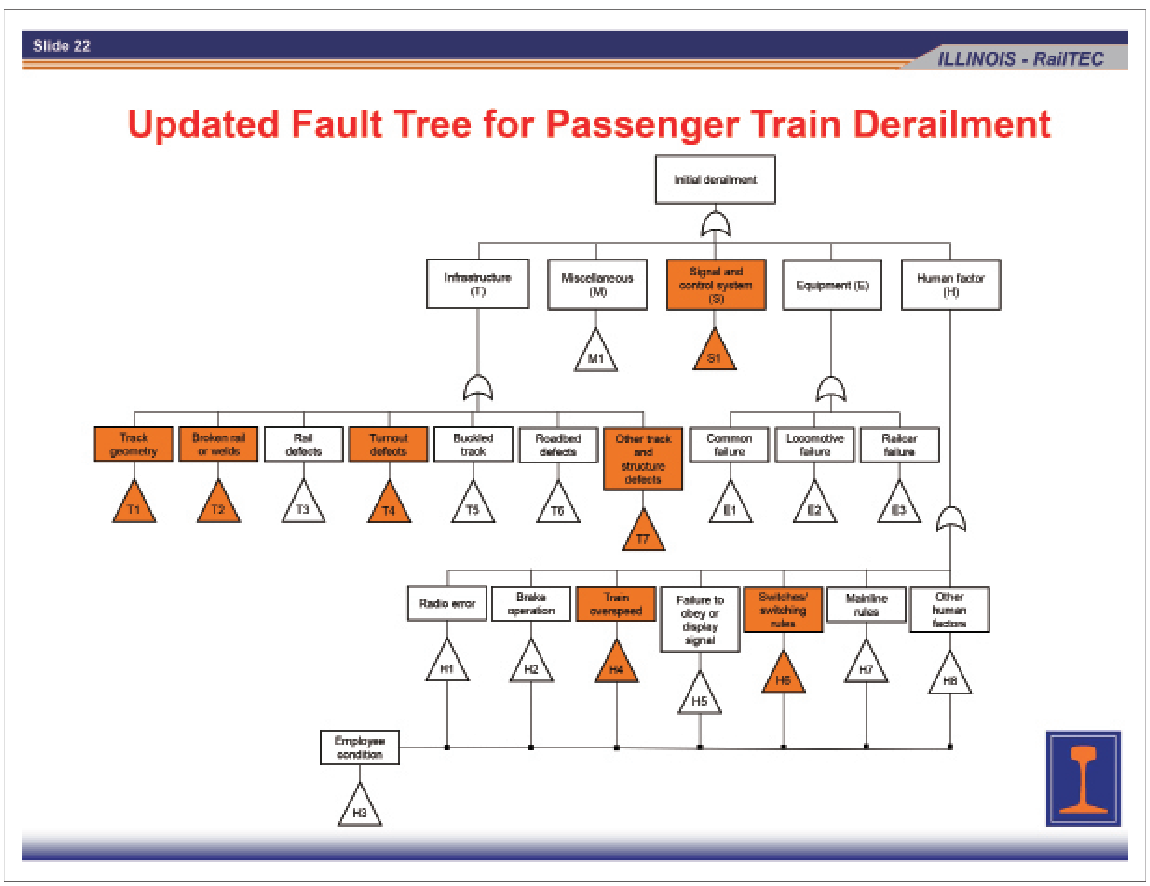

Slide 22
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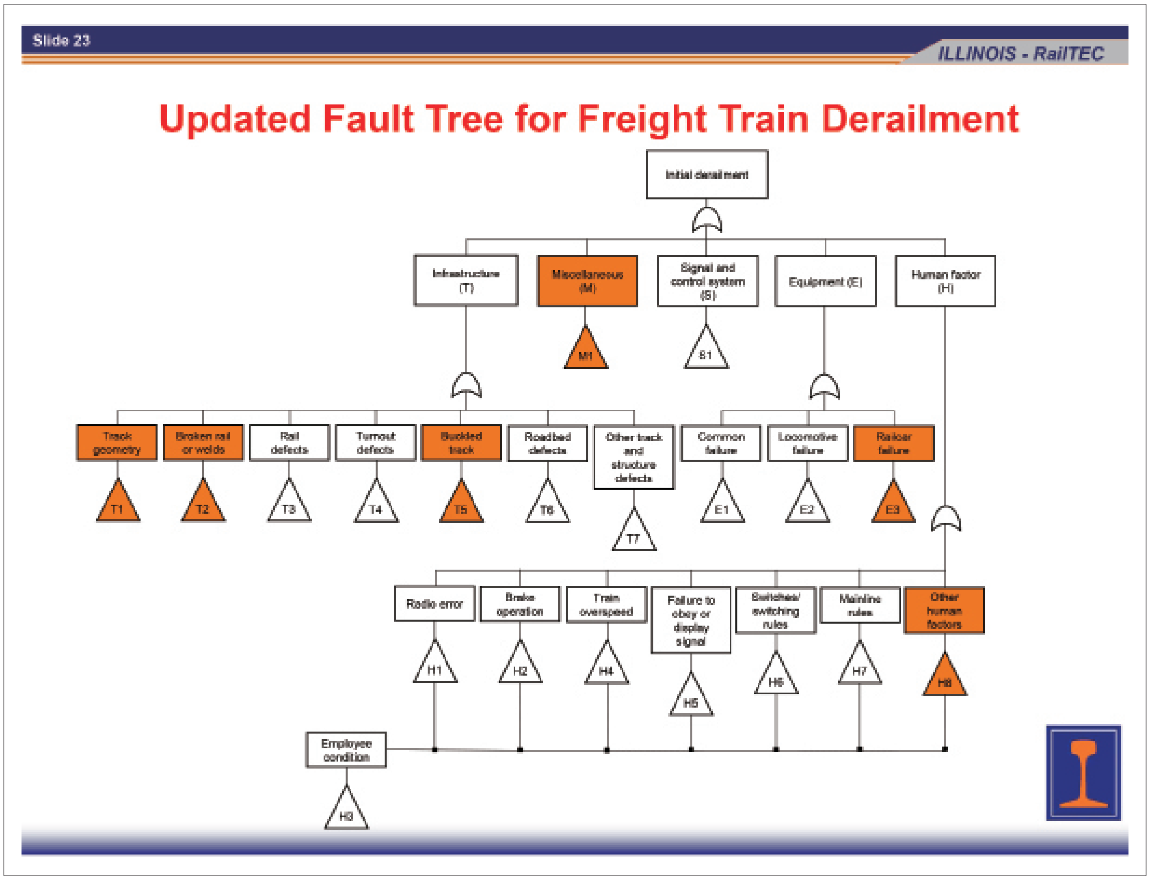
Updated Fault Tree for Passenger Train Derailment
Initial derailment
Infrastructure (T)
Miscellaneous (M)
Signal and control system (S)
Equipment (E)
Human factor (H)
M1
S1
Track geometry
Broken rail or welds
Rail defects
Turnout defects
Buckled track
Roadbed defects
Other track and structure defects
Common failure
Locomotive failure
Railcar failure
T1
T2
T3
T4
T5
T6
T7
E1
E2
E3
Radio error
Brake operation
Train overspeed
Failure to obey or display signal
Switches/ switching rules
Mainline rules
Other human factors
H1
H2
H4
H5
H6
H7
H8
Employee condition
H3


Slide 23
ILLINOIS - RailTEC
Updated Fault Tree for Freight Train Derailment
Initial derailment
Infrastructure (T)
Miscellaneous (M)
Signal and control system (S)
Equipment (E)
Human factor (H)
M1
S1
Track geometry
Broken rail or welds
Rail defects
Turnout defects
Buckled track
Roadbed defects
Other track and structure defects
Common failure
Locomotive failure
Railcar failure
T1
T2
T3
T4
T5
T6
T7
E1
E2
E3
Radio error
Brake operation
Train overspeed
Failure to obey or display signal
Switches/ switching rules
Mainline rules
Other human factors
H1
H2
H4
H5
H6
H7
H8
Employee condition
H3

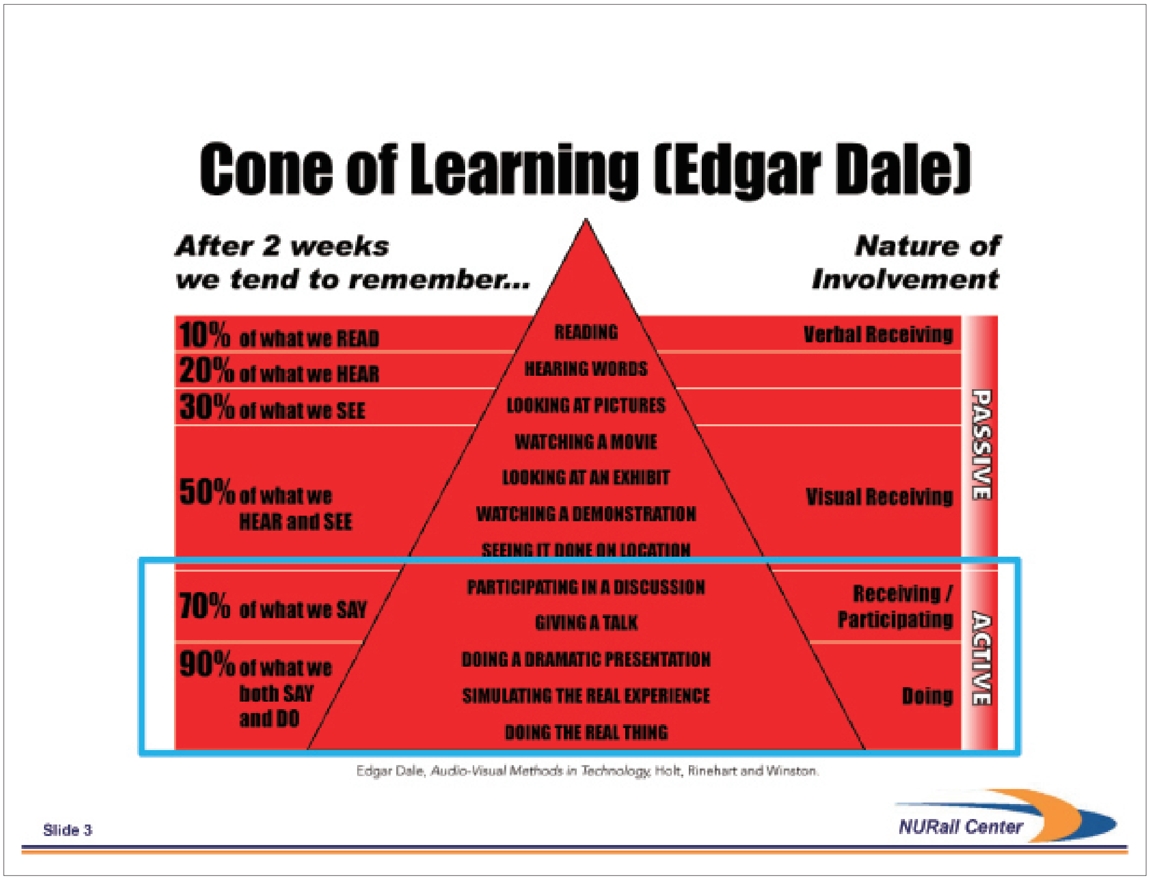
MICHIGAN TECHNOLOGICAL UNIVERSITY
–
Undergraduate Research Projects

Pasi Lautala and David Nelson,
Michigan Technological University

NURail Annual Meeting
Chicago, IL
June 3-4, 2015

Overview

- Senior Design / Enterprise structure
- Diverse projects and students
- Center Beam Railcar Conversion
- UP Shunt
- Wayne Industries Warehouse Plan
- Ongoing and Future Projects



Senior Design / Enterprise Structure

- Senior Design
  - Typically a two-semester program
  - Term I: Research, design, and analysis
  - Term II: Prototype construction and validation
  - Teams of 4-6 students (all seniors, but potentially from multiple disciplines)
  - Industry sponsored
- Enterprise
  - Undergraduate student-driven companies (20-100 students working on multiple projects)
  - 25 enterprises in various departments
  - 2+ year program
  - Potential for multiyear projects
  - Industry sponsored

Slide 4

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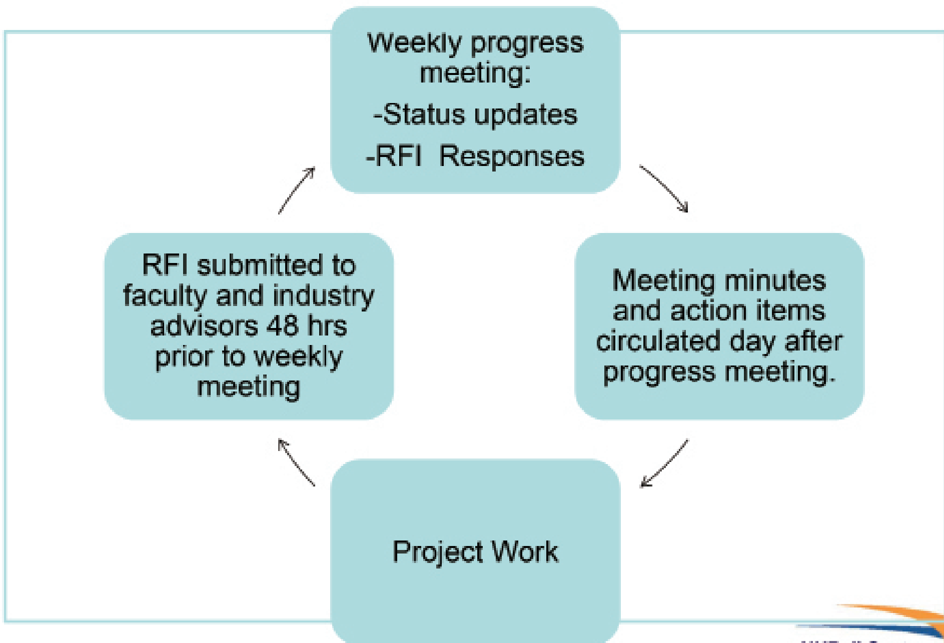
Project Coordination

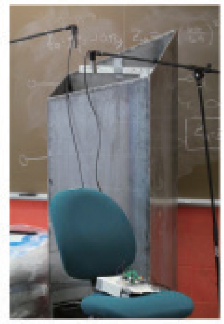


Recent / Current Student Projects

Project	Majors	Sponsor
Locomotive Sand Level Sensor	EE	Union Pacific
Type E Coupler Redesign	ME, MSE, CE	RTP (Amsted, BNSF, TTCI)
Grade Crossing Surface Perf. Evaluation	CM, CE	MDOT
RTP Promo Video	HU, SBE	RTP
Intelligent Grade Crossing Signal Maintainer	EE	Union Pacific, Norfolk Southern
Centerbeam Rail Car Conversion & Box car insulation	ME	RTP (E&LS)
TEN Market Study	EE, SBE	Tech Exp. Network
System to Measure the Effectiveness of a Rail Shunt	EE	Union Pacific
Wayne Industries Warehouse Expansion	CEE	Wayne Industries

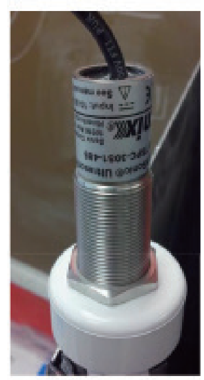
Locomotive Sand Level Sensing

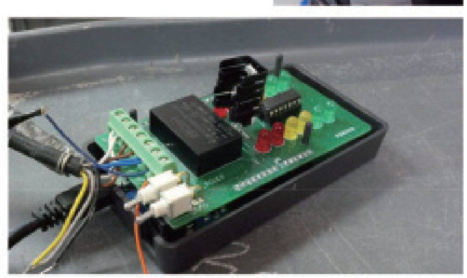
- Dangerous conditions
  - Wet, slippery, high risk of falling
- Wasted man-hours
  - Checking/Filling tanks that are already full
  - Can't leave yard, if uncertain levels
- Large chance of error
  - Looking in a small hole with a flashlight



Solution – Ultrasonic sensor with waveguide tube and digital readout.

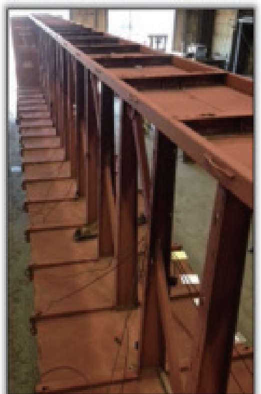
- Piezoelectric Crystal, 128 kHz
- Stainless Steel Housing, range 4 inches – 10 ft
- LED Display Board
- Can be Retrofit to Older Locomotives
- Future upgrades could talk with rail yards and sanding towers.
- Perforated PVC waveguide





Center Beam Rail Car Conversion

- Thousands of idle centerbeam railcars stored in UP of Michigan (at least was…)
- Demand for other types
  - Frac sand..
- Objectives
  - Load capacity
  - Complexity
  - Time
  - Cost
  - Rail weight constraints



Center beam railcar top angle

Center beam railcar

Slide 9

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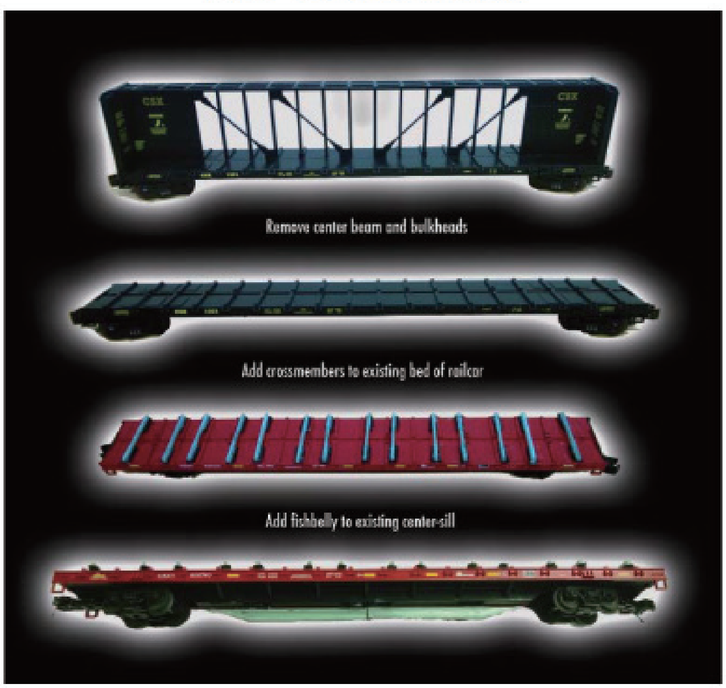
The Conversion



Conversion process

Slide 10

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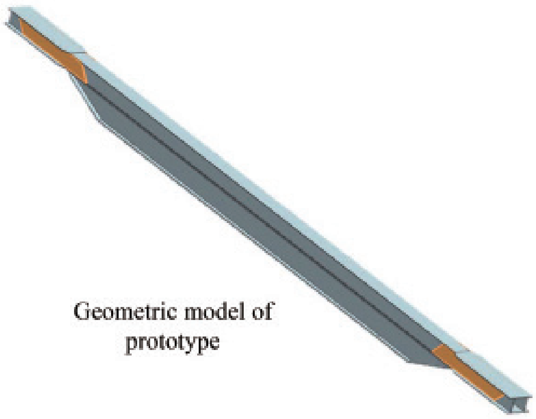
Prototype Design & Testing



Geometric model of prototype

Prototype testing setup

Slide 11

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UP SCD SHUNT – MEASURING THE EFFECTIVENESS OF A RAIL SHUNT

Purpose

- Test and calibrate equipment
- Improve accuracy
- Provide protection
- Enabling automation

Method

- Performed using two rail clamps connected by wire
- Hard-wired (no resistance)
- Low-resistance (0.06 Ohms)

Rail Shunt Clamp (0.06 Ohms)

Problem

- Appropriate resistance is not always achieved
- Corrosion issues
- Inadequate clamping force / failure of shunt device

Slide 12

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Proposal

- Kelvin Bridge
- Multiple point clamp
- Custom electric circuit
- Microcontroller
- Instant feedback and status

Problems

- Compatibility with existing track systems
- DC and AC signals
- Frequencies
- Durability and Reliability
- Accuracy of device

Original Modified Shunt Clamp (0 Ohms)

Laboratory outcomes

- Kelvin Bridge must use specialized power sources
- Microcontroller recalibrates device before each usage
- New shunt clamp parts machined from stainless steel and high grade plastic.

