



Rail Transportation Program

Michigan Tech Transportation Institute • Michigan Technological University



Annual Report

Sept 2015 - August 2016



**Michigan
Technological
University**

Michigan Tech Transportation Institute



Rail Transportation Program Vision:

“Develop leaders and technologies for 21st century rail transportation.”

Mission:

“To participate in the development of rail transportation and related engineering skills for the 21st century through an interdisciplinary and collaborative program that aligns Michigan Tech faculty and students with the demands of the industry.”

Director's Message

One of the easiest tasks for the Michigan Tech's Rail Transportation Program Director is writing the message for the annual report. We never seem to be short of stories and while much of our work is about consistency from year to year, each one of them also contains highlights that are special for the year in question, and 2015-2016 was no exception.

Perhaps the greatest achievement for the year was the approval of our Rail Transportation minor to the university curriculum. The minor follows our RTP vision by being multidisciplinary and flexible and we're hoping that our first graduate with the minor will be during next academic year. The second special moment of the year took place in mid-August when we hosted the 4th Annual Michigan Rail Conference for the first time in the Upper Peninsula. The conference (held in Marquette with field visits to Escanaba) had a record participation and sponsorship levels and our field trips turned out as an experience beyond belief. For two days, it was great to be a "Yooper railroader".



From the projects/research perspective, we were pleased to have our first two projects with the greatest industry supporter of our program, CN Railway. Even more exciting was the fact that our student project investigating alternative techniques for dye penetrant on rail defect detection led into an internship with CN for the student project leader, an event that he described as a "busy, but rewarding summer". Our student researchers excelled in other ways as well. Sumanth Kalluri continued our streak of best student conference papers by taking home the honor at the 2016 Joint Rail Conference and Aaron Dean was selected to receive one of the prestigious Summer Undergraduate Research Fellowships to continue his work on automated head tracking for driver behavior research.

The last thing I want to touch on our achievements is one that would make any railroader proud. With its adherence to standard safety procedures that prevail in the industry, the RTP and REAC have become models for the whole university's efforts to improve the safety culture on campus. Our students have presented our safety briefing for various entities on campus and were most recently invited to visit the meeting of our Board of Control. We are extremely proud to bring the attention to safety that has long prevailed in the industry to our campus environment.

As usual, I will finish my message with the recognition that despite all success, there are always rough waters to cross. It's no secret that past year has been challenging for the rail industry. We've been delighted to see that the internship levels have remained high, but we can't say the same from the full time hires. The fact that other industries have taken over the campus by storm certainly makes recruitment even more challenging. We still believe that there's plenty of interest toward the rail industry among our students, but we also believe that these times require even closer coordination and collaboration between our program and our industry partners. We hope that our industry supporters see this the same way and "help us to help them" in their recruitment process, so we can continue to maximize the number of Tech graduates who make rail industry their next home.

Pasi



Rail Transportation Advisory Board

The Rail Transportation Advisory Board (RTAB) continued its active role in shaping the RTP in 2015-2016. The Board continued under Matt Glynn's (CN) leadership. Three Michigan Tech alumni (see below) were invited to join the Board.

In addition to guiding yet another successful organization of our 2nd Rail Day and Expo and Railroad Night XI, the RTAB provided excellent advice in the development and review of the proposal for Minor in Rail Transportation. RTAB members for this reporting period and their company affiliations are presented below, including brief introductions of new members. The RTP wants to thank all the Board members for their indispensable guidance in the continuing development of the Program.

Welcome to our new members: Rob Bingham, Beau Ihnken, and Brent Marsh!

September Update: Martita Mullen was elected Chair, Tim Hoeffner as Vice Chair and Brent Marsh as Secretary/Treasurer. Darryl Babbitt and Richard Stewart resigned from the board. Thank you for your help and guidance during your period of service!



Matt Glynn
Chair
Chief Engineer, Signals & Communications, CN



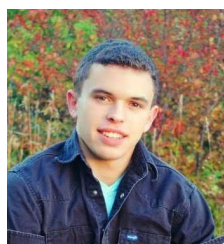
Darryl Babbitt
Vice Chair
Fleet Maintenance Manager, The Andersons, Inc



Kevin Kesler
Secretary/Treasurer
Chief of Rolling Stock R&D, FRA



Pasi Lautala
Assistant Professor/
Director, Rail Transportation Program, Michigan Tech



Aaron Dean
REAC President, Michigan Tech



Tim McKay
Executive VP of Growth & Regional Development, DART



Tim Hoeffner
Director, Office of Rail, MDOT



Martita Mullen
System Manager, Track Standards, CN



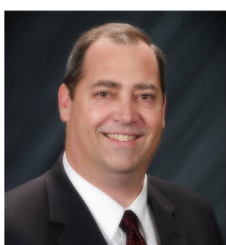
Jon Cool
President, Michigan Railroads Association



Beau Ihnken
Shop Supervisor, Loram Maintenance of Way



Brian Sykes
Chief Engineer, C&S Engineering, NS Railroad



David Thomson
President, Engineered Rail Solutions, LLC



Richard Stewart
Professor/Director, Trans & Logistics Research Center, UW-Superior



Rob Bingham
Marketing Manager, Midwest Region, Genesee and Wyoming, Inc.



Brent Marsh
Project Engineer Wisconsin Southern



**2015-2016
Program Partners:**