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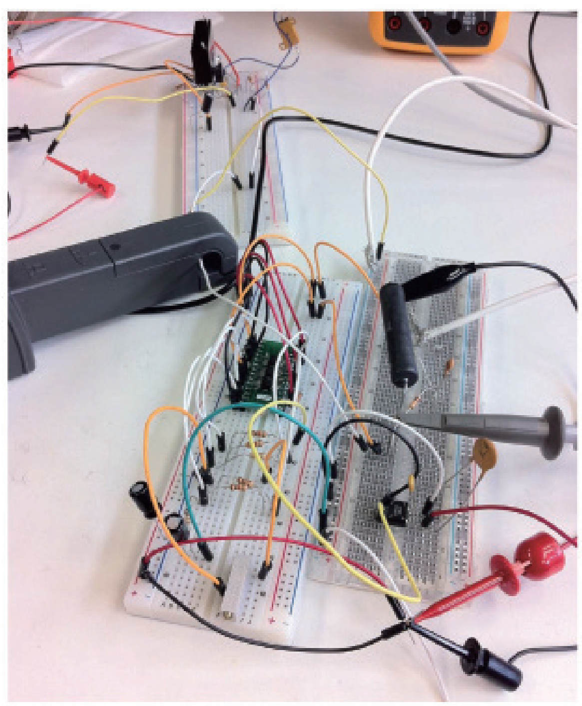
Laboratory outcomes

- Power source works
- Results in progress
- Fine tuning and filtering in progress

Conclusion

- Acknowledgement of good shunt connection possible
- Existing rail shunts can be modified
- Accuracy of calibrations
- Safety improvements
- Other future applications for automation



Prototype circuit for testing

Slide 14

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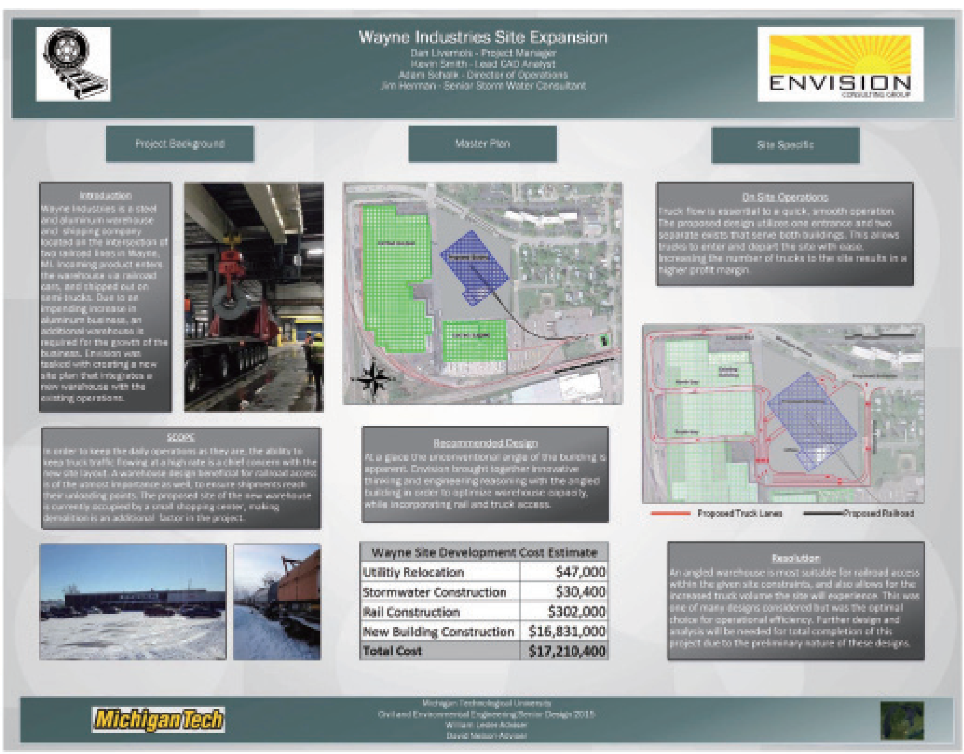
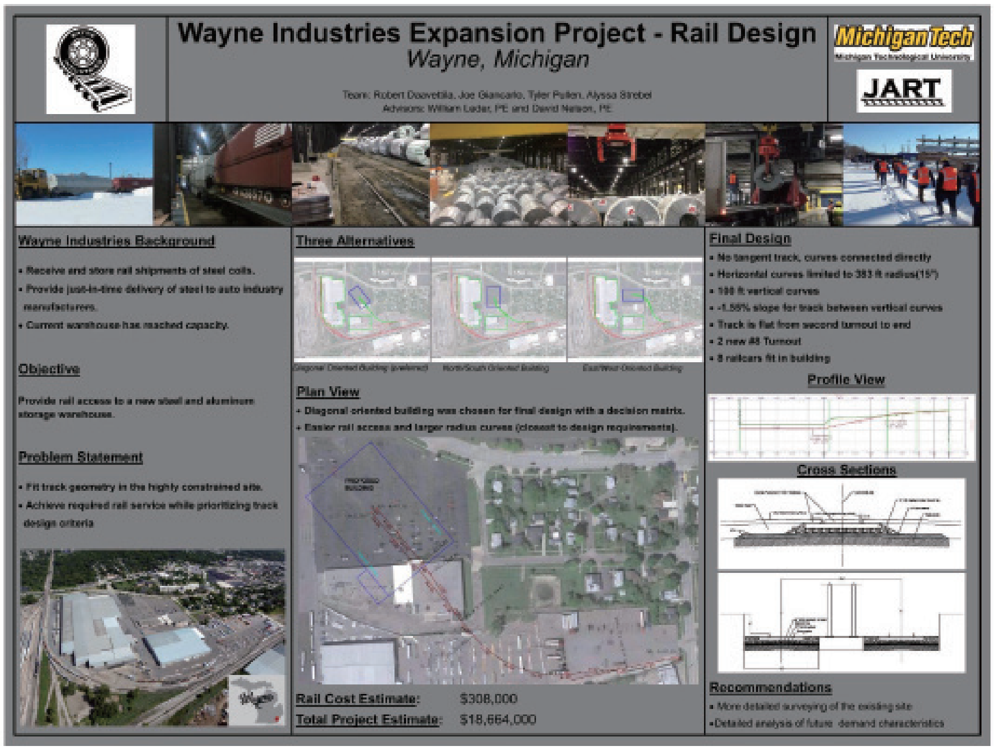
Wayne Industries Warehouse Expansion

Rail Served Warehouse on site of current Kroger facility and strip mall





Slide 17

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Slide 18

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Ongoing and Future Student Projects

Project	Majors	Sponsor
Redesign spike puller	ME, CE, MSE	BNSF
Insulation package for boxcar	CM, ME, MSE	WSoR
Yard Improvements, Saginaw	CE, SU, ENVE	Lake State Railway, MDOT
Wheel Contaminant Sensor	MSE, CM, ME	NS, UP
Dye Penetrant Rail Flaw Detector, Winter	MSE, CM, ME, CE	CN?
Peshekee Yard Expansion	CE, ENVE	Longyear

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THANK YOU!

- Center Beam Senior Capstone Design Team, E&LS Railroad
- UP Shunt Senior Capstone Design Team, Tom Bartlett, Union Pacific

"This project was supported by the National University Rail (NURail) Center - a US DOT RITA University Transportation Center"

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

Michigan Tech · MIT Massachusetts Institute of Technology · UIC University of Illinois at Chicago · Illinois · Rose-Hulman Institute of Technology · UK University of Kentucky · The University of Tennessee Knoxville

Slide 20

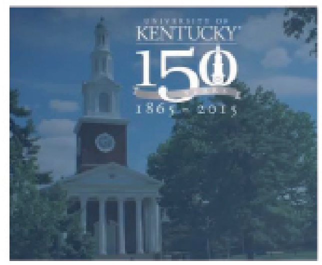
University of Kentucky
Rail Highway Crossing Research Implementation

Jerry Rose and Reg Souleyrette, PIs

Brett Malloy, Graduate Research Assistant

Kentucky Transportation Cabinet (DOT), partner agency

Norfolk Southern, TTI, and Paducah and Louisville, informal partners



History

- >200,000 crossings in the USA
- UK: 30 years of research on structural support
- Kentrack program
- Current work on evaluation, management, and guidance

Evaluation

- Performance
  - Maintenance
  - Life
  - Performance
  - Disruption
  - Rideability

Slide 3

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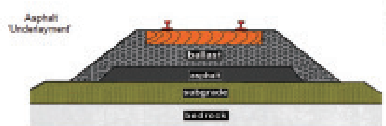
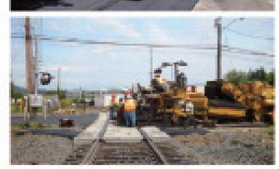
Problems Addressed

- Track pumping
- Ballast fouling
- Track settlement



Solution



- Asphalt underlayment
- 11 US agencies and RRs identified
- Performance of 89 problem crossings evaluated (10-30 years)
- Zero failures!

Slide 4

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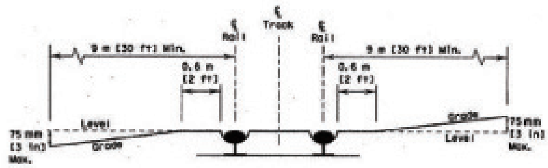
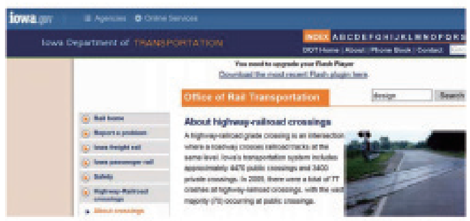
Management

- Guidance referenced
  - AASHTO
  - AREMA
  - FRA
  - FHWA
  - MUTCD
  - Several states (Illinois, Indiana, Iowa, Georgia, Michigan, and West Virginia)





Slide 5

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Typical Rubber Seal/Asphalt Crossing Surface

Slide 6

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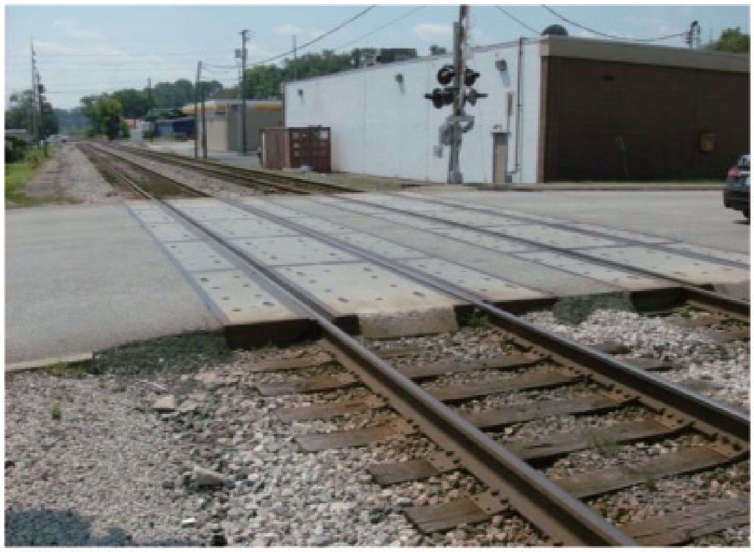
Typical Concrete Panel Crossing Surface



Slide 7

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Typical Timber/Asphalt Crossing Surface

Slide 8

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Typical Composite Crossing Surface

Slide 9

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Management Conclusion

- Technology-based design parameters and crossing management techniques for assessing optimal engineering solutions are now common practice for agencies responsible for crossing management and oversight.
- Several models for guidance assessed and presented

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Guidance

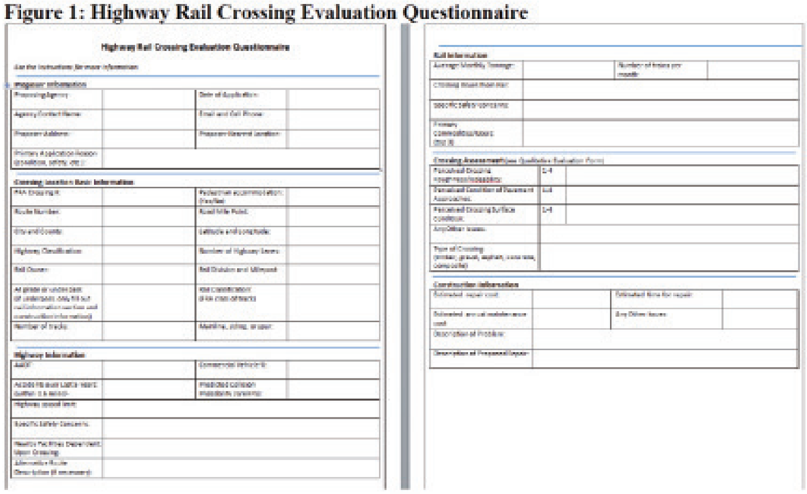
- Recommendations and guide
  - Step-by-step guidance to see a project from its planning stages through to its implementation and post-construction management
  - Pre-project administration, including economic appraisal
  - Rehabilitation activities
  - Post-project administration.

Pre-project Administration

- reviewing historical maintenance cost data
- determine the optimal rehabilitation method
  - using an intuitive decision-option diagram
- categorizing/separating major work and cost items
- calculating unit costs
- evaluating the cost effectiveness of various alternatives
- selecting a design

Economic appraisal

Figure 1: Highway Rail Crossing Evaluation Questionnaire



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Spreadsheet Tool

Index Tab from Scoring Workbook

Crossing	Assessment of Roughness/Rideability	Assessment of Crossing Surface Material	Assessment of Crossing Pavement Approaches	Predicted Collision Probability	Index Score
Line X	3	2	3	10.50%	185.56
Line Y	2	4	4	15.25%	248.56
Line Z	1	3	2	5.54%	147.21
					0.00
					0.00
					0.00
					0.00
					0.00

Economic Valuation Tab from Scoring Workbook

Crossing	AADT	% Trucks	Total Trucks	Truck Value (Truck GDP/Registrations)	Current Daily Truck Economic Impact	Monthly Tonnage	Number of trains per month
Line X	2354	10%	235	$8,677	$2,042,566	750000	150
Line Y	6520	25%	1630	$8,677	$14,143,510	450000	100
Line Z	1050	50%	525	$8,677	$4,555,425	900000	30
0			0	$8,677	$0		
0			0	$8,677	$0		

Total Tab from Scoring Workbook

Crossing	Index Score	Economic Impact of Crossing	NPV Cost of Crossing Rehab and Maintenan	Economic Impact-Cost (Importance)	Index Score Rank	Economic Impact Rank	Cost Rank	Economic Impact-Cost (Importance) Rank
Line X	185.56	$2,199,300	$238,554	$1,960,746	2	3	3	3
Line Y	248.56	$14,237,550	$332,108	$13,905,443	1	1	2	1
Line Z	147.21	$4,743,506	$410,662	$4,332,844	3	2	1	2

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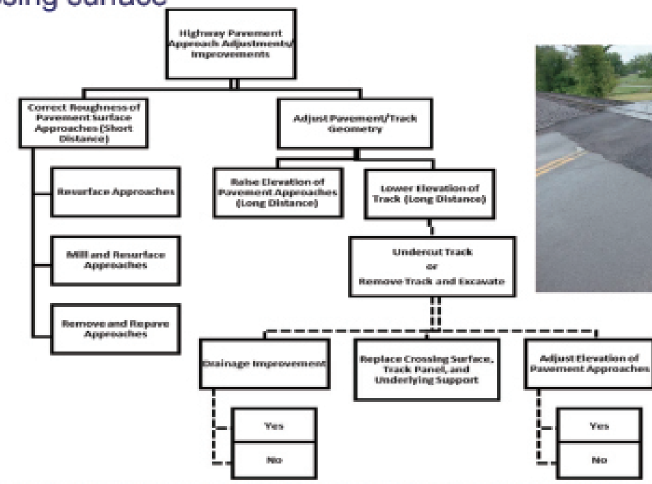
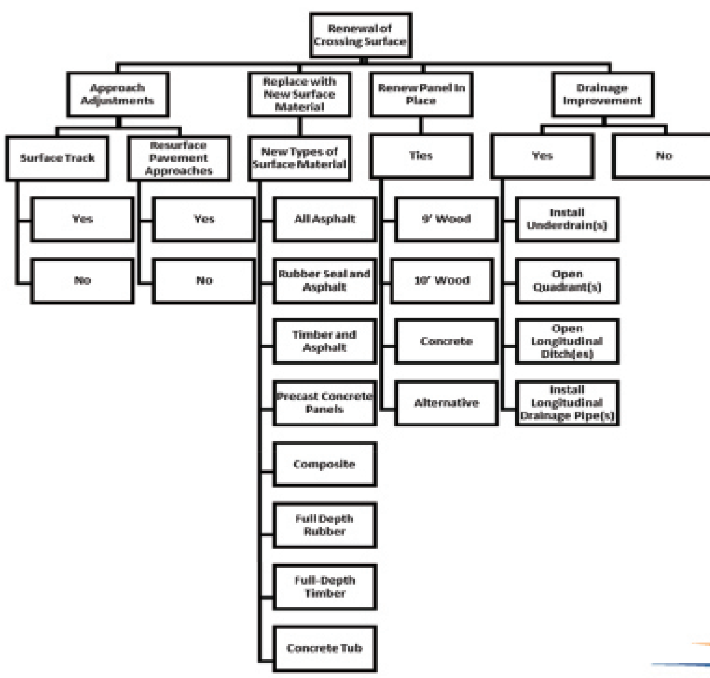
Rehabilitation Activities

- adjusting/improving the highway pavement approaches
- removing and replacing the crossing surface material
- removing and replacing the structural sub-layers, track, and crossing surface



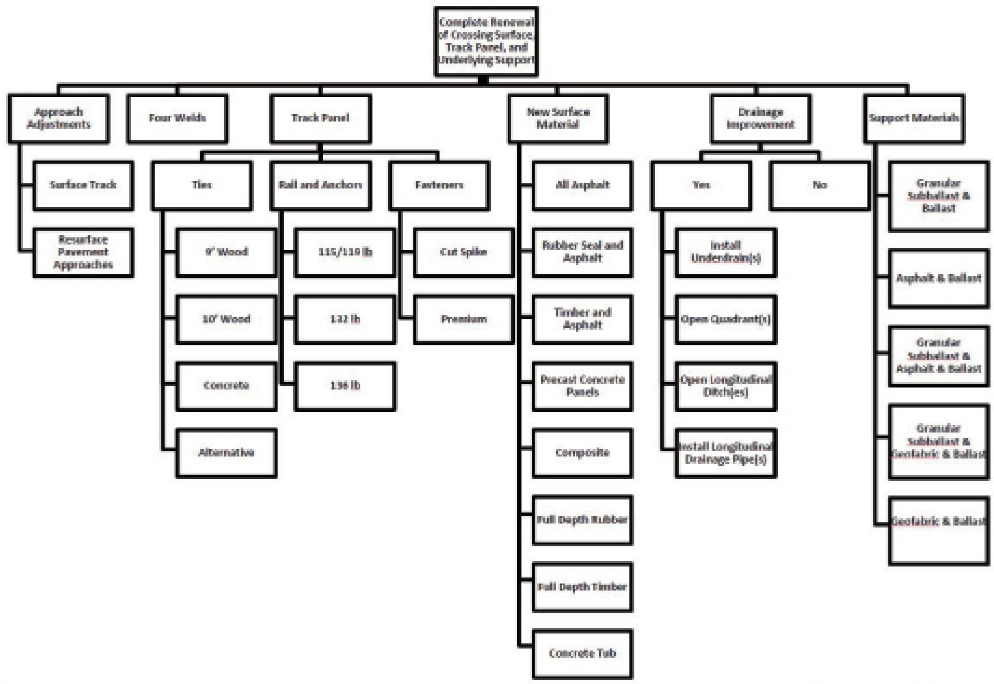
Slide 15 *Adjustments/Improvements to the Highway Pavement Approaches Decision-Option Diagram* NURail Center

Renewal of Crossing Surface Decision-Option Diagram



Slide 16 NURail Center

Complete Renewal of Crossing Surface, Track Panel, and Underlying Trackbed Support Decision-Option Diagram



Post-project Administration

- post-installation inspection
- reinstalling drainage
- disposing of the released track material
- clearing vegetation from the immediate crossing area

Bottom Line

… with this guidance, KYTC is in a better position to provide a safe, smooth, cost-effective, economical crossing with long service life.

Slide 19

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HSR as a Complex Sociotechnical System

Professor Joseph Sussman
MIT

NURail Annual Meeting, June 3,4, 2015

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Complex Sociotechnical Systems

- Complex Sociotechnical Systems (CSS)
  - Complex in the sense of a high degree of connectivity, feedback and uncertainty
  - A high degree of technological complexity
  - Substantial and wide-ranging social impacts

Regions/HSR Research Group
web.mit.edu/hsr-group

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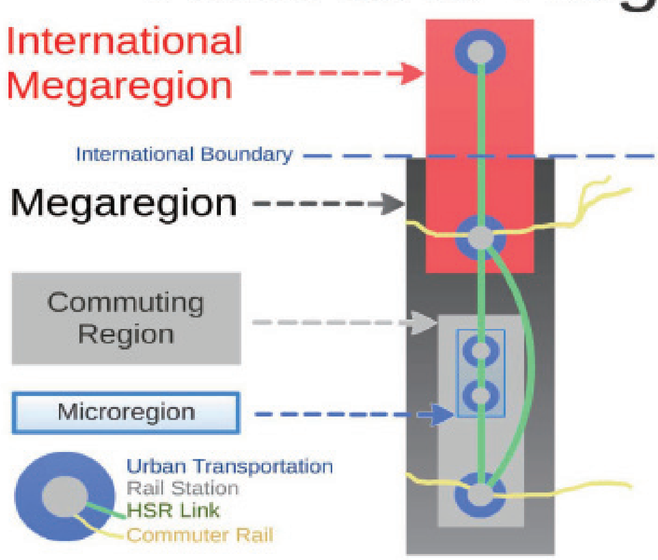
HSR and Regions



Motivation

- Globalization has magnified the role of **regions**, restructuring social and economic relationships into networks that span increasing distances.
- At the same time, greater attention is paid to **urban quality**, as non-vehicular modes and compact forms of development become critical in an **environmentally conscious** world.
- HSR has the potential to **integrate cities into mutually supportive networks** across long distances while also supporting more sustainable forms of development.
- For HSR to become a sustainable investment, however, requires **coordinated policy** efforts across levels of government and at different points in a project's life-cycle.

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Research Goal

The goal is to improve understanding of the
role that HSR could play in guiding sustainable future growth.

Image source: http://www.sustainablesch... /uploads/2011/09/3Es-diagram.jpg

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A Systems Perspective

To help address the complexity of HSR systems, our work:

examines ways of coupling **institutional change with technological change**

- addresses the importance of **uncertainty** as a driver of system behavior
- investigates **multiple scales** of both the physical environment and institutional sphere

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Discontinuous Regions

- Our analysis concerns **inter-jurisdictional relationships**
- Special attention is paid to **cities** brought within one-hour's travel time of a larger metropolis by HSR services
- Mid-distance service (<250 km) has strong spatial implications and can expand connections to the scale of new ***discontinuous regions***—single labor and commercial markets that spans long distances but do not include all intermediate areas.

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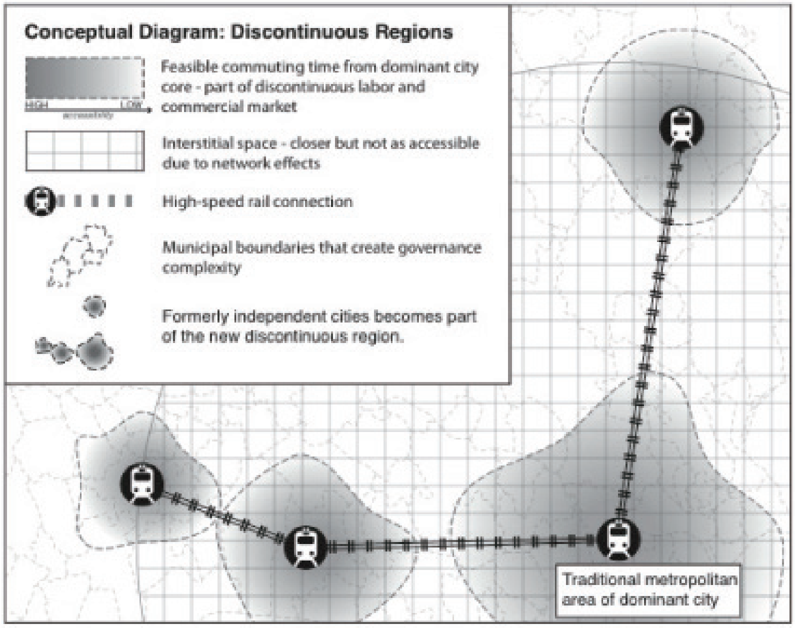

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"High-speed rail infrastructure should not be considered the end objective, but rather the initiation of a long process of developing actions and strategies to enhance its effects."

osé Maria de Ureña, "Preface," in Territorial Implications of High Speed Rail: A Spanish Perspective, ed. José Maria de Ureña (Farnham, Surrey ; Burlington, VT: Ashgate, 2012), xix.

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Our HSR research (* denotes completed thesis)

- Northeast Corridor
  - Capacity Allocation *
  - Safety *
  - On-time performance *
  - Productivity *
  - Penn Station
- California *
- Singapore/ Kuala Lumpur *
- Comparative Study *
  - Chicago/ Kankakee/ Urbana-Champaign
  - Lisbon/ Lieria/ Coimbra

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Northeast Corridor (NEC) 101

- 457-mile Washington – Boston
- Crosses eight states
  - (MA, RI, CT, NY, NJ, PA, DE, MD) and DC
- Amtrak owns 79% (363 miles)
  - MNRR 56 miles, MBTA 38 miles
- Shared-use rail corridor
  - 153 Amtrak including Acela Express, Northeast Regional, other
  - 2,000 commuter trains
  - 70 freight trains daily
- Busiest railroad in the U.S
  - ~750,000 daily riders (Amtrak and commuters)

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ANALYZING CAPACITY PRICING AND ALLOCATION MECHANISMS IN SHARED RAILWAY SYSTEMS –

Lessons for the Northeast Corridor

Maite Pena-Alcaraz, PhD, MIT

MIT Regional Transportation and HSR Group
Research Advisor: Professor Joseph M. Sussman

NURail Annual Meeting
Chicago, IL
June 3, 4 2015

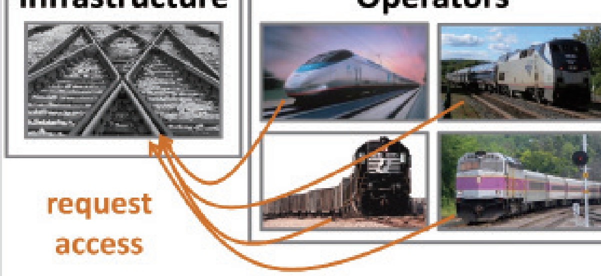
Introduction – Motivation

Past (up until 1988):
Integrated railway companies

Railway Company

Today (last 10-15 years):
Promotion of shared systems

Infrastructure **Operators**



Capacity Pricing and Allocation Mechanisms:
Rules to decide who gets access to the tracks, when and at what price

+ Efficient use of infrastructure
+ Introduction of competition
– Coordination problems

Image credits: infrawindow.com, evworld.com, riverfarmproperties.com, america2050.org, hamptonroads.com

References: Drew, 2006; Gomez-Ibanez, 2003

Research Question

How do alternative **capacity pricing and allocation mechanisms affect** the **performance** of **shared railway** systems?

Performance *(multiple criteria)*:

- **infrastructure manager** (cost recovery, utilization)
- **train operators** (timetable, access charges)
- **end users** (timetable, fares)

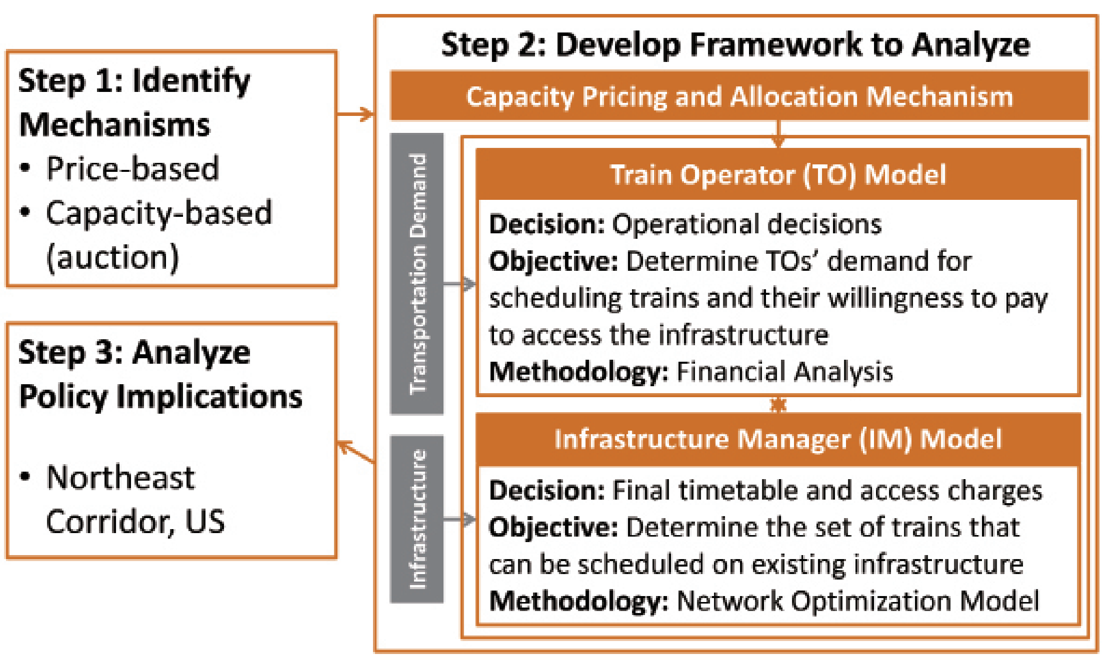
Thesis objectives

1. Identify and study representative mechanisms for capacity pricing and allocation

2. Develop a framework to evaluate them

3. Understand and communicate trade-offs between different mechanisms for pricing and allocating railway capacity

Research Plan & Methodology



Northeast Corridor – Results

Today's Bilateral Contracts

- Train services: **153 intercity, 458 commuters**
- IM Revenues: **$0.8m per day (10% recovery** considering a need of $7.1m per day from 2010-2030 for state-of-good-repair; Gardner, 2013**)**

Price-based Mechanism
Proposed by NEC Commission, 2009

- Access charges: **$50 per train mile**
- Train services: **60 intercity, 284 commuters**
- TOs' profits: **$0.3m per day**
- IM revenues: **$4.2m (60% recovery)**

Capacity-based (auction) Mechanism
Proposed by Affuso, 2003; Perennes, 2014

- Access charges: **$50 per train mile**
- Train services: **118 intercity, 325 commuters**
- TOs' profits: **-$0.5m per day**
- IM revenues: **$6.0m (85% recovery)**

- **More profits for train operators**
- **Easier to implement**
- **20% more services**
- **20% more infrastructure revenues**
- **NEC stakeholders** should **analyze alternative mechanisms** before **locking** their systems into one of them

Pena-Alcaraz, Sussman, Webster, Perez-Arriaga (2015)

Research Takeaways

1. Railway infrastructure **shared use requires capacity pricing and allocation mechanisms** for coordination purposes
2. The **analysis** of such mechanisms **requires frameworks that consider interactions between infrastructure operations and infrastructure capacity**
3. There are **important trade-offs** among alternative capacity pricing and allocation mechanisms
4. The design and implementation of **adequate mechanisms help mitigate coordination problems and preserve benefits** of shared railway systems

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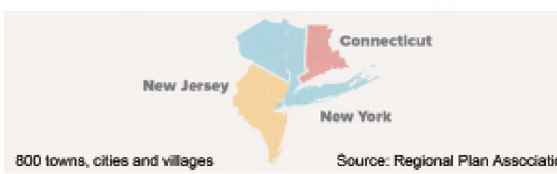
IMPACT OF HUB STATION GOVERNANCE ON REGIONAL TRANSPORTATION SYSTEMS

A case study of Penn Station, NYC

Rebecca Heywood, Graduate Research Assistant, MIT

MIT High Speed Rail and Regional Transportation Group
Professor: Joseph Sussman

Penn Station | Institutional sphere



- *Railroads*
  - Amtrak
  - LIRR
  - NJT
  - MNR
- *Regional Organizations*
  - Port Authority
  - Regional Plan Association (non-profit)
  - NYMTC
  - NJTPA
- *DOTs*
  - New York
  - New Jersey
  - Connecticut
- *City Planning Agencies*
- *Civil Society*
  - Straphangers Association
  - Municipal Arts Society
- *Transit Agencies*
  - MTA
    - NYC Transit
  - New Jersey Transit
- *City governments*
  - Mayor of New York
- *State Governments*
  - Governors of New York, New Jersey and Connecticut
- *Federal government*

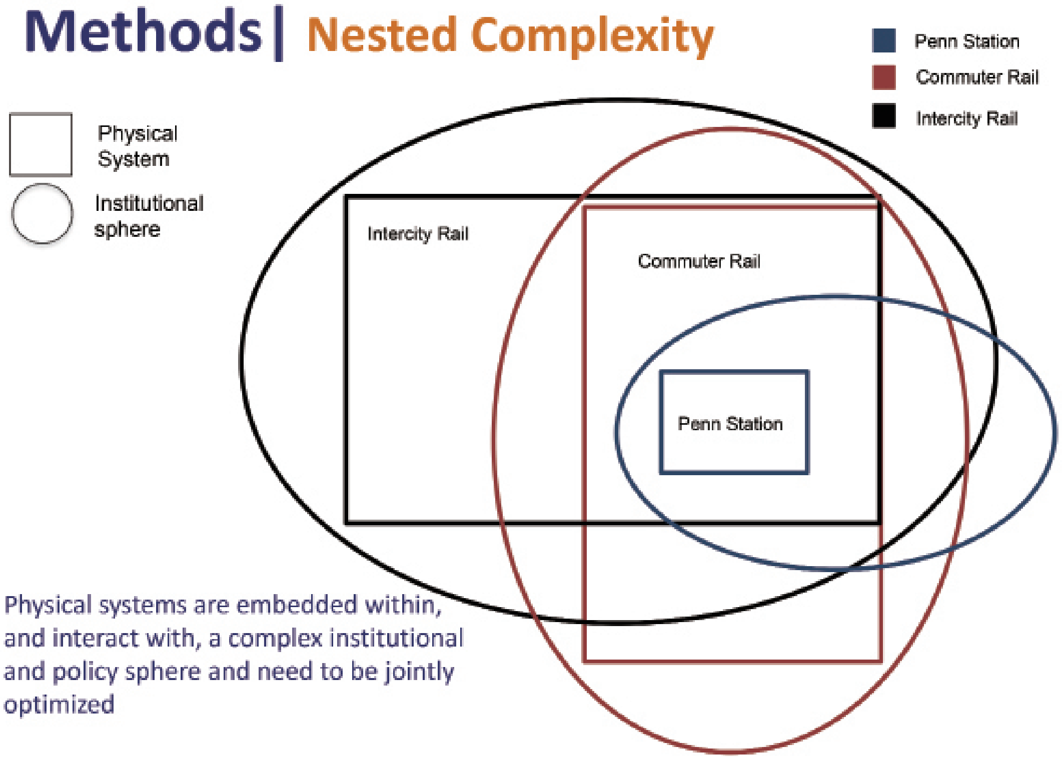
And the list goes on....

Research Question

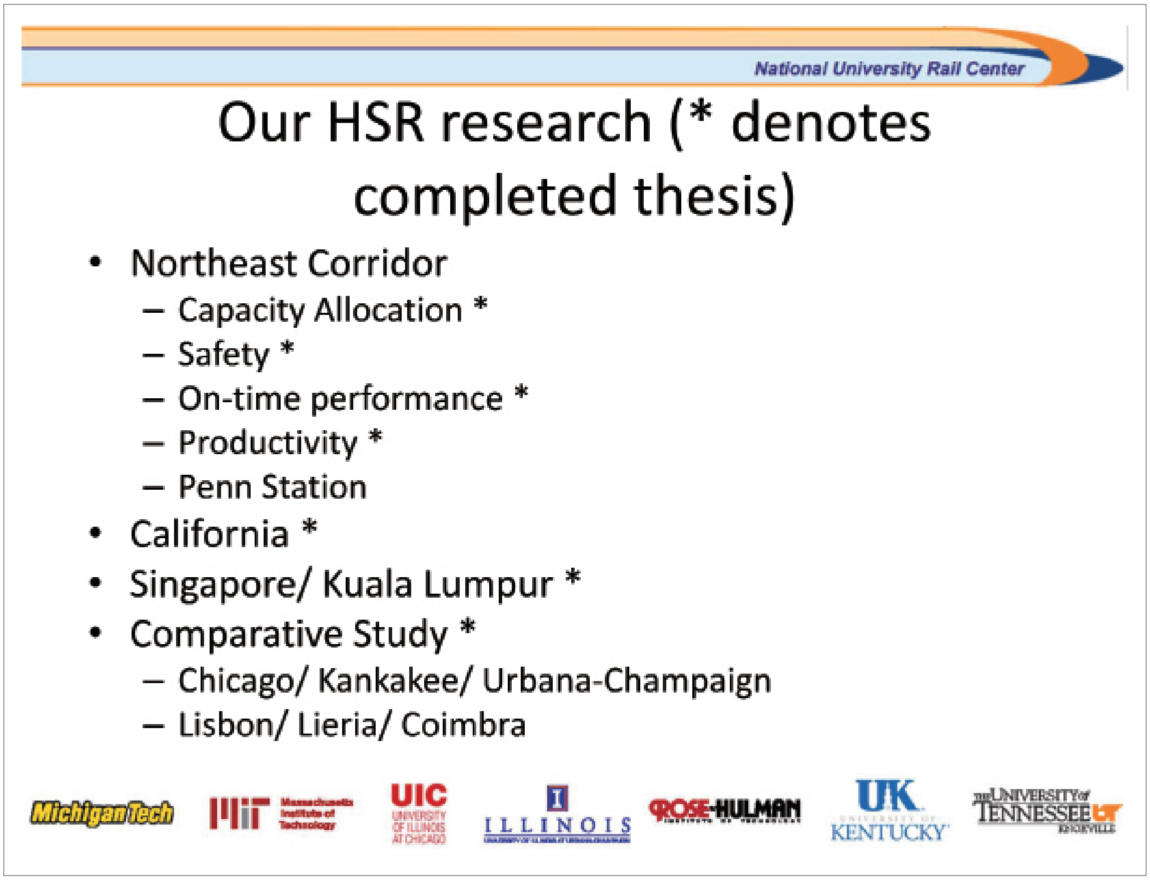
How do substantial changes in hub station governance affect station and system characteristics and service, and ultimately regional economic development?

- What is the magnitude of impact on the regional economy from changes at a station level?
- How can this understanding help better reimagine the characteristics of governing institutions and transportation authorities?

Methods | Nested Complexity



Physical systems are embedded within, and interact with, a complex institutional and policy sphere and need to be jointly optimized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Our HSR research (* denotes completed thesis)
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• California *
• Singapore/ Kuala Lumpur *
• Comparative Study *
– Chicago/ Kankakee/ Urbana-Champaign
– Lisbon/ Lieria/ Coimbra


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THANK YOU!
You can find completed theses online at our group website: web.mit.edu/hsr-group
These projects were supported in part by the National University Rail (NURail) Center – a US DOT University Transportation Center

Partnering to Create an Off Peak Delivery Pilot Program in Metropolitan Chicago

June 4, 2015
Jim LaBelle

URBAN TRANSPORTATION CENTER

The Premise

Businesses generally want deliveries during normal hours. Truckers need to meet those demands. So, most truck deliveries occur during congested peak daytime periods.

If more businesses would accept deliveries in off peak times, trucks could deliver goods faster and at less cost. That would reduce congestion and cost of goods, and yield economic and environmental benefits.

Image credit: www.flickr.com/photos/63172294@N00/8142553406/

UTC URBAN TRANSPORTATION CENTER

Our Approach to the Project

- Research
  - Literature review
  - Case studies
  - Data analysis: Zip Code Business Patterns, Hoover's Business Database, CMAP Congestion Maps
  - Draft research paper and invite critique
- Designing the Pilot Project in Partnership with Implementers
  - Primary Partner: Supply Chain Innovation Network of Chicago, a unit of World Business Chicago
  - Chicago Department of Transportation
  - Chicago Loop Alliance
  - Chicago Metropolitan Agency for Planning
  - Illinois Department of Transportation
  - And many others . . .

3

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Other Regions Have Tried OPD

New York	•Initially a pilot project with 35 receivers, the long-term program now has more than 400 participants.
PierPass, Ports of Long Beach and Los Angeles	•PierPass began OffPeak in 2005 and by 2008 shifted 45% of container cargo to off peak shifts; still reporting more than 30% shift from peak to off peak.
Barcelona	•Began in 2003 with two grocery stores receiving off peak deliveries, by 2010 spread to over 400 stores in 35 provinces.
London	•Implemented off peak deliveries during the 2012 Olympics and currently conducting OPD trials.
Dublin	•In 2011, approximately 25% of all food deliveries occurred during off-peak hours.
The Netherlands	•Fostered innovations in low-noise technologies and behaviors resulting in standards now used in over 50 cities with 1,400 quiet deliveries a week.
Orlando Pilot	•Hospital system Orlando Health is currently piloting OPD on their main campus in "South of Downtown Orlando."
Washington D.C. Pilot	•OPD was listed as a strategy to improve the movement and delivery of goods in the District's 2014 freight plan and is now being implemented through a pilot project.

4

UTC URBAN TRANSPORTATION CENTER

Traffic Congestion & Delay Cost Our Region.

- Congestion costs our economy $7.6 billion annually.
- Travel in AM peak periods takes 60% longer than free flow travel.
  - Trucks are 6-10 percent of the region's traffic.
  - Most truck traffic happens in peak times.
- Peak period deliveries cost carriers 30-40% more.
- 70 percent* of our communities reported to CMAP that peak period deliveries are a challenge.

* weighted by population

5

OPD Can Yield Significant Benefits to Rail and Intermodal Businesses and Their Customers.

- Companies up and down the supply chain can benefit.
- In the Chicago region, the six class one railroads generate 15,000 daily truck trips to and from their customers and 7,500 daily truck trips between intermodal facilities.
- According to the 2012 Commodity Flow Survey, 25% of goods destined for Chicago by train (measured by value) will make some portion of their journey on a truck.

Photo credit: Russell Sekeet, www.flickr.com/photos/73784413@N00/4599014520/

6

OPD Can Yield Significant Benefits to Carriers, Receivers, and Travelers.

- **In LA, PierPass Off Peak shifted more than 30% of traffic to off peak times.**
- **The New York City pilot project concluded:**
  - Off-hour deliveries cost carriers about 30% less – carriers save about 48 minutes in travel time and 1 to 3 hours in total service time for each delivery tour.
  - Parking fines, often exceeding $1,000 per truck per month, are reduced.
  - Increased reliability was the main reason receivers cited for continuing OPD.
  - OPD policies in Manhattan could save all highway users 3-5 minutes per trip.
  - Long term OPD policies would save between $100 and $200 million/year in travel time and pollution reduction.
  - Reduced peak time congestion makes it safer for pedestrians, cyclists and vehicles.
  - Reduced travel time leads to a reduction in environmental pollutants.

Several Factors Affect OPD Participation.

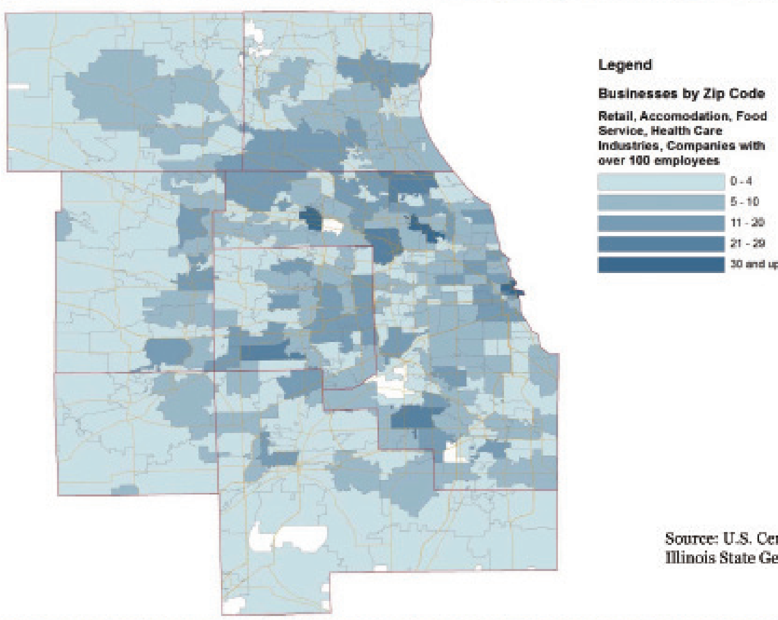
- **There is a market failure.**
  - Most of the benefits are spread throughout the greater community.
  - Carriers mostly receive positive net benefits while receivers have often perceived that their direct costs (staff, security, etc.) would exceed their benefits.
- **Businesses generally want to receive deliveries during daytime hours when they are open.**
  - Receiving businesses are the customers and specify delivery times.
  - Carriers must meet required pick-up and delivery times of shippers and receivers.
- **Location and industry type can affect participation.**
  - Businesses most receptive to off-peak deliveries are those that would likely be open anyway, such as restaurants, bars, hotels, 24-hour supermarkets, medical facilities and many retailers.
  - Larger establishments, buildings with many businesses and more densely developed areas yield greater savings in the number of truck trips and cost effective implementation, as added costs can be shared among more customers.

Unassisted off peak delivery may have more potential for some types of businesses.

- It involves providing a setting for unassisted drop-offs.
- It may require some investment to create a secure area – options include:
  - Delivery lockers
  - Double doors
  - Electronic key boxes
  - Virtual cages with deliveries entered through a hand-held scanner
- Less ongoing staff expense can enhance long term success.

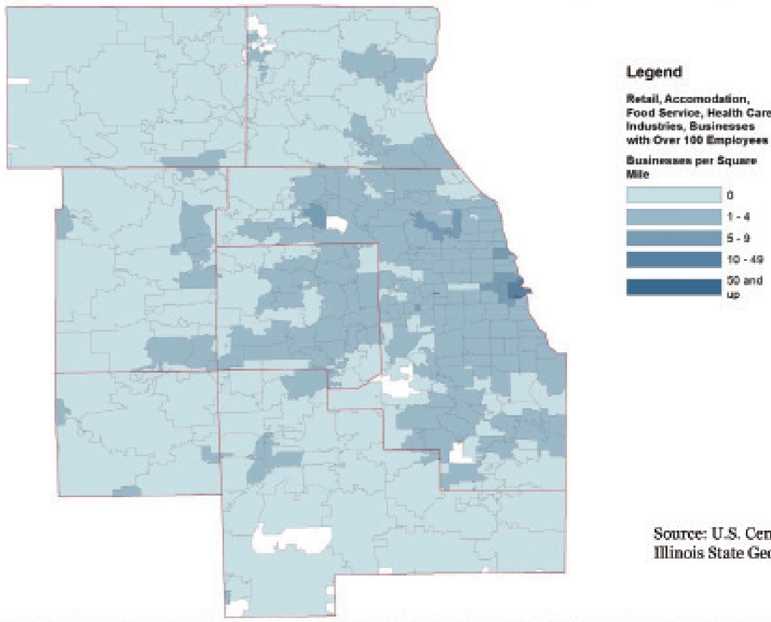


OPD Target Locations: Selected Industries, Companies with over 100 Employees by Zip Code



Source: U.S. Census Bureau, Illinois State Geological Survey

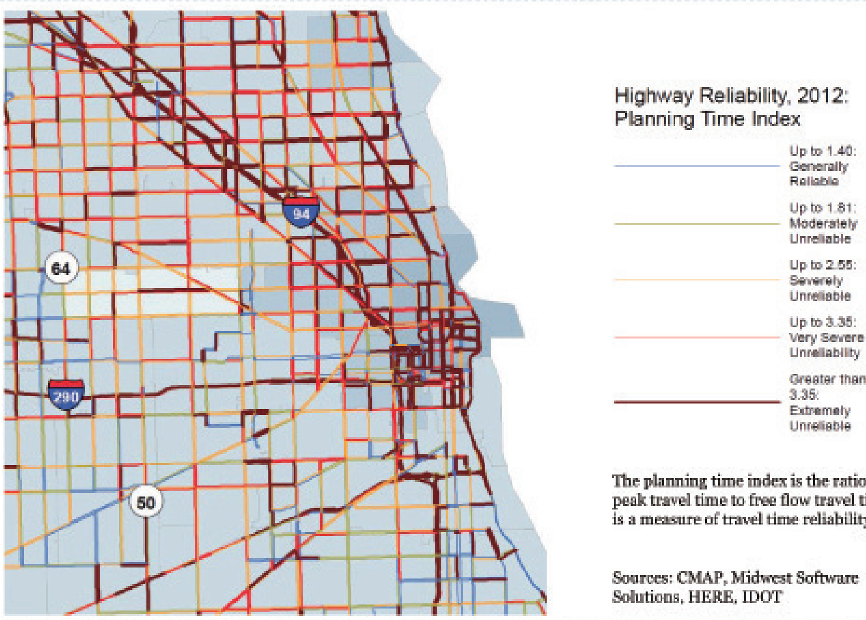
OPD Target Locations: Density of Selected Industries, Companies with Over 100 Employees by Zip Code



Source: U.S. Census Bureau, Illinois State Geological Survey

UTC URBAN TRANSPORTATION CENTER

Congestion: Travel Time Reliability

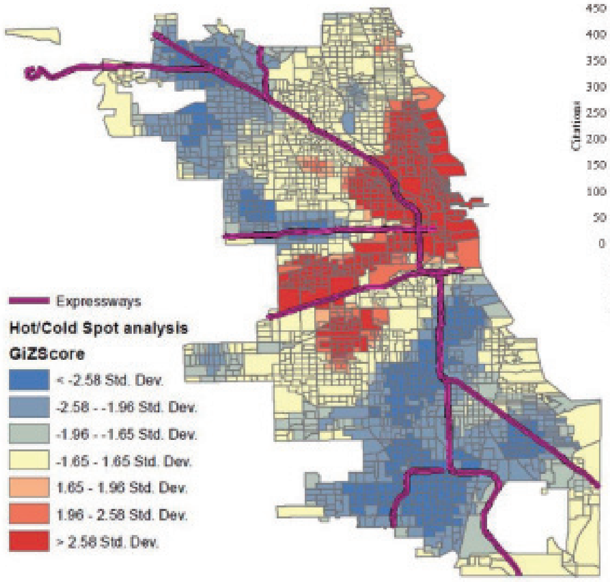


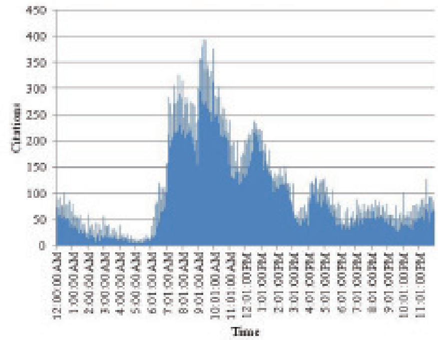
The planning time index is the ratio of peak travel time to free flow travel time. It is a measure of travel time reliability.

Sources: CMAP, Midwest Software Solutions, HERE, IDOT

UTC URBAN TRANSPORTATION CENTER

Parking Ticket Violation Hot Spots and Time Of Day





Prepared by: Kazuya Kawamura, P.S. Sriraj, Havan Raj Surat, Martin Menninger, College of Urban Planning and Public Affairs and Urban Transportation Center, UIC (Analysis of Factors Affecting Truck Parking Violation Frequency in Urban Areas)

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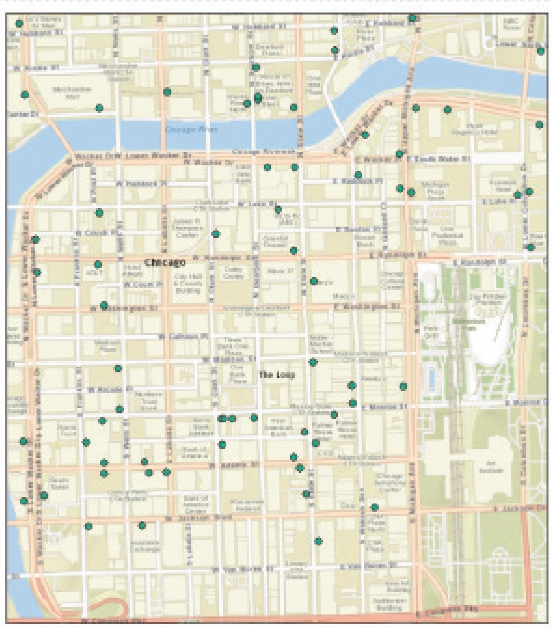
Loop Off Peak Delivery Receiver Candidates



Source: Mergent Intellect

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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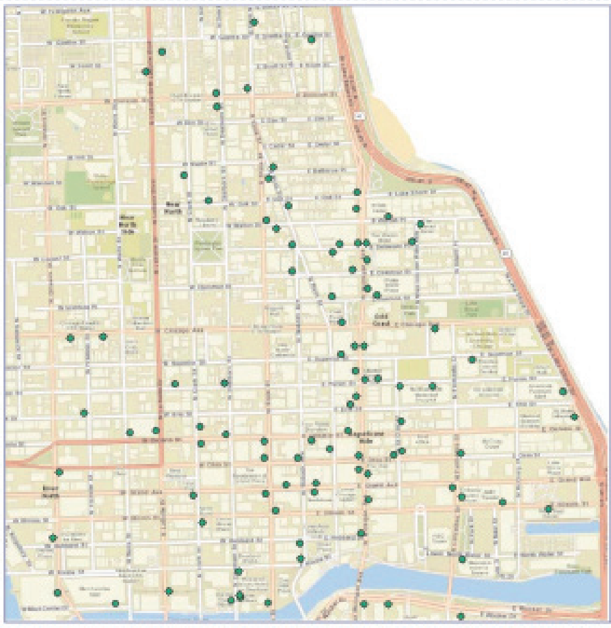
North Michigan Avenue Area Off Peak Delivery Receiver Candidates



Source: Mergent Intellect

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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Incentives can attract participation.

- Public recognition – who wouldn't like that?
- Direct monetary incentives – subject to funding
- Discounted pricing by carriers – could be coordinated
- Organized business support and encouragement
- Discounted fees from governments or businesses
- List of "Trusted Vendors" that certify quiet delivery practices

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Possible models for an OPD program

Traditional Approach –

Using grant funding as a financial incentive as in the New York pilot, seek out receivers in a particular corridor or area to implement off peak delivery on a trial basis.

One Large Receiver Approach –

Identify one large receiver to be a demonstration project. A major healthcare facility would have ideal scale and volume. This may or may not require a financial incentive; none was needed in Orlando.

Package Approach –

Piece together an attractive package of discounts and non-monetary incentives, such as:

- Public recognition through a coordinated program
- Coordinated direct discounts by carriers to receivers for off peak deliveries
- Coordinated participation by receiving businesses
- Discounted fees and charges from governments and supportive businesses.
- One-time funding for physical improvements such as storage lockers for unstaffed OPD or sound-reducing technologies (if funds are available).
- Other financial incentives
- List of "Trusted Vendors" that certify certain safe and quiet delivery practices

Any of these approaches would need coordinated administration and publicity.

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Key decisions are needed.

- Design and location(s) for the pilot
- Gaining participation of:
  - Receiving businesses
  - Carriers
- Incentives
- Type of OPD (staffed, unstaffed or both?)
- Administrative requirements
- Budgeting and paying for the program:
  - Can it pay for itself?
  - Grants needed?
  - Sponsorships?
- Publicity and communication
- Possible supportive government actions

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We are grateful for the contribution of data, advice, and information from many partner organizations, including: Supply Chain Innovation Network of Chicago, Chicago Metropolitan Agency for Planning, Chicago Department of Transportation, Illinois Department of Transportation, World Business Chicago, Rensselaer Polytechnic Institute, New York City Department of Transportation, Florida Department of Transportation, District of Columbia Department of Transportation, and PierPass.

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National University Rail Center

NURail Center

U.S. DOT OST-R Tier 1 University Transportation Center

Rail-Trespassing Crashes in the Past Decade: Analyzing Injury Severity

Reporter: Asad Khattak, Ph.D.
Beaman Professor of CEE, University of Tennessee, Knoxville

THE UNIVERSITY OF TENNESSEE KNOXVILLE

TESP

Broad research issues

- Big Data—crash + inventory + social media + GPS + video…
- Computational power
- Analytics-MS&V
  - Pre-crash behaviors-path analysis
  - Geographically weighted regressions
  - Naturalistic driving & driving data analytics-GPS data
- Frequency and severity
- Rail trespassing crashes, derailments, crude oil, …
- Countermeasures: behaviorally-based & spatially appropriate

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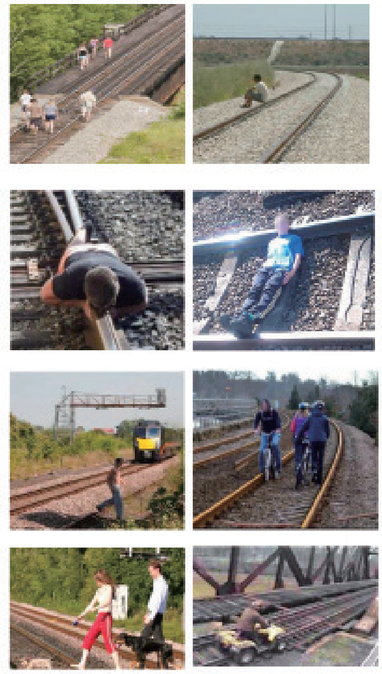
Introduction

- Trespassers–individuals who commit the act of trespassing on railway property without the permission of the property owner

- Railroad trespassing (other than at designated grade crossings)
  → Crashes with trains
  → Costs billions of dollars annually in injuries and fatalities



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Research objectives

- Focus on non-crossing rail-trespassing (limited in literature)
- Take advantage of Geo-referenced data
- Research questions:
  - How are rail-trespassing crashes distributed spatially in the US?
  - What are the correlates of trespasser injuries?
  - Do correlates vary in space?

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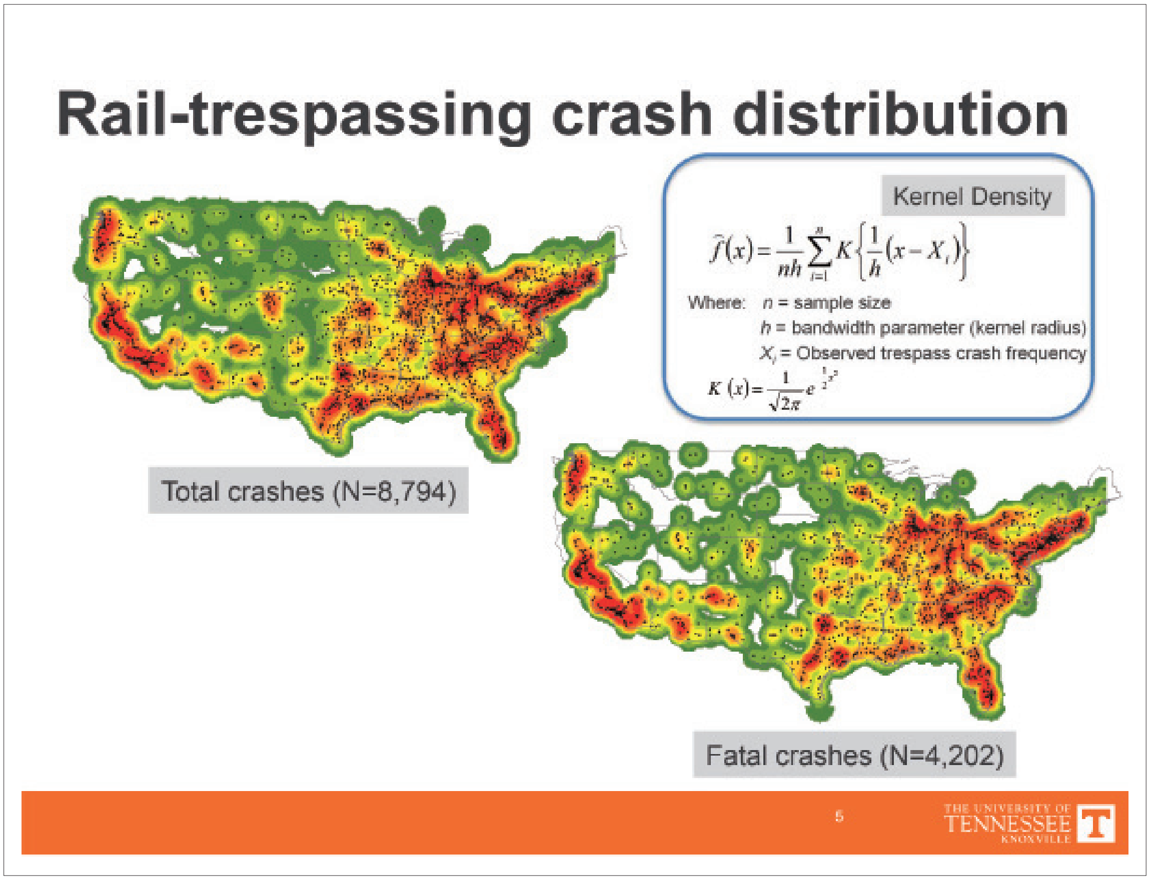
Rail-trespassing crash distribution
Kernel Density
$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left\{\frac{1}{h}(x - X_i)\right\}$
Where: n = sample size
h = bandwidth parameter (kernel radius)
X_i = Observed trespass crash frequency
$K(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
Total crashes (N=8,794)
Fatal crashes (N=4,202)
5
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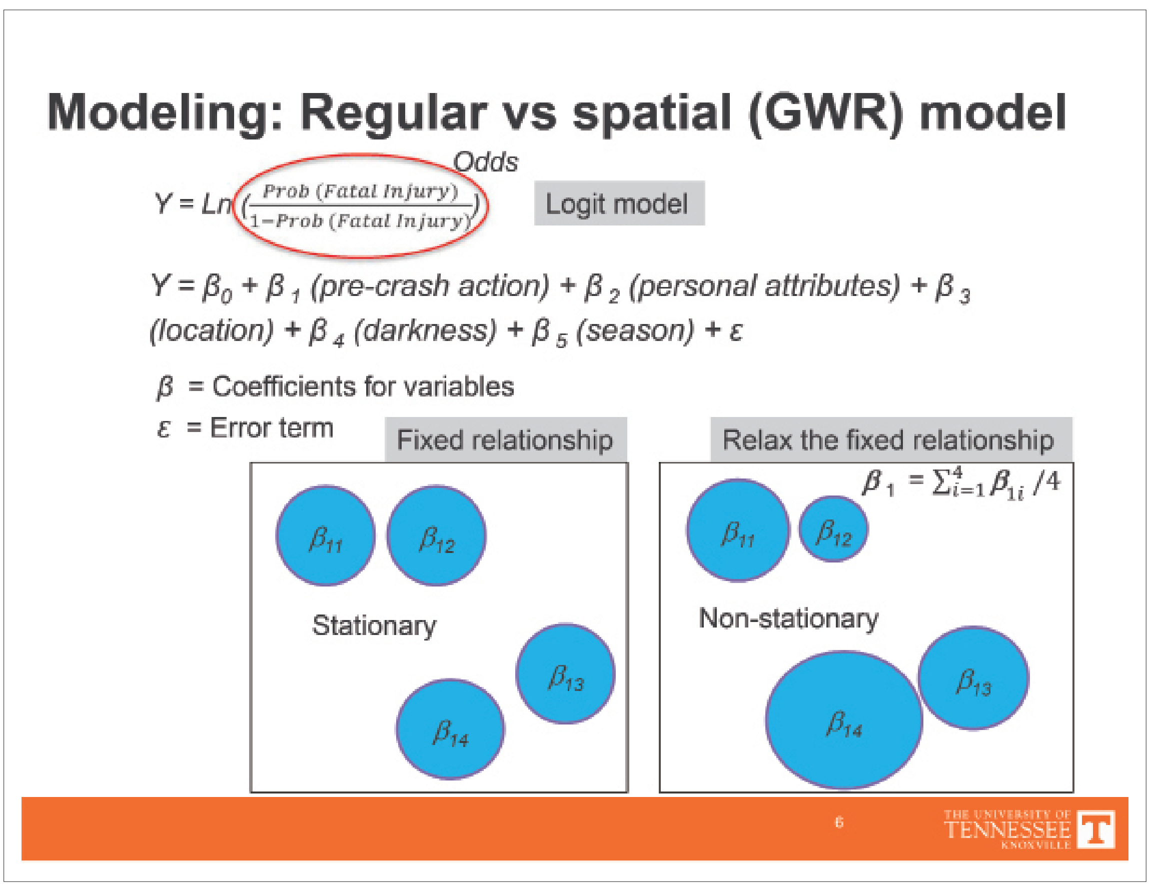
Modeling: Regular vs spatial (GWR) model
Odds
$Y = Ln\left(\frac{Prob\ (Fatal\ Injury)}{1 - Prob\ (Fatal\ Injury)}\right)$
Logit model
Y = β_0 + β_1 (pre-crash action) + β_2 (personal attributes) + β_3 (location) + β_4 (darkness) + β_5 (season) + ε
β = Coefficients for variables
ε = Error term
Fixed relationship
Relax the fixed relationship
$\beta_1 = \sum_{i=1}^{4} \beta_{1i} / 4$
β_{11}
β_{12}
Stationary
β_{13}
β_{14}
β_{11}
β_{12}
Non-stationary
β_{13}
β_{14}
6
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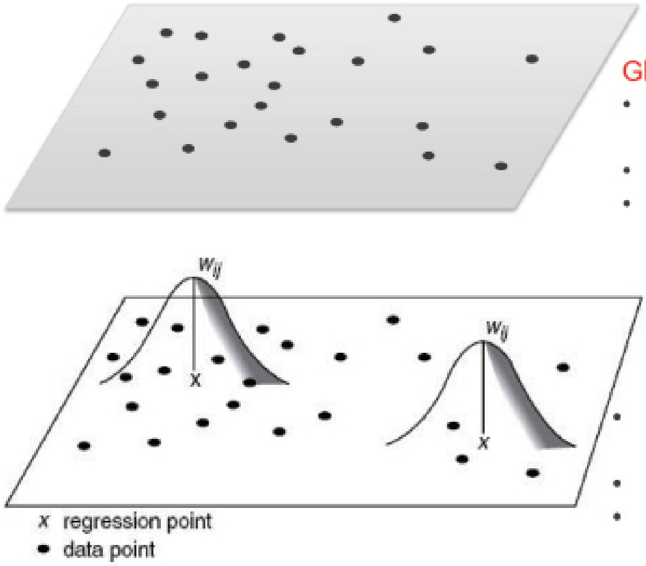
Global model→ Local (GWR) Model



Global model (regular model):

- Use all samples to estimate model
- Each sample has equal weight
- Associations are stationary and are *location independent*

Local model:

- Use sub-sample to estimate model for each location
- Neighbours have more weight
- Associations can be *location depenedent*

Selected descriptive statistics

Variable		Mean / Percent	Std. Dev.	Min	Max
Injury Severity (0-other, 1-fatal)		52.19%	0.500	0	1
Age	<=16 years old	6.50%	0.247	0	1
	17-29 years old	27.91%	0.449	0	1
	30-39 years old	28.35%	0.451	0	1
	40-54 years old	26.62%	0.442	0	1
	55-64 years old	7.04%	0.256	0	1
	>=65 years old	3.58%	0.186	0	1
Env. attributes	Darkness (0-no, 1-yes)	51.16%	0.500	0	1
Time	Weekend (0-no, 1-yes)	33.64%	0.472	0	1
	Summer (0-no, 1-yes)	29.55%	0.456	0	1
	Winter (0-no, 1-yes)	19.10%	0.393	0	1
	Spring or Autumn (0-no, 1-yes)	51.34%	0.500	0	1
Location attributes	Land Use Mix Index	0.419	0.280	0.000	0.980
	Railway Yard (0-no, 1-yes)	3.71%	0.189	0	1
Pre-crash trespasser actions	Climbing, jumping, stepping	8.56%	0.280	0	1
	Riding, operation	5.32%	0.224	0	1
	Lying, sleeping (on or near tracks)	23.35%	0.423	0	1
	Running, walking	35.07%	0.477	0	1
	Crossing, crawling (over tracks)	2.44%	0.154	0	1
	Sitting, standing, bending, stooping	16.60%	0.372	0	1
	Driving	5.53%	0.229	0	1
	Others (0-no, 1-yes)	3.13%	0.174	0	1

Trespasser injury correlates: GWR results

Models →		Global Model (dropped insignificant variables)		Local GWLR Model				
Variable		*b*	*SE*	Min	Max	Lwr Qtl	Upr Qtl	(Up-Lw)>2SE
Constant		0.261 *	0.131	-1.832	1.486	-0.369	0.669	TRUE
Age (Base: 30-39 years old)	<=16 years old	-0.294 **	0.100	-1.189	0.795	-0.491	0.107	TRUE
	17-29 years old	-0.007	0.060	-0.546	0.670	-0.107	0.130	TRUE
	40-54 years old	0.186 **	0.061	-0.149	0.841	0.027	0.363	TRUE
	55-64 years old	0.250 **	0.095	-0.517	1.294	0.075	0.529	TRUE
	>=65 years old	0.641 **	0.131	-0.175	2.094	0.412	0.949	TRUE
Env. attributes	Darkness (0-no, 1-yes)	-0.110 *	0.047	-0.543	0.288	-0.185	-0.024	TRUE
Time	Weekend (0-no, 1-yes)	Dropped						
	Summer (Base: Spring and Autumn)	-0.142 **	0.052	-0.812	0.352	-0.290	-0.038	TRUE
	Winter (Base: Spring and Autumn)	0.053	0.060	-0.325	0.370	-0.102	0.149	TRUE
Location attributes	Land Use Mix Index	Dropped						
	Railway Yard (0-no, 1-yes)	-1.036 **	0.142	-4.765	0.359	-1.258	-0.652	TRUE
Pre-crash trespasser actions (Base: Other actions)	Climbing, jumping, stepping	-1.359 **	0.151	-4.213	0.537	-1.811	-0.850	TRUE
	Riding, operation	-1.035 **	0.160	-2.596	0.605	-1.541	-0.564	TRUE
	Lying, sleeping (on or near tracks)	0.467 **	0.132	-1.113	2.468	-0.107	1.194	TRUE
	Running, walking	-0.024	0.128	-1.435	1.907	-0.523	0.493	TRUE
	Crossing, crawling (over tracks)	-0.767 **	0.191	-4.605	2.227	-1.412	-0.461	TRUE
	Sitting, standing, bending, stooping	0.170	0.134	-1.364	1.968	-0.292	0.740	TRUE
	Driving	-1.299 **	0.162	-3.371	0.548	-1.828	-0.497	TRUE
Summary Statistics		Sample Size: 8794 Log likelihood = -5642.12 Prob > χ^2 = 0.00 R^2 = 0.073 AIC = 11318.24		Local Sample Size**: 500 Percent deviance explained: 0.115 AIC = 11308.19				

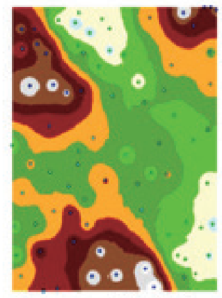
Inj. distribution-Coeff. for each sample point

Table
tracklogitmo…

	Location		β_0	Std. Err.	T-stat.	β_1			β_2			β_3	
Area_num	x_coord	y_coord	est_intercept	se_intercept	t_intercept	est_kid	se_kid	t_kid	est_elder	se_elder	t_elder	est_yard	se_yard
0	-88.000002	41.344002	-0.065253	0.079934	-0.81634	-0.620129	0.153404	-4.042448	0.451374	0.229789	1.964297	-0.934489	0.235884
1	-87.816902	41.839901	-0.047259	0.080381	-0.587935	-0.590183	0.152489	-3.870852	0.475362	0.232111	2.047997	-0.939075	0.240882
2	-119.849	36.758202	0.031807	0.081547	0.390044	-0.324475	0.167588	-1.936149	0.865772	0.224439	3.590152	-1.342309	0.222219
3	-118.73	35.342899	0.0256	0.080696	0.317234	-0.333904	0.166263	-2.008284	0.792968	0.221874	3.573686	-1.318283	0.218829
4	-116.178	34.8414	0.011606	0.079428	0.146123	-0.347136	0.163712	-2.120405	0.775873	0.217676	3.560674	-1.29393	0.21484
5	-119.849	36.758202	0.031807	0.081547	0.390044	-0.324475	0.167588	-1.936149	0.865772	0.224439	3.590152	-1.342309	0.222219
6	-87.816902	41.839901	-0.047259	0.080381	-0.587935	-0.590183	0.152489	-3.870852	0.475362	0.232111	2.047997	-0.939075	0.240882
7	-111.771	35.838699	-0.023413	0.077869	-0.300668	-0.369191	0.16007	-2.306433	0.745865	0.211267	3.530443	-1.272756	0.211941
8	-73.883899	43.107399	0.134652	0.071728	1.877266	-0.547664	0.138959	-3.941182	0.584606	0.207144	2.82222	-1.110885	0.252089
9	-102.356	48.201302	-0.176555	0.094188	-1.874506	-0.490635	0.184048	-2.665801	0.471119	0.241906	1.947511	-1.218819	0.248722
10	-117.761	33.702801	0.01736	0.0797	0.217821	-0.347025	0.164703	-2.106976	0.775278	0.218868	3.542219	-1.291568	0.215319
11	-116.178	34.8414	0.011606	0.079428	0.146123	-0.347136	0.163712	-2.120405	0.775873	0.217676	3.560674	-1.29393	0.21484
12	-108.262	35.580601	-0.081148	0.07867	-1.031494	-0.415865	0.16434	-2.530521	0.682786	0.210212	3.24809	-1.248883	0.217295
13	-108.262	35.580601	-0.081148	0.07867	-1.031494	-0.415865	0.16434	-2.530521	0.682786	0.210212	3.24809	-1.248883	0.217295
14	-90.834396	43.593899	-0.090791	0.084629	-1.072807	-0.61361	0.159532	-3.84632	0.443239	0.23943	1.851225	-0.908799	0.238289
15	-108.262	35.580601	-0.081148	0.07867	-1.031494	-0.415865	0.16434	-2.530521	0.682786	0.210212	3.24809	-1.248883	0.217295
16	-106.809	34.715401	-0.11272	0.079769	-1.413094	-0.453851	0.169882	-2.671566	0.628139	0.212762	2.952364	-1.248297	0.228225
17	-87.816902	41.839901	-0.047259	0.080381	-0.587935	-0.590183	0.152489	-3.870852	0.475362	0.232111	2.047997	-0.939075	0.240882
18	-91.544502	40.9879	-0.107643	0.080401	-1.338823	-0.658547	0.156979	-4.195134	0.416257	0.228238	1.823782	-0.933254	0.229611
19	-121.271	37.934898	0.039433	0.08248	0.465969	-0.316692	0.169191	-1.871806	0.816386	0.227291	3.591816	-1.365492	0.226121
20	-98.031097	30.0581	-0.1424	0.084858	-1.678083	-0.645542	0.189819	-3.400823	0.288454	0.235813	1.223232	-1.146679	0.231394
21	-98.031097	30.0581	-0.1424	0.084858	-1.678083	-0.645542	0.189819	-3.400823	0.288454	0.235813	1.223232	-1.146679	0.231394
22	-97.946601	29.583	-0.139863	0.086003	-1.626252	-0.646601	0.192785	-3.354004	0.278964	0.238917	1.167619	-1.142701	0.234123
23	-87.816902	41.839901	-0.047259	0.080381	-0.587935	-0.590183	0.152489	-3.870852	0.475362	0.232111	2.047997	-0.939075	0.240882
24	-106.235	31.7687	-0.115898	0.079114	-1.464949	-0.499494	0.170965	-2.92332	0.55948	0.211153	2.649643	-1.221907	0.216444
25	-112.491	33.348801	-0.021777	0.077358	-0.281511	-0.38571	0.160134	-2.408671	0.724364	0.210283	3.444714	-1.246751	0.218083
26	-112.491	33.348801	-0.021777	0.077358	-0.281511	-0.38571	0.160134	-2.408671	0.724364	0.210283	3.444714	-1.246751	0.218083
27	-87.732803	46.183399	-0.041264	0.077192	-0.534568	-0.624833	0.149274	-4.185799	0.448531	0.221912	2.021211	-0.955744	0.233182
28	-84.838303	42.5961	0.005788	0.076349	0.075811	-0.525578	0.144843	-3.628599	0.538641	0.218275	2.467719	-0.967366	0.245429
29	-82.389801	27.929199	0.136618	0.08826	1.547882	-0.483339	0.177297	-2.726158	0.441844	0.255005	1.732681	-1.329143	0.301417
30	-97.721497	46.3694	-0.156286	0.088858	-1.758831	-0.545714	0.167923	-3.249794	0.430428	0.237713	1.8107	-1.054093	0.229343
31	-82.536797	38.598499	0.049846	0.06949	0.717306	-0.512571	0.13328	-3.845834	0.527427	0.196667	2.681837	-1.007362	0.237917
32	-83.492401	33.590801	0.070227	0.079934	0.878558	-0.609455	0.15713	-3.878664	0.353869	0.225199	1.571317	-1.182694	0.283824

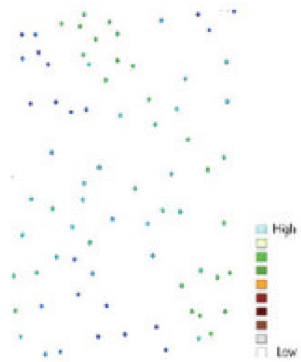
Spatial interpolation: understanding distribution of correlates

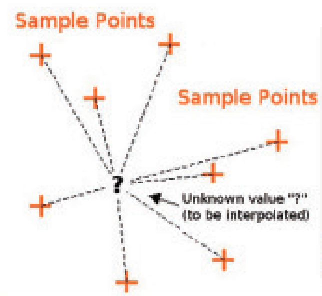
Interpolate coefficients to create coefficient surface in space

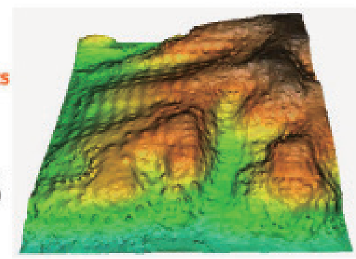


Contour coefficient map

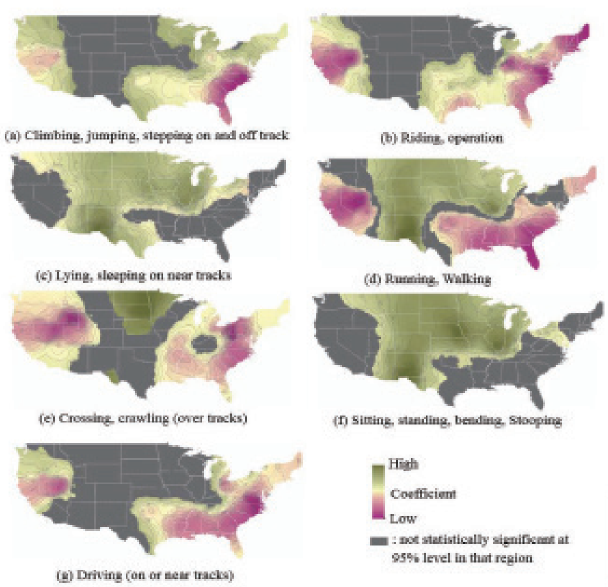
IDW- Inverse distance weighted (IDW) interpolation







Distribution of trespasser injury coefficient estimates



Local estimates associated with pre-crash action types

Summary: trespasser injury coefficient estimates

Odds of fatality for different pre-crash behaviors in mega-regions of USA compared with base pre-crash action

Regions	Climbing, jumping, stepping	Riding Operation	Lying on or near tracks	Running Walking	Crossing	Sitting or Standing	Driving	Other pre-crash actions (base)
Northeastern	-75%	-90%	-	-14%	-55%	-	-77%	0
Great Lakes	-45%	-	570%	172%	-55%	350%	80%	0
Northern CA and NV	-90%	-90%	-	-63%	-83%	-	-86%	0
Southern CA	-75%	55%	-	-14%	-45%	-	-	0
Piedmont Atlantic	-98%	80%	-	-63%	-90%	-	-95%	0
Cascadia Area	-63%	-52%	82%	-	-63%	-	-	0
New Mexico	-	-	1000%	420%	-	500%	-	0
Gulf Coast	-80%	-74%	-	-53%	-70%	-	-92%	0
Florida	-94%	-74%	-	-65%	-70%	-	-80%	0

Note, "-"means no statistical significant associations (95% level) found in such area

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Closure

- Trespassing crashes not geographically random
- Correlates of trespassing fatality (given a crash):
  - Pre-crash behaviors (lying/sleeping, sitting, running, riding, driving and climbing)
  - Personal attributes (age)
  - Environmental attributes (darkness)
  - Time (season)
  - Location (yard)
- Associations vary for age and pre-crash actions
- Investigate further & identify countermeasures
- Targeted investments in engineering solutions at locations, ed., enforcement that vary by region

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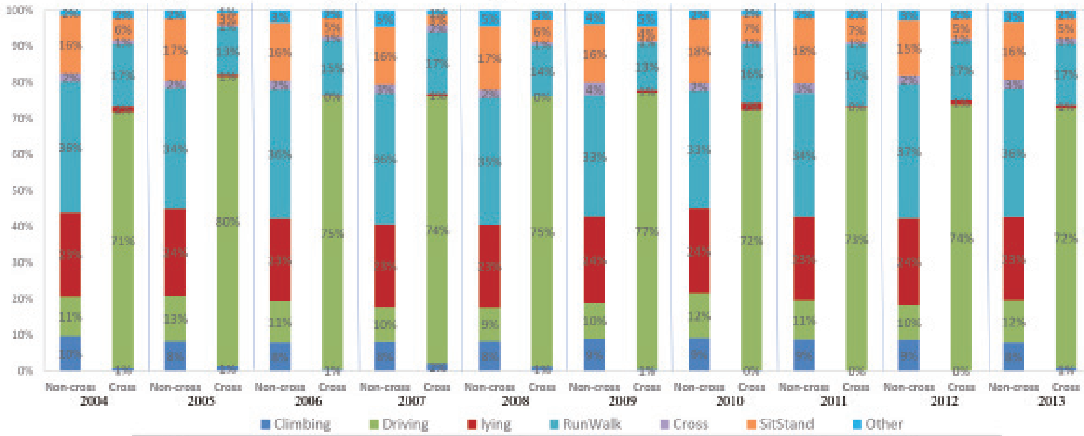
Rail Crossings vs. Non-crossing Crashes

Research objectives

- Differences between rail crossing and non-crossing trespassing crashes
- Research questions:
  - How do rail-trespassing crashes differ across crossings and non-crossings?
  - How do the correlates of injury severity differ across crossings and non-crossings?

Crossing vs. Non-crossing (2004-2013)

- 8,794 (4,024 fatalities) non-crossing trespassing crashes
- 3,561 (1,268 fatalities) grade crossing trespassing crashes



Trespassing crashes by pre-crash action types across crossings and non-crossings (2004-2013)

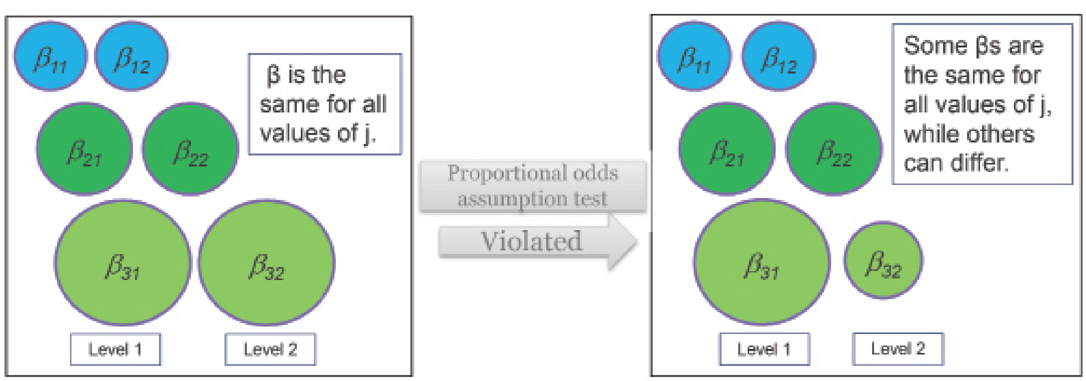
Federal Railroad Administration (FRA) railway safety information database (http://safetydata.fra.dot.gov/)

Modeling: Ordered vs. Partial proportional odds (Gologit2) model

Ordered logit

Partial prop. odds model

$$P(Y_i > j) = \frac{exp(\alpha_j + X_i\beta)}{1+[exp(\alpha_j + X_i\beta)]},\ j=1,2,\ldots,M-1$$



X = Explanatory variables, e.g. pre-crash behavior.

α = Constant term

β = Coefficients for variables

ε = Error term

Selected descriptive statistics

	Variables	Total (N=12355) Mean	Total Std. Dev	Non-crossing (N=8794) Mean	Non-crossing Std. Dev	Crossing (N=3561) Mean	Crossing Std. Dev	%Diff of Mean	Min	Max
Personal attributes	Youths (<=16 years old)	0.067	0.250	0.065	0.247	0.073	0.260	11.82%	0	1
	Middle (17-35 years old)	0.489	0.500	0.505	0.500	0.449	0.497	-11.09%	0	1
	Adult (36-64 years old)	0.380	0.485	0.394	0.489	0.345	0.475	-12.50%	0	1
	Seniors (>=65 years old)	0.064	0.245	0.036	0.186	0.133	0.340	272.39%	0	1
Temporal attributes	Darkness (0-no, 1-yes)	0.479	0.500	0.512	0.500	0.399	0.490	-22.00%	0	1
Seasonal attributes	Summer (0-no, 1-yes)	0.279	0.449	0.301	0.459	0.227	0.419	-24.68%	0	1
	Winter (0-no, 1-yes)	0.216	0.411	0.214	0.410	0.220	0.414	2.69%	0	1
	Spring and autumn (0-no, 1-yes)	0.505	0.500	0.485	0.500	0.553	0.497	14.13%	0	1
Location	Urban (0-no, 1-yes)	0.439	0.496	0.445	0.497	0.424	0.494	-4.69%	0	1
	Yard (0-no, 1-yes)	0.028	0.166	0.037	0.189	0.007	0.082	-81.82%	0	1
Trespassing pre-crash actions	Climbing, Jumping	0.063	0.243	0.086	0.280	0.008	0.088	-90.82%	0	1
	Driving	0.291	0.454	0.108	0.311	0.743	0.437	585.20%	0	1
	Lying, sleeping	0.169	0.374	0.233	0.423	0.009	0.093	-96.27%	0	1
	Running, walking	0.295	0.456	0.351	0.477	0.156	0.363	-55.40%	0	1
	Crossing, crawling	0.020	0.141	0.024	0.154	0.010	0.100	-58.65%	0	1
	Sitting, standing, bending, stooping	0.133	0.339	0.166	0.372	0.051	0.220	-69.22%	0	1
	Other actions	0.029	0.167	0.024	0.174	0.022	0.148	-28.16%	0	1
Injury	Minor injury (level 1)	0.190	0.392	0.147	0.354	0.296	0.457	101.00%	0	1
	Severe injury (level 2)	0.336	0.472	0.331	0.471	0.348	0.476	5.27%	0	1
	Killed (level 3)	0.474	0.499	0.522	0.500	0.356	0.479	-31.83%	0	1

"% Diff of mean" refers to (Crossing mean – Non-crossing mean) /Non-crossing mean;

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Partial prop. odds model

		Pooled model: Total				Separate model: Non-crossing				Separate model: Crossing			
		Injury level 1		Injury level 2		Injury level 1		Injury level 2		Injury level 1		Injury level 2	
	Variables	β	Log odds	β	Log odds	β	Log odds	β	Log odds	β	Log odds	β	Log odds
Personal attributes (base: senior)	Youths (<=16 years old)	-0.435*	-35%	-0.912*	-60%	-0.562*	-43%	-0.882*	-59%	-0.461*	-37%	-0.825*	-56%
	Middle(17-35 years old)	-0.352*	-30%	-0.591*	-45%	-0.487*	-39%	-0.487*	-39%	-0.397*	-33%	-0.718*	-51%
	Adult(36-64 years old)	-0.306*	-26%	-0.706*	-51%	-0.403*	-33%	-0.607*	-46%	-0.384*	-32%	-0.815*	-56%
Temporal attributes	Darkness (0-no, 1-yes)	0.069	-	-0.025	-	-0.084	-	-0.084	-	0.197*	22%	0.197*	22%
Seasonal attributes (base: spring and autumn)	Summer (0-no, 1-yes)	0.049	-	0.049	-	0.024		0.024	-	0.084	-	0.084	-
	Winter (0-no, 1-yes)	0.038	-	0.038	-	0.035	-	0.035	-	0.065	-	0.065	-
Location	urban (0-no, 1-yes)	-0.008	-	-0.008	-	0.001	-	0.001	-	-0.022	-	-0.022	-
	yard (0-no, 1-yes)	-0.526*	-41%	-1.030*	-64%	-0.592*	-45%	-0.997*	-63%	-0.638	-	-0.638	-
Trespassing pre-crash actions (base: other action)	Climbing, Jumping	0.262	-	-1.085*	-66%	0.029	-	-1.331*	-74%	0.674	-	0.674	-
	Driving	-0.476*	-38%	-0.982*	-63%	-0.550*	-42%	-1.122*	-67%	-0.010	-	-0.010	-
	Lying, sleeping	1.265*	254%	0.709*	103%	1.063*	190%	0.482*	62%	2.433*	1039%	2.433*	1039%
	Running, walking	0.853*	135%	0.292*	34%	0.597*	82%	0.014	-	1.584*	387%	1.584*	387%
	Crossing, crawling	0.701*	102%	-0.379*	-32%	0.444	-	-0.731*	-52%	1.350*	286%	1.350*	286%
	Sitting, standing, bending, stooping	0.691*	100%	0.358*	43%	0.589*	80%	0.194	-	0.761*	114%	0.761*	114%
Year control (base: 2004)	Crash year	Absorbed		Absorbed		Absorbed		Absorbed		Absorbed		Absorbed	
Constant	cut 1	1.311*	271%	0.513*	67%	1.749*	475%	0.677*	97%	0.779*	118%	-0.496*	-39%
Sample size		12355				8794				3561			
Pseudo-R2		0.0681				0.0556				0.0551			
Log Likelihood at β		-11927.115				-8200.346				-3665.5855			
Prob>ChiSq		<.0001*				<.0001*				<.0001*			
Likelihood ratio test						82.367, <0.0001*							

*Absorbed coefficients of crash years are shown in Figure (next page).

"-"means no statistical significant associations (95% level) were found.

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Partial prop. odds model

Trends in odds of fatality in rail trespassing crashes (relative to base 2004 year) by time series (2004-2013)

Closure

- Crossing and non-crossing trespassing different (as expected)
- Correlates include:
  - Grade crossings: age, environmental attributes (darkness), pre-crash behaviors
  - Non-crossings: age, location (yard) and pre-crash behaviors
- Associations vary across grade crossings and non-crossings, especially for pre-crash actions
- More fluctuations for crossing crashes; non-crossings more stable (10 years)

Thank You / Questions?

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NURail Student Groups: Building Professional Networks

presented by:

Tyler Dick – UIUC, Sam Levy – MIT
James O'Shea – UIC, Alex Wang - UK

June 4th, 2015

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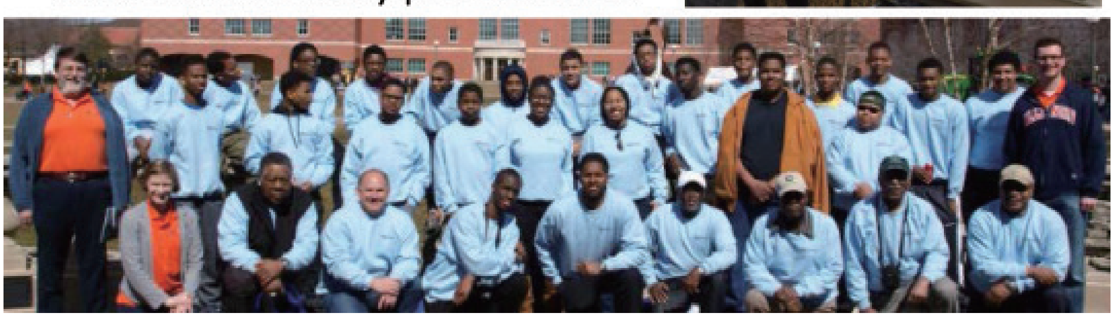
NURail Student Groups

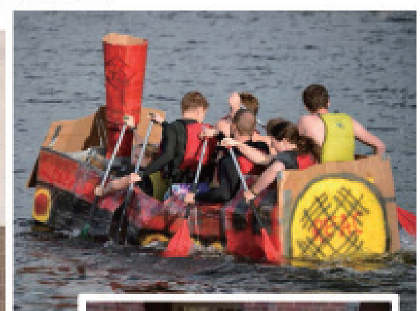
- Increase campus awareness of industry opportunities
- Outreach to K-12 students and underrepresented groups
- Bring together the next generation of railroad industry professionals



Visits to Rail Facilities & Projects

- Student coordination sheds light upon and promotes the hidden world of railroading
- Experiential learning
- Course concepts → "real world"

While having fun!



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Inaugural AREMA Student Quiz Bowl

2014 Annual Conference

All-NURail Final!

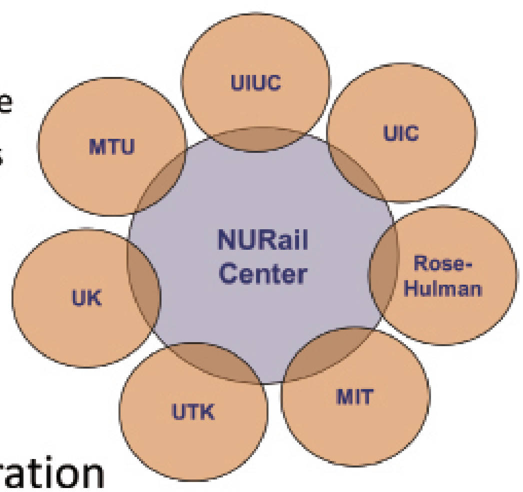
Student collaborators today…

Student collaborators today…
…industry collaborators tomorrow!

7

Building Professional Networks at the Student Level

- Win-Win-Win!
  - Research team synergy
  - Enriched educational experience
  - Stronger future industry leaders
- NURail Student Leadership Council
- Student Research Collaboration



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NURail Student Leadership Council (SLC)

Sam Levy (acting vice-chair)
Massachusetts Institute of Technology

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NURail Center

Objectives

- Improve communication and coordination across campuses
- Facilitate student input to the development of NURail research, education, workforce development and outreach activities
- Help promote NURail activities
- Help recruit future NURail students and build academic & professional networks

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NURail Center

Structure

- 2 Representatives per NURail University
  - 1 year commitment if possible- three years max
- Led by Chair and Vice-Chair
- By-Laws drafted, scheduled to be passed 7/15
- Monthly phone calls with in-person meetings at major rail conferences (NURail, AREMA, TRB, JRC).

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NURail Center

SLC Activities

This Year

- LinkedIn Group for current students and alumni (search for "NURail" on LinkedIn)
- NURail Professor Video Series
- Website SWOT Analysis
- Meetups at Conferences
  - JRC Karaoke Night, last night

Goals for next year

- Transition to new leadership
- Complete video series, SWOT Analysis, student database
- More formalized student event at TRB or AREMA Conference

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Closing Thoughts

- More involvement need from first year masters students
- Grow interaction between students and NURail leadership
- Use AREMA student chapters to grow
- Exchange program/other ideas?

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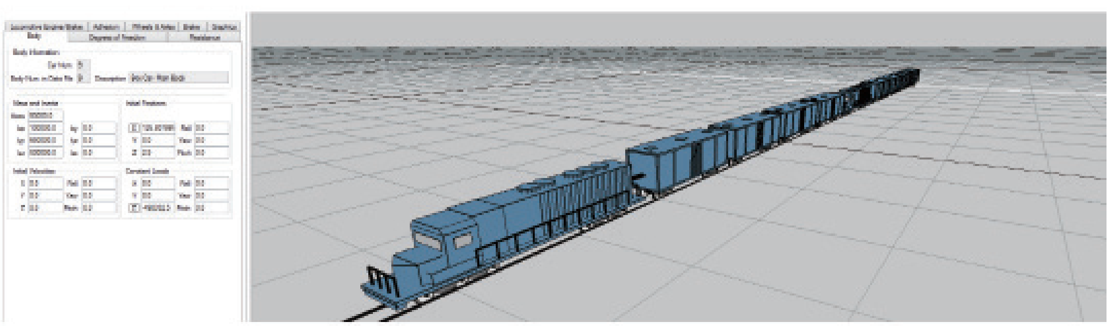
Large Angle Of Attack Wheel Climb: A NURail Student Collaboration



James O'Shea – University of Illinois - Chicago

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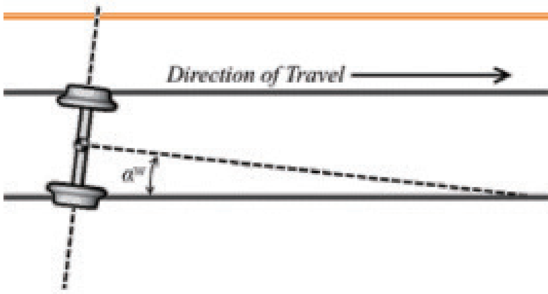
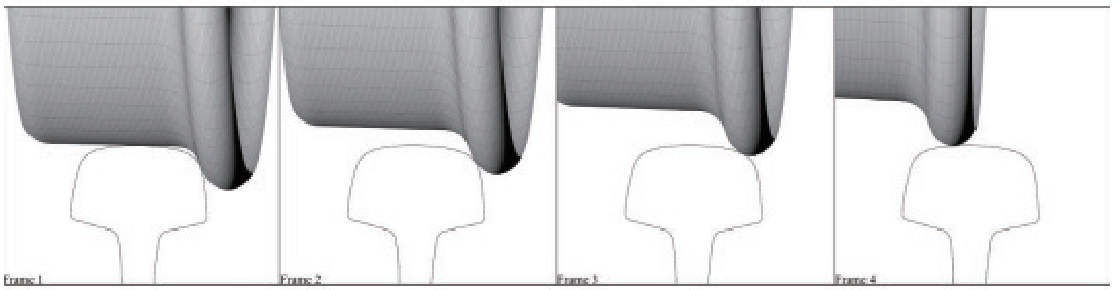
Large Angle of Attack Wheel Climb



- What is a wheelset angle of attack?
- Why does it cause derailment potential?
- Is this a problem worth investigation?
- Why is this still a problem?



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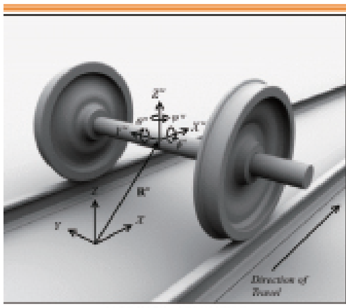
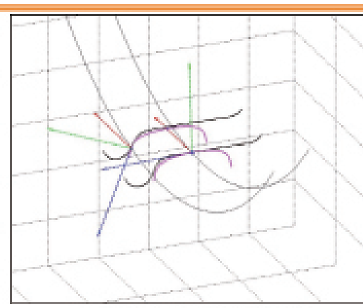
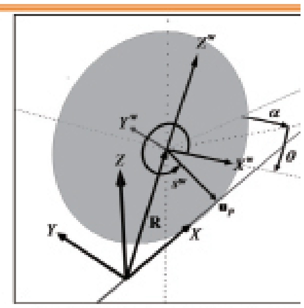
Large Angle of Attack Wheel Climb



Multibody System



Kinetic & Kinematic Analysis



Simplified Semi-Analytic Model

- Major Findings
  - Large angle of attack wheel climb is a significantly kinematic process
  - Under sufficient force, wheel climb can occur without friction
  - Derailment can occur without prediction by "conservative" criteria
  - The derailment initiation configuration can be determined for a given angle of attack

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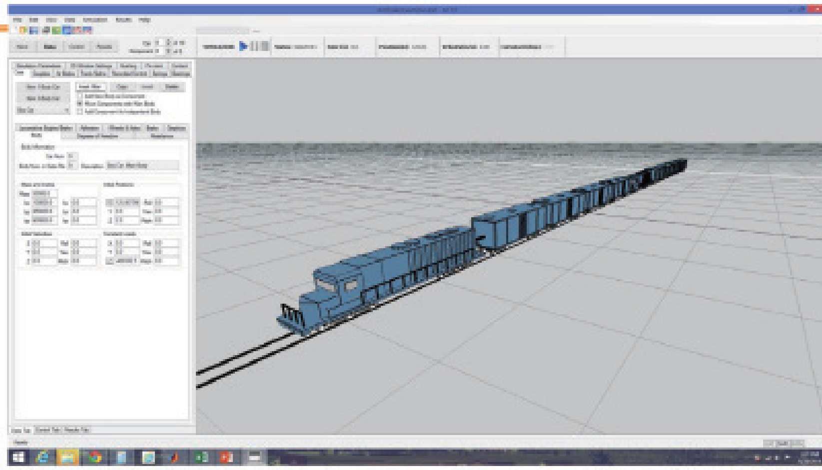
Collaboration:
Analysis of Train/Track Interaction Forces (ATTIF)



- ATTIF is a free-to-use, specialized code used to model and simulate the dynamics of long trains – developed at UIC
- ATTIF makes use of a specialized non-linear formulation that allows for the fast simulation of large and detailed models

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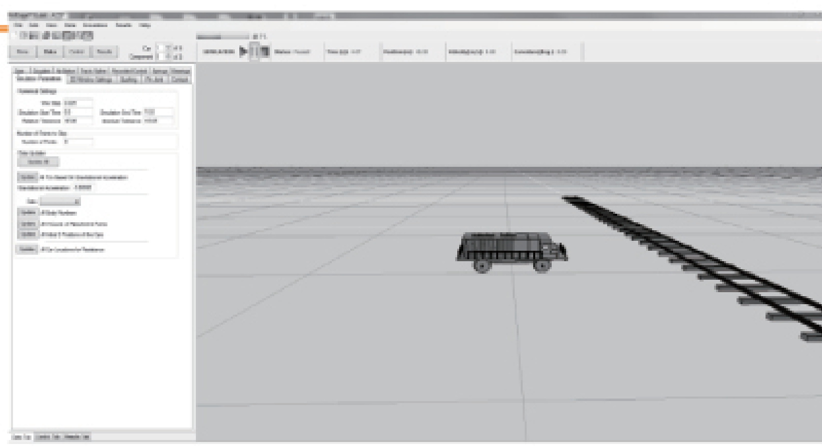
Collaboration:
Analysis of Train/Track Interaction Forces (ATTIF)



- Modification by UIC to facilitate UK's use for investigation and publication
- Choosing a NURail partner university gave UK the benefit of free software as well as in-depth assistance and support that would not likely be available from other sources

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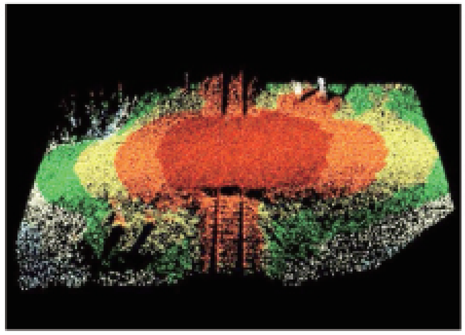
Quantifying Rail-Highway Grade Crossing Roughness: A NURail Student Collaboration

UK UNIVERSITY OF KENTUCKY



UIC UNIVERSITY OF ILLINOIS AT CHICAGO

Teng (Alex) Wang, Reginald Souleyrette & Daniel Lau
- University of Kentucky,
Ahmed Aboubakr - University of Illinois at Chicago

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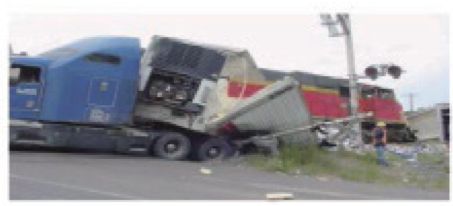

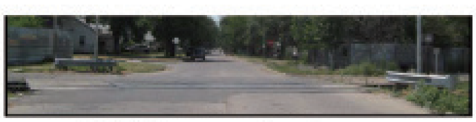

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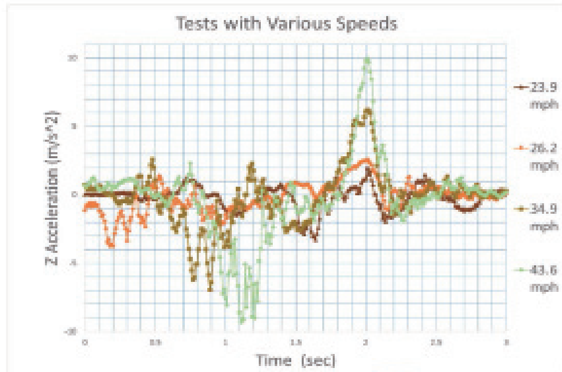

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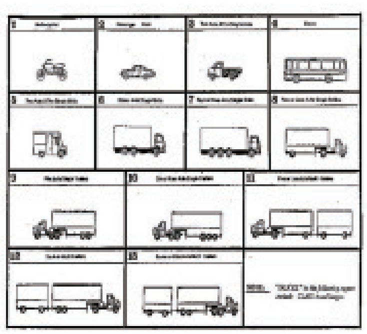
In KY alone, 2300 *public* crossings



Different vehicles perform differently

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Vehicle attributes | Speed | Vehicle path profile

↓

Acceleration Simulator

↓

Accelerations

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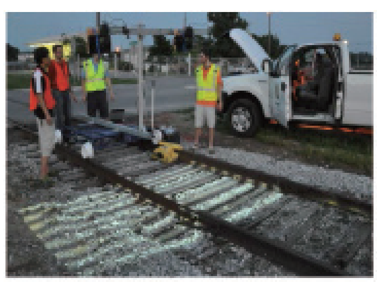

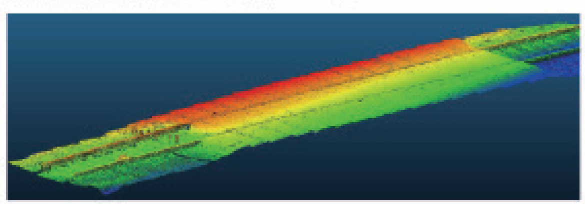

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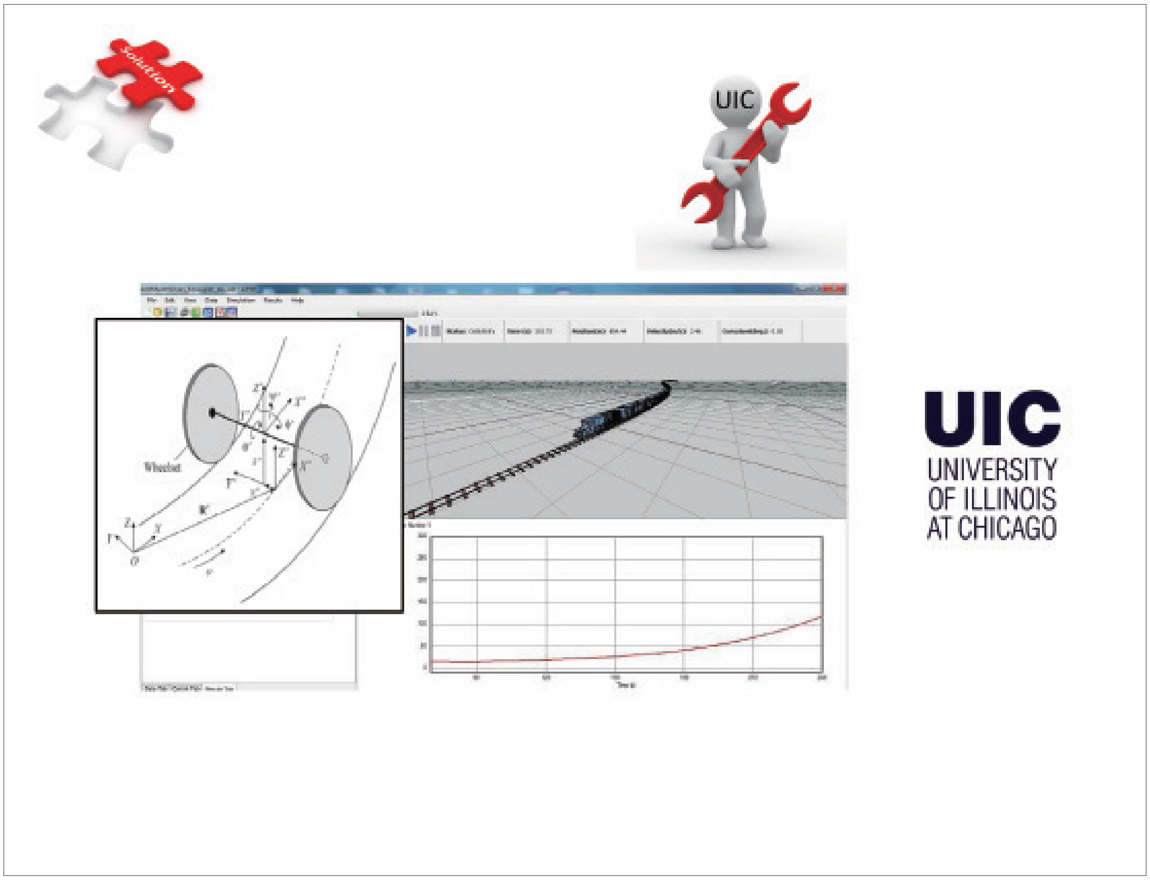
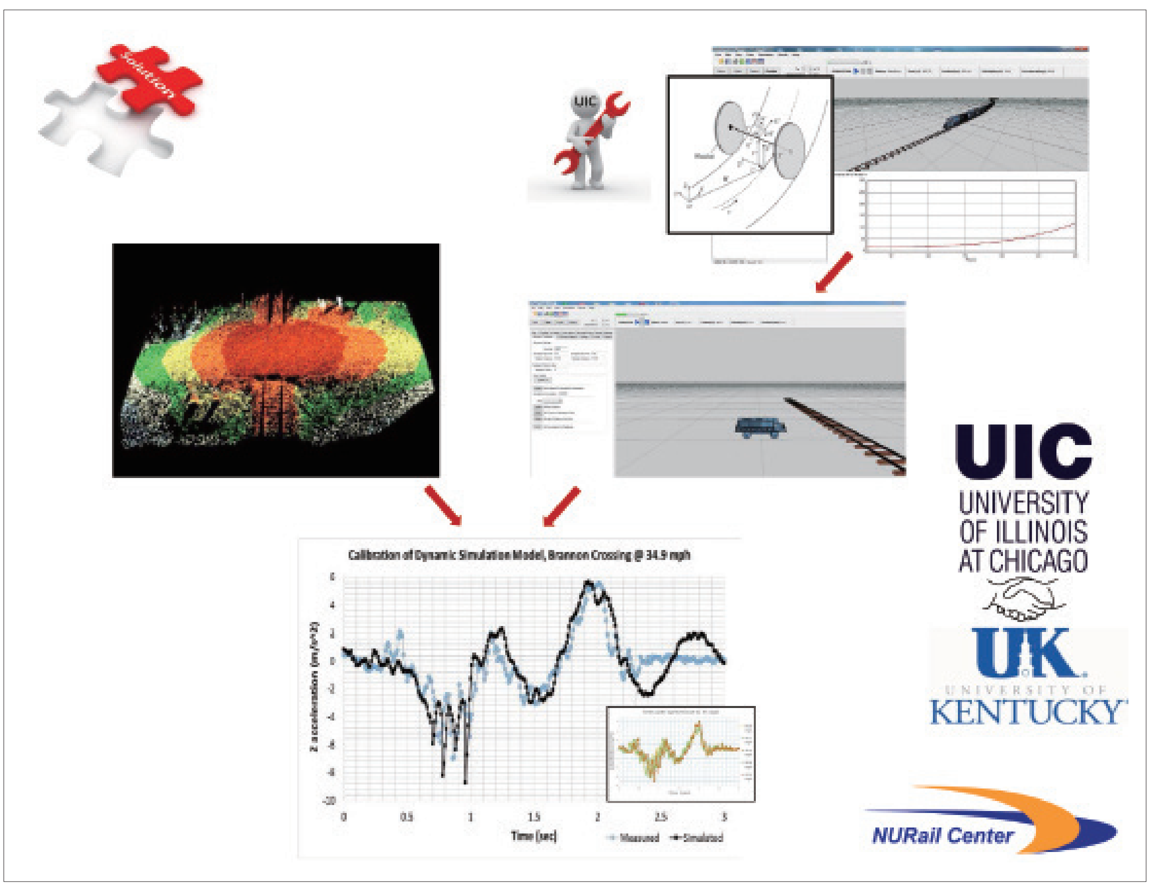

Solution
UIC
Wheelset
UIC
UNIVERSITY
OF ILLINOIS
AT CHICAGO


Solution
UIC
Calibration of Dynamic Simulation Model, Brannon Crossing @ 34.9 mph
Z acceleration (m/s^2)
Time (sec)
Measured
Simulated
UIC
UNIVERSITY
OF ILLINOIS
AT CHICAGO
UK
UNIVERSITY OF
KENTUCKY
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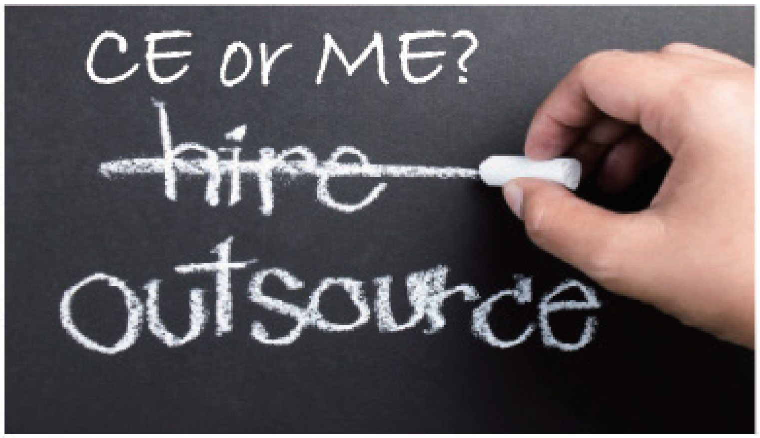

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Michigan Tech

ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

THE UNIVERSITY of TENNESSEE UT
KNOXVILLE

MIT
Massachusetts Institute of Technology

THE UNIVERSITY OF ILLINOIS AT CHICAGO
UIC

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UK
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Thank you for your attention!

These projects are supported by the National University Rail (NURail) Center,
a USDOT OST-R Tier 1 University Transportation Center.

U.S. Department of Transportation

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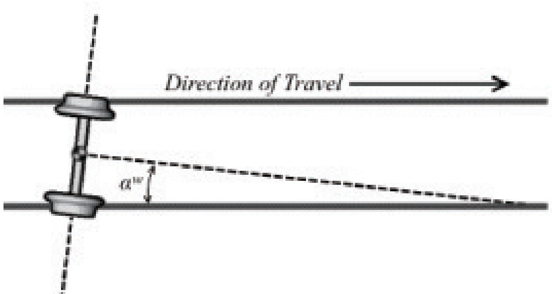
NURail Center

LARGE ANGLE OF ATTACK WHEEL CLIMB
&
NURAIL COLLABORATION

Presenter: James J. O'Shea, University of Illinois at Chicago (UIC)

NURail Annual Meeting
University of Illinois at Chicago (UIC)
June 3-4, 2015

Large Angle of Attack Wheel Climb



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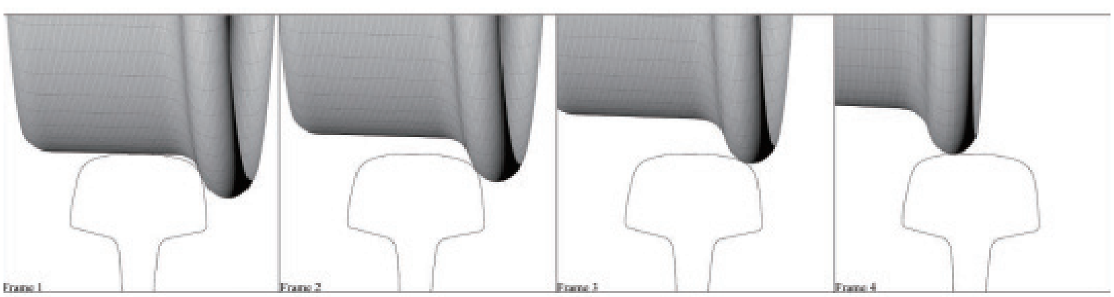
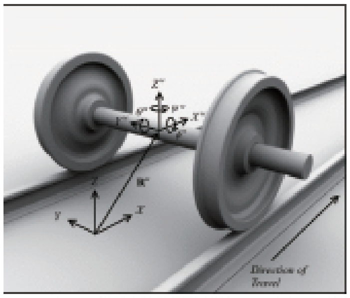
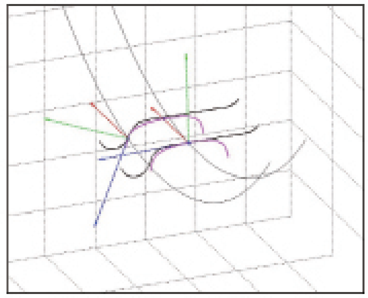


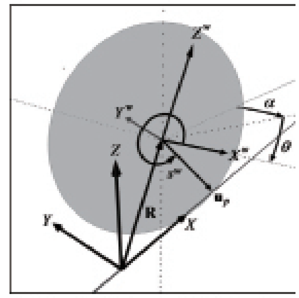
Large Angle of Attack Wheel Climb



Multibody System



Simplified Semi-Analytic Model



Kinetic & Kinematic Analysis

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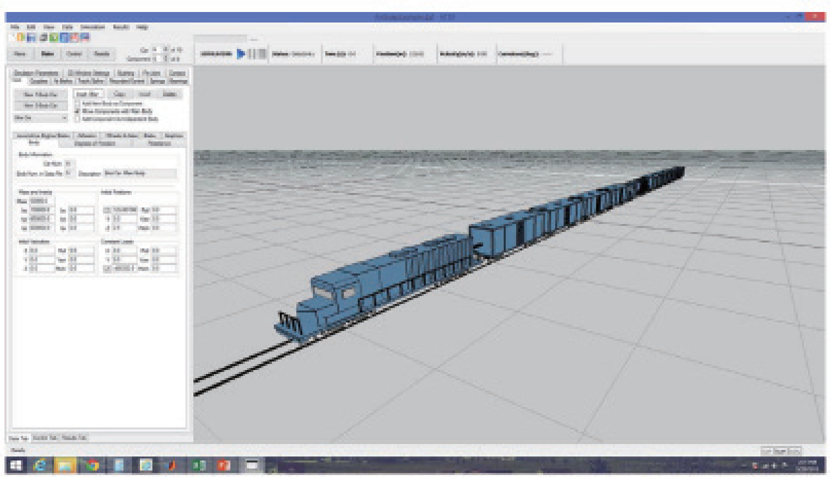
Collaboration: Analysis of Train/Track Interaction Forces (ATTIF)



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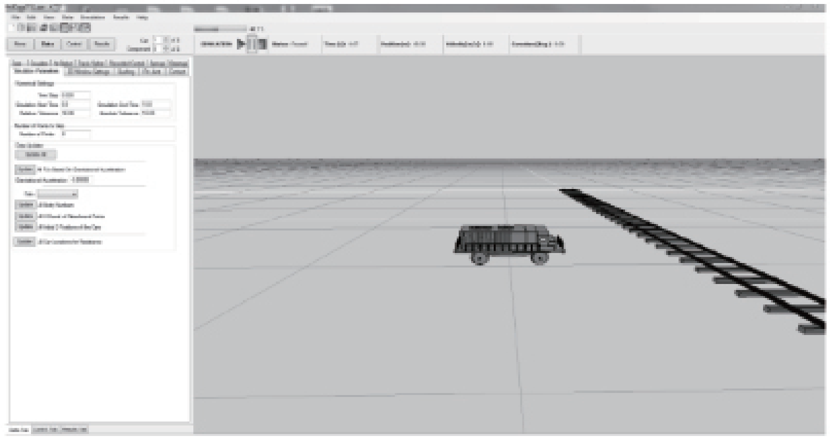
- ATTIF makes use of a specialized non-linear formulation that allows for the fast simulation of large and detailed models

Collaboration: Analysis of Train/Track Interaction Forces (ATTIF)



- Modification by UIC to facilitate UK's use for investigation and publication
- Choosing a NURail partner university gave UK the benefit of free software as well as in-depth assistance and support that would not likely be available from other sources

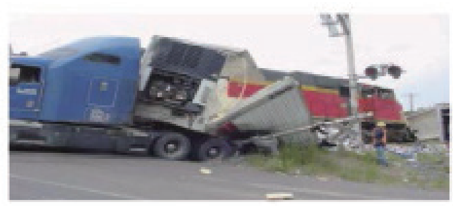
THANK YOU!

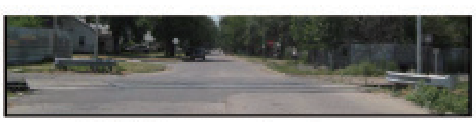
NURail Annual Meeting
University of Illinois at Chicago (UIC)
June 3-4, 2015

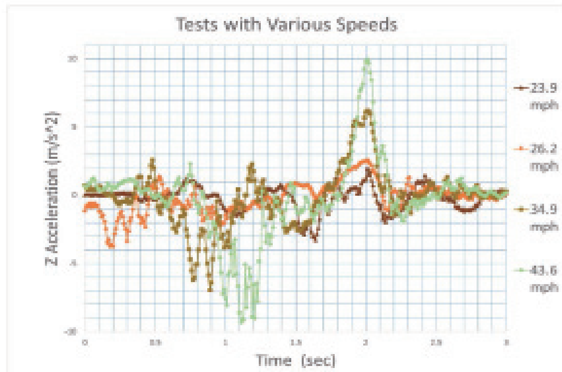
Quantifying Rail-Highway Grade Crossing Roughness
A NURail Collaboration

Teng (Alex) Wang, Reginald Souleyrette & Daniel Lau
University of Kentucky, Lexington, KY
Ahmed Aboubakr
University of Illinois at Chicago, Chicago, IL

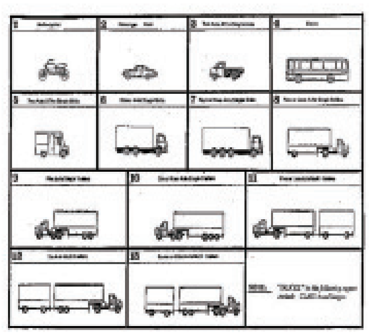
UK UNIVERSITY OF KENTUCKY   NURail Center   UIC UNIVERSITY OF ILLINOIS AT CHICAGO







In KY alone, 2300 *public* crossings



Different vehicles perform differently

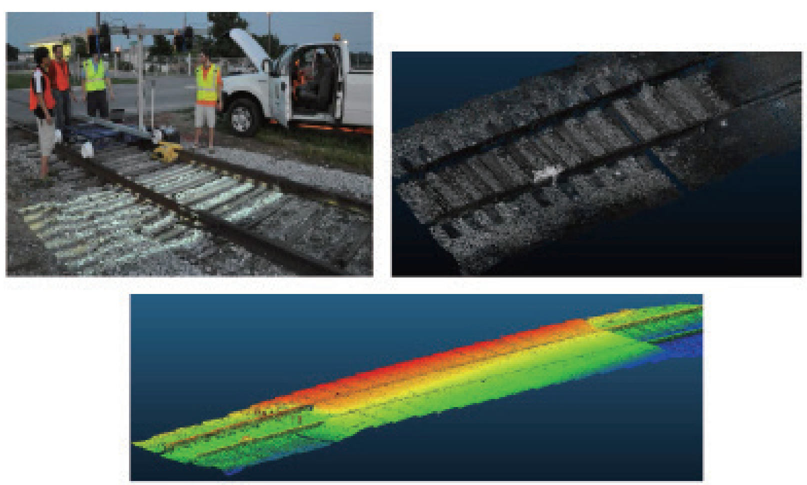
Vehicle attributes → Speed → Vehicle path profile

↓

Acceleration Simulator

↓

Accelerations



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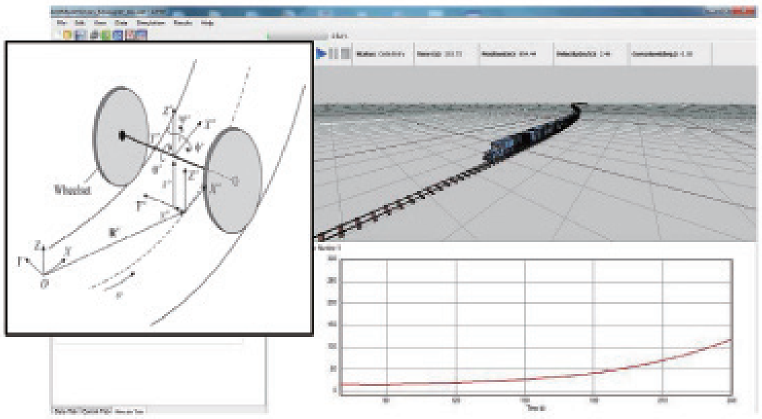
KENTUCKY



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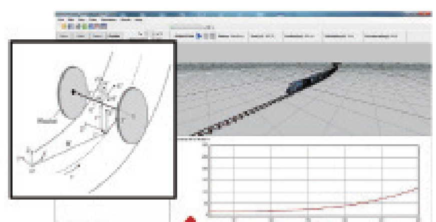

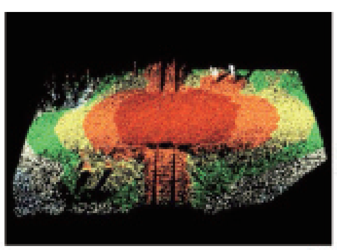

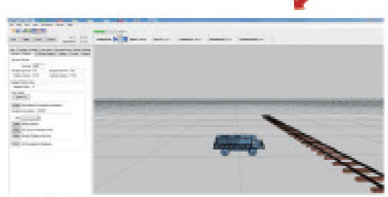

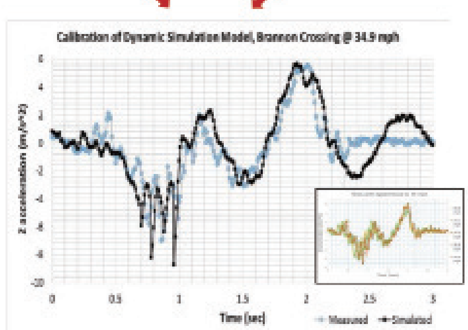

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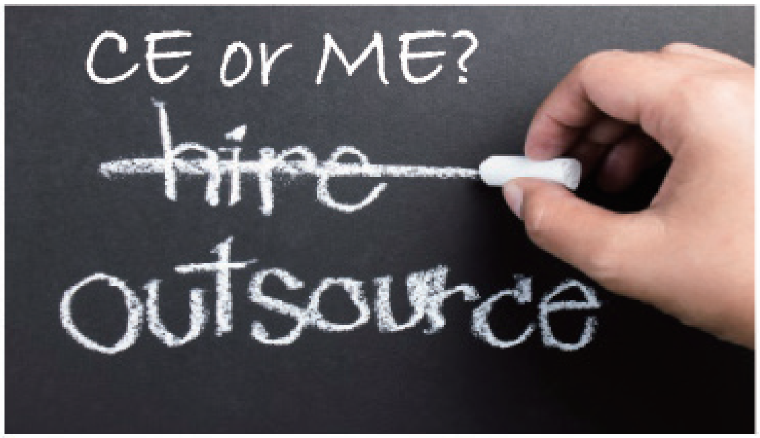


ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Michigan Tech

ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

THE UNIVERSITY of TENNESSEE UT
KNOXVILLE

Massachusetts Institute of Technology

THE UNIVERSITY OF ILLINOIS AT CHICAGO

NURail Center

UK
UNIVERSITY OF KENTUCKY

NURail Center

Will be 3 ½ years old on July 1,

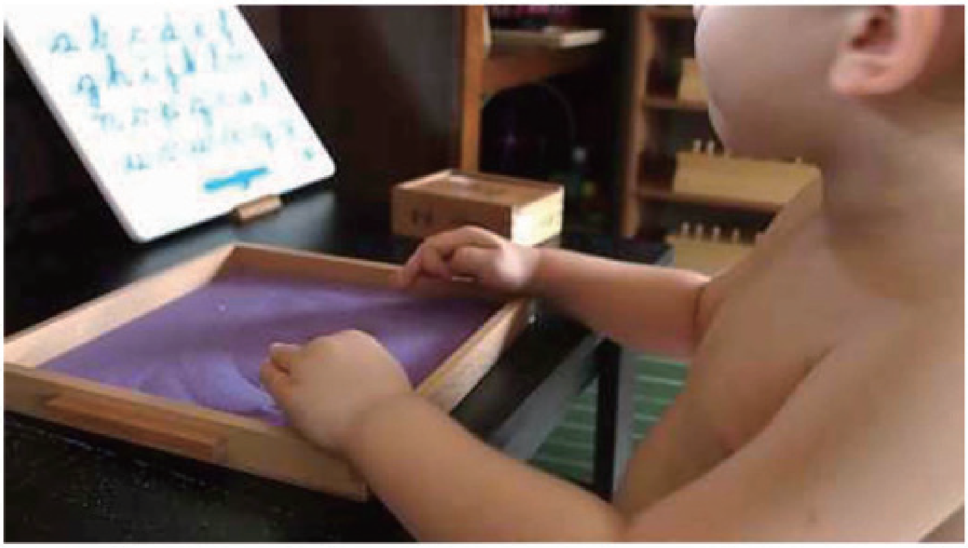
so we did a little research on what it's like to be 3 ½

Michigan Tech | MIT Massachusetts Institute of Technology | UIC University of Illinois at Chicago | Illinois | Rose-Hulman | UK University of Kentucky | The University of Tennessee Knoxville

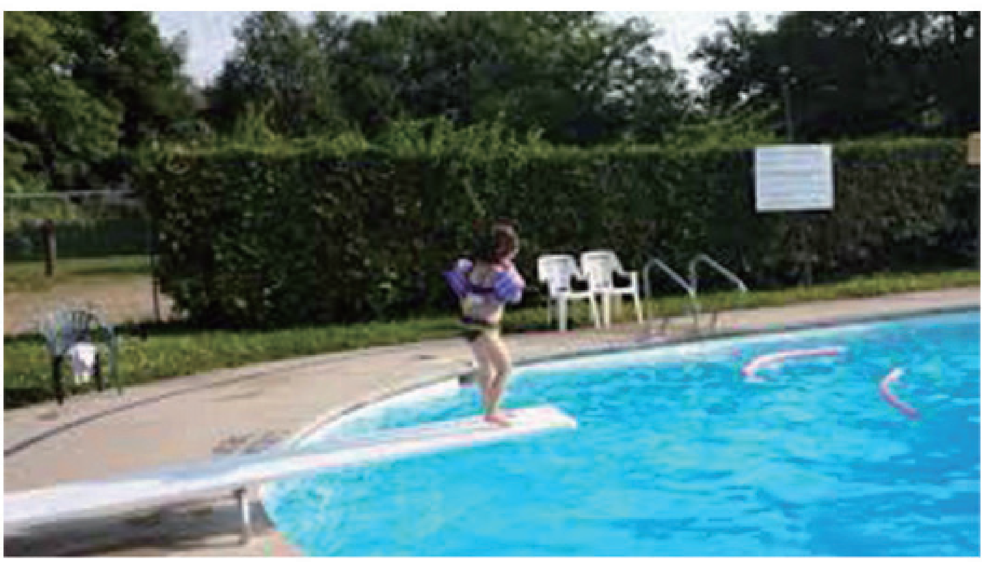
We are very happy to be here… but still trying to figure a few things out!

We like transportation

We like learning new things

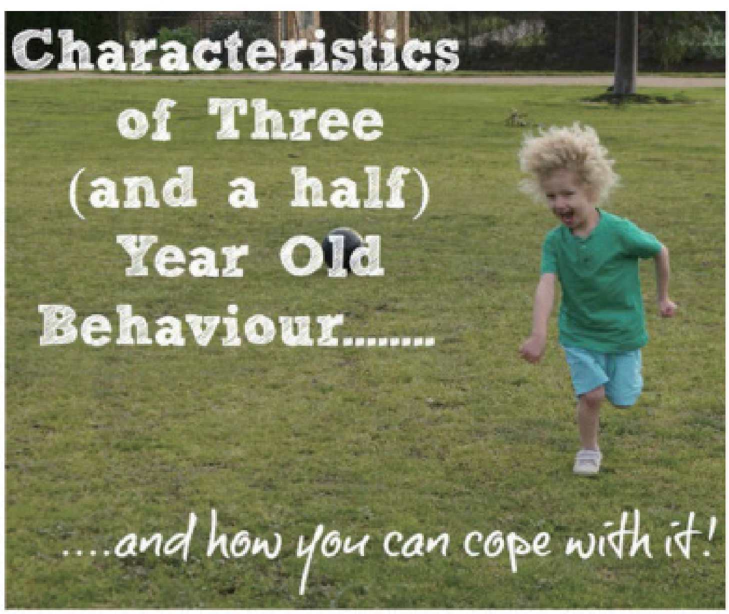


We like jumping into the DEEP END!



We are a collegial group!

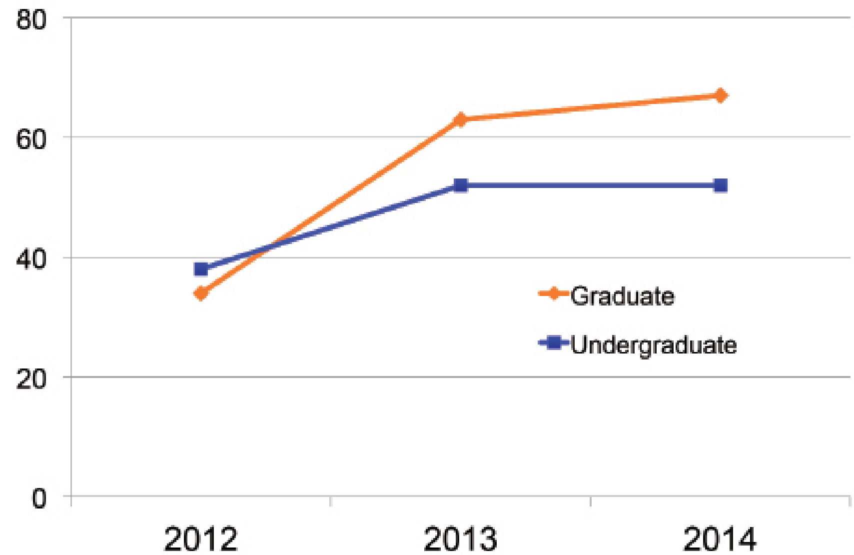
We found some resources for Lydia to use managing (or at least coping) with us!

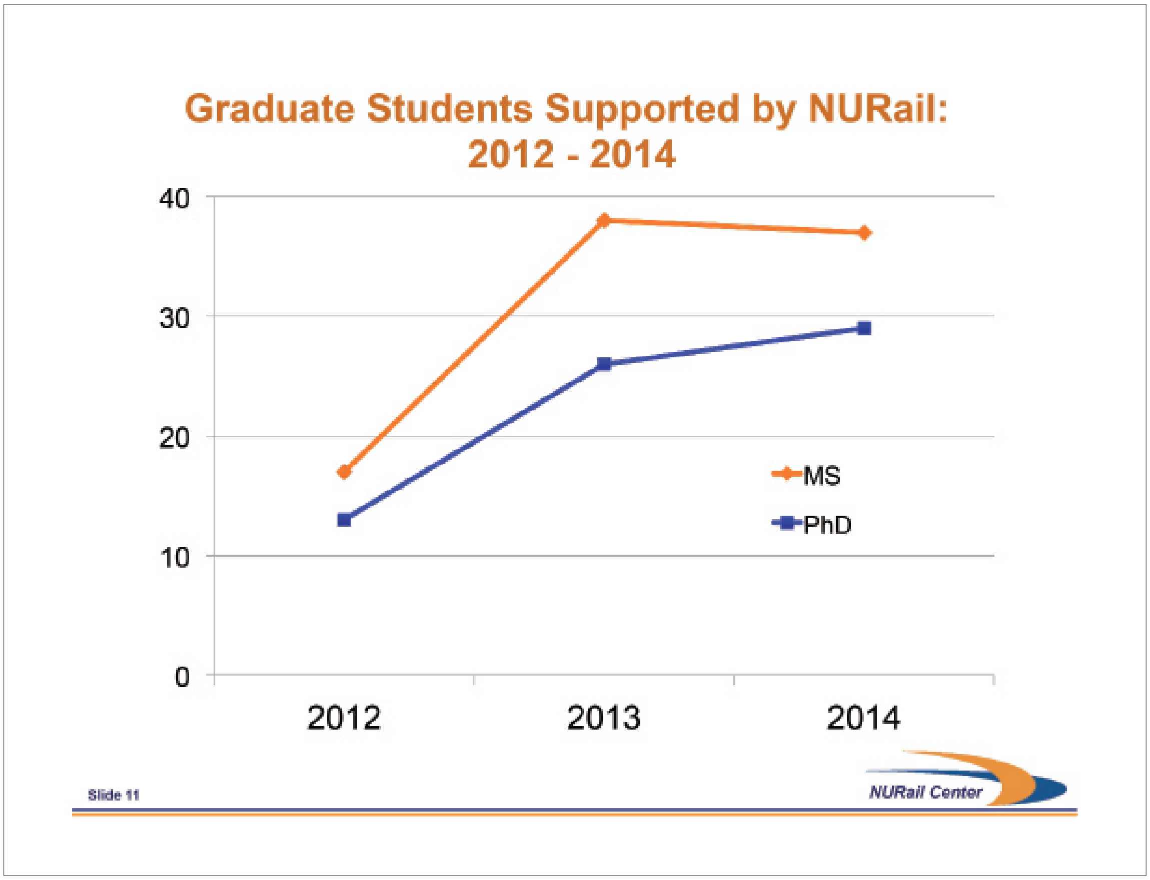


NURail in Action

- Past the crawling & toddler stage, walking and even running in a few cases
- NURail performance metrics and trends
  - Students
  - Research Publications
  - Technology Transfer
  - Collaboration
- Panel discussion

Students Participating in NURail-Supported Research Projects: 2012 - 2014




Graduate Students Supported by NURail: 2012 - 2014
40
30
20
10
0
2012
2013
2014
MS
PhD
Slide 11
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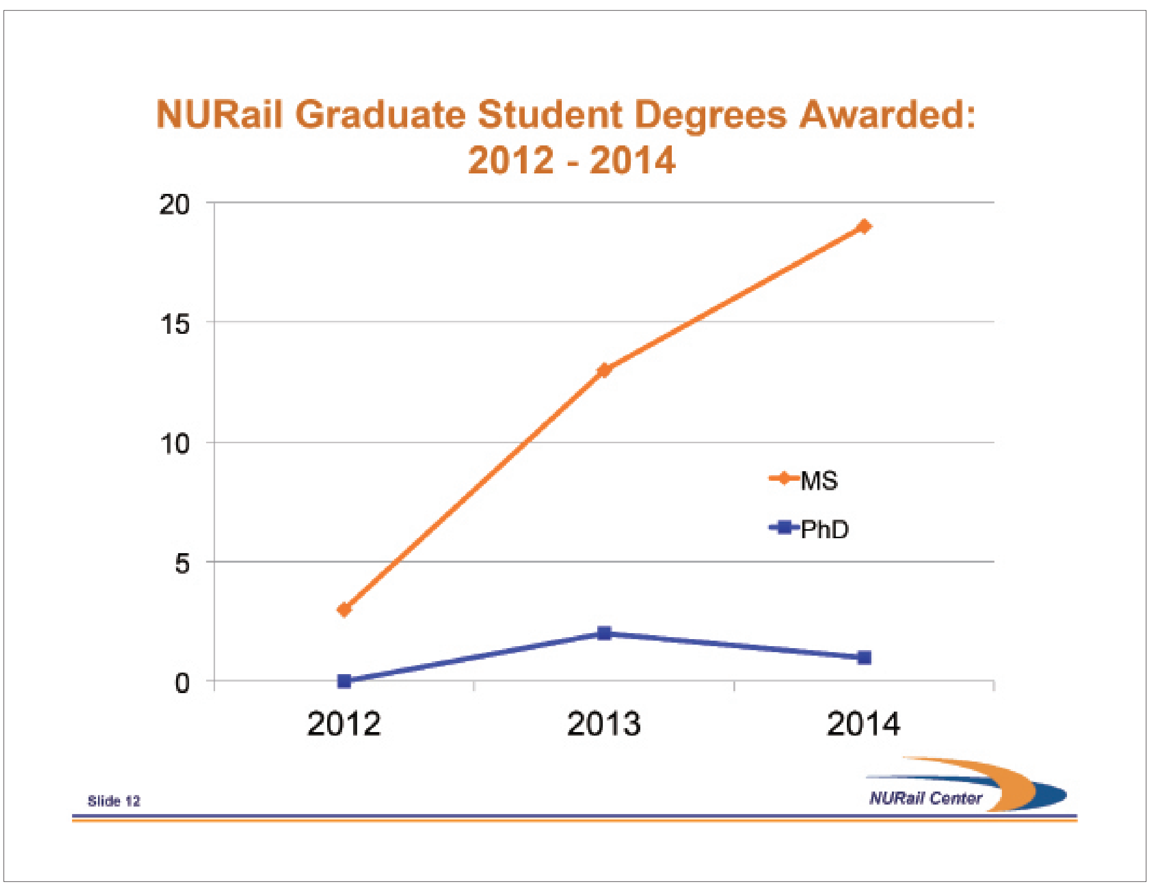
NURail Graduate Student Degrees Awarded: 2012 - 2014
20
15
10
5
0
2012
2013
2014
MS
PhD
Slide 12
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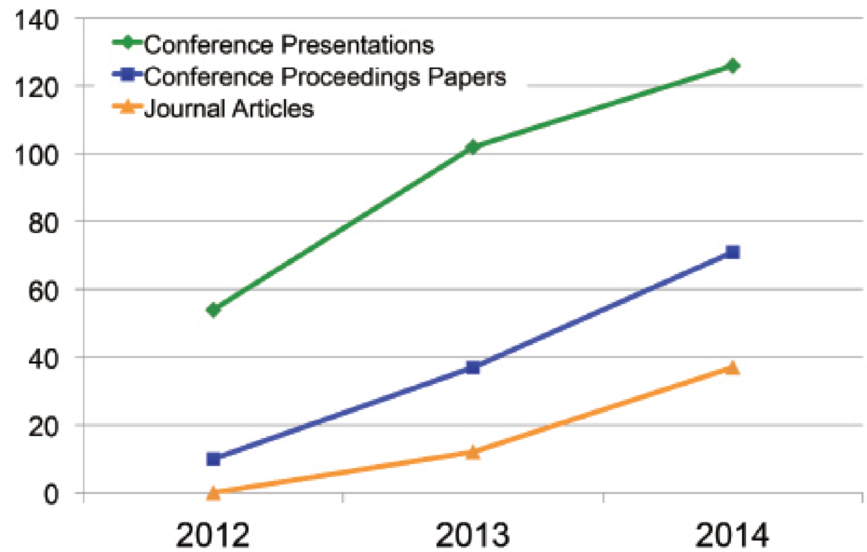
NURail Publications 2012 - 2014



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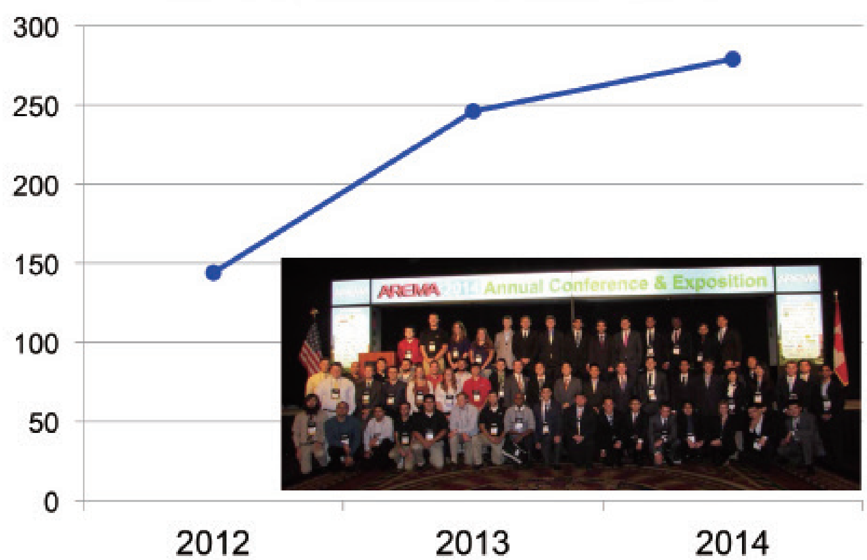
NURail Student Attendance at Rail Conferences: 2012 - 2014



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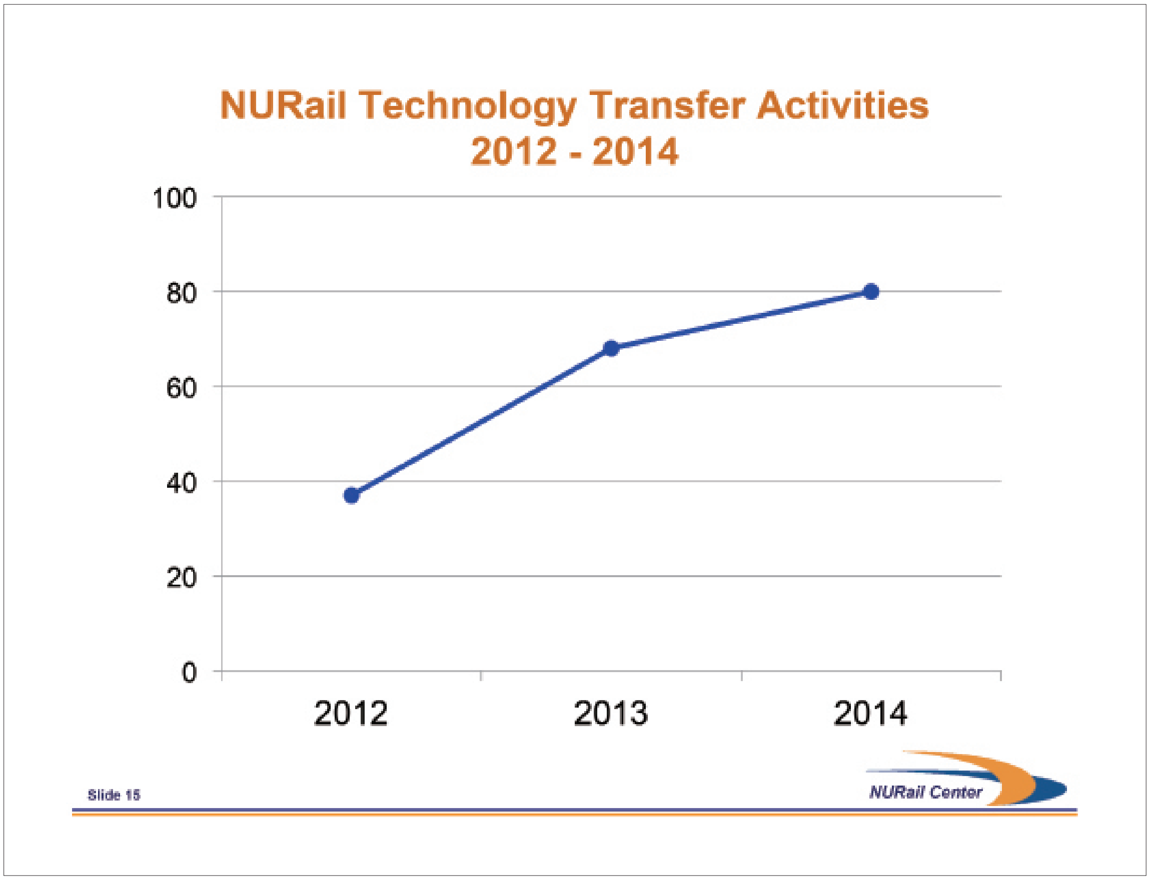
NURail Technology Transfer Activities
2012 - 2014
100
80
60
40
20
0
2012
2013
2014
Slide 15
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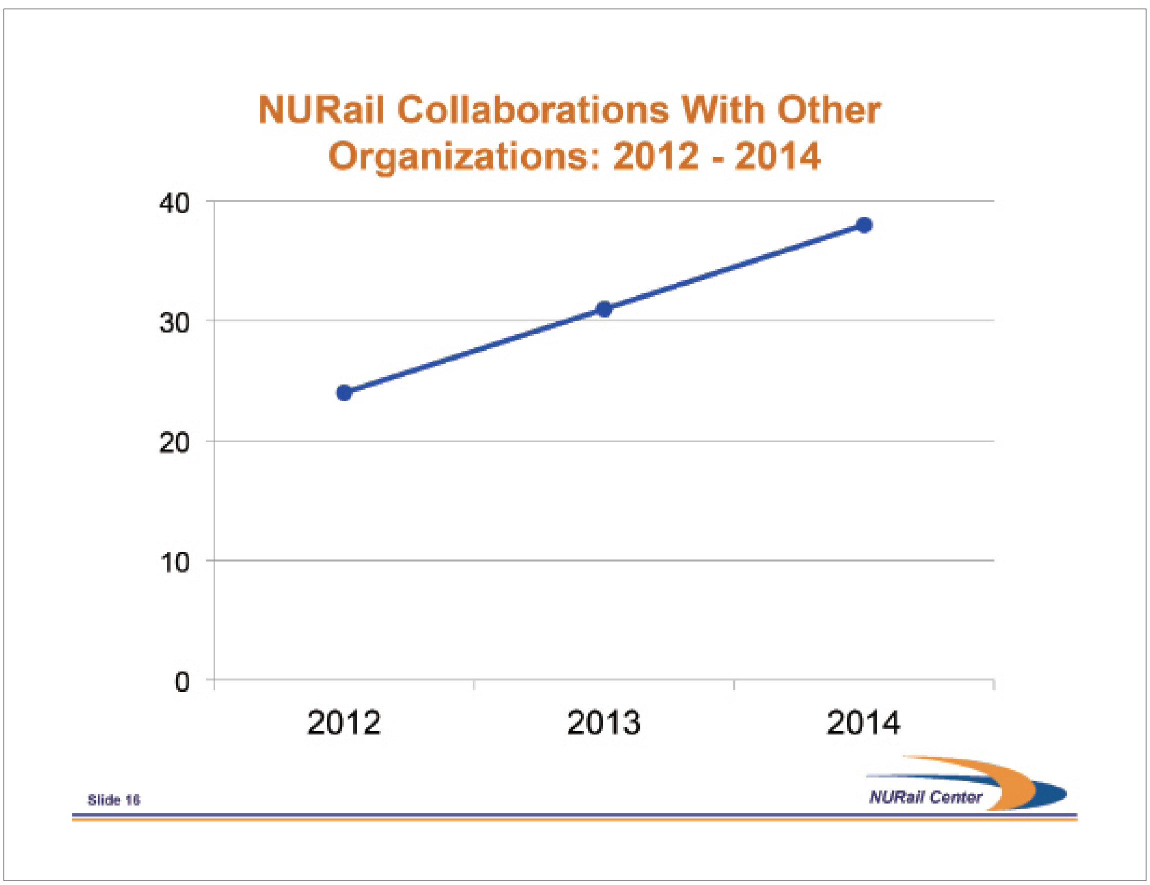
NURail Collaborations With Other
Organizations: 2012 - 2014
40
30
20
10
0
2012
2013
2014
Slide 16
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NURail in Action

- Invited representatives from private and public sector partners of NURail members
- Asked them to briefly discuss their interactions with NURail
- Interaction types include:
  - Research affecting practice, policy and standards development
  - Technology transfer activities
  - STEM education and minority community support
  - Employment of NURail graduates

NURail in Action Panel

- Doug Whitley, Supply Chain Innovation Network of Chicago
- Robert VanderClute, Association of American Railroads
- Ryan Kernes, GIC
- Nikkie Johnson, Michigan DOT
- Sergio "Satch" Pecori, Hanson Professional Services Inc.
- Michael McLaughlin, Chicago Transit Authority
- Vinaya "Vinny" Sharma, Sharma & Associates

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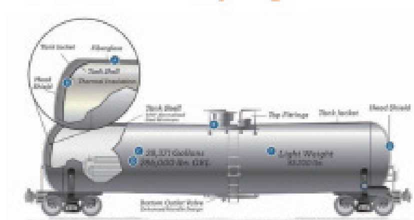
SUPPLY CHAIN INNOVATION NETWORK OF CHICAGO (SINC)
University of Illinois at Chicago - Urban Transportation Center

- SINC – freight CEOs – rail, truck, logistics, intermodal
- SINC & UTC – partnering to research and design an Off Peak Delivery (OPD) Pilot Project
- This is a model for connecting academic research with implementing organizations for maximum impact
- Research began Fall 2014; now in design phase; hoping to launch pilot OPD project in Fall 2015
- Benefits of OPD will spread throughout the supply chain – faster deliveries, less congestion, reduced costs, improved economy, healthier environment
- Thanks to NURail for supporting this great partnership

National University Rail Center

ASSOCIATION OF AMERICAN RAILROADS
University of Illinois at Urbana-Champaign

- Research
- Conducted 2012 - 2015
- Risk analysis of railroad tank car transportation of alcohol, N.O.S. and petroleum crude oil



- Rail industry used research to develop consensus and recommendations for safer tank car designs recently adopted as regulations by US DOT
- Ongoing research on unit-train and tank car safety

"NURail-supported research provided timely, data-driven information that helped the industry make fact-based policy decisions"

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GIC
University of Illinois at Urbana-Champaign

- Research
- Conducted 2012 - 2013
- Analysis of mechanics and failure modes of concrete crossties and fastening systems
- Rail industry used research to support improvements to AREMA Manual regarding component loading and design framework
  - GIC implemented innovative design features based on several outcomes of ongoing research on concrete crossties and fasteners

"UIUC research is impacting the way the industry discusses and collaborates to solve concrete crosstie and fastener challenges"

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MICHIGAN DEPARTMENT OF TRANSPORTATION
Michigan Technological University

- Research / Planning
- 2012-2014 & on-going
- Rural Freight Rail & Multimodal Transportation Improvements / Michigan Rail Conference
- Adding data into our systems and using research to inform MDOT's outreach efforts
- Currently planning 3rd annual conference

"The NURail collaboration with MTU brings theory into practice."

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HANSON PROFESSIONAL SERVICES
University of Illinois at Urbana-Champaign
Michigan Technological University

- Education and Outreach
- Conducted 2014 - 2015
- *"Grow Your Own"* Initiative
- Outreach to minority community encouraging student interest in STEM education and careers
- Ongoing activities

"*Our goal with NURail is to use their resources to help educate minority youth in our communities and help our company look more like the communities we work in*"

National University Rail Center

CHICAGO TRANSIT AUTHORITY
University of Illinois-Chicago - CUPPA

- Recruitment and employment of alumni
- CTA has employed many CUPPA/UTC grads
- Many have or currently worked in the CTA's Planning Department handling service planning, strategic planning, or schedule planning.
- Future plans / Recommendations for improvements
- Recommend focus on Transportation Curriculum

"*The CTA has had great success with UIC grads because the transportation classes combined with many internship opportunities prepares UIC grads for the rigors of working at the CTA.*"

SHARMA & ASSOCIATES
University of Illinois-Chicago - Engineering

- Recruitment
- 2011 onward
- Recruitment and hiring of engineering graduates
- Analysis of rail vehicles for railroads, rolling stock and component manufacturers and the FRA
- Supporting summer interns, recruitment of rail engineering graduates possible sponsorship of graduate student research

"***We are excited that there are now universities teaching rail transportation engineering and have knowledge of the topic*** "

NURail in Action Discussion Questions: Research

- What do you think are the greatest threats to rail transport in North America?
- What are the most important technical challenges facing your organization that might benefit from research?
- What are the most important business challenges?
- What are the most important rail or transportation policy questions?
- How might NURail contribute in solving these?
- What do academic researchers need to understand before embarking on a rail research initiative?

NURail in Action Discussion Questions: Technology Transfer

- What are the most important areas that academia offers in support of rail operation or development?
- Besides research what can NURail do to facilitiate implementation of new technology to advance rail transport?
- How could NURail strengthen the link between basic academic research and applied research and demonstration projects with full industry support?
- Where should NURail showcase research results and developed technology to have the greatest impact on practice?

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NURail in Action Discussion Questions: Workforce Development

- Can you identify how NURail graduates "separate" from other candidates as they enter rail workforce?
- What could NURail do that would further improve its students' preparedness?
- Where are greatest shortages in terms of attracting qualified applicants?
- What are biggest challenges in attracting women/ minority candidates?
- How might NURail support your organization's outreach and workforce development programs?

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NURail in Action Discussion Questions

- What do think NURail's most important accomplishments have been to date?
- Can you discuss an example of one tangible way to improve the coordination between industry and NURail?
- What was your primary motivation in collaborating with NURail and how did you become aware of the potential opportunity?
- Do you see collaboration with NURail as a way to add value to your organization or as part of your service to industry and if so how and why?

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On behalf of the NURail consortium members, *THANK YOU!*

NURail Center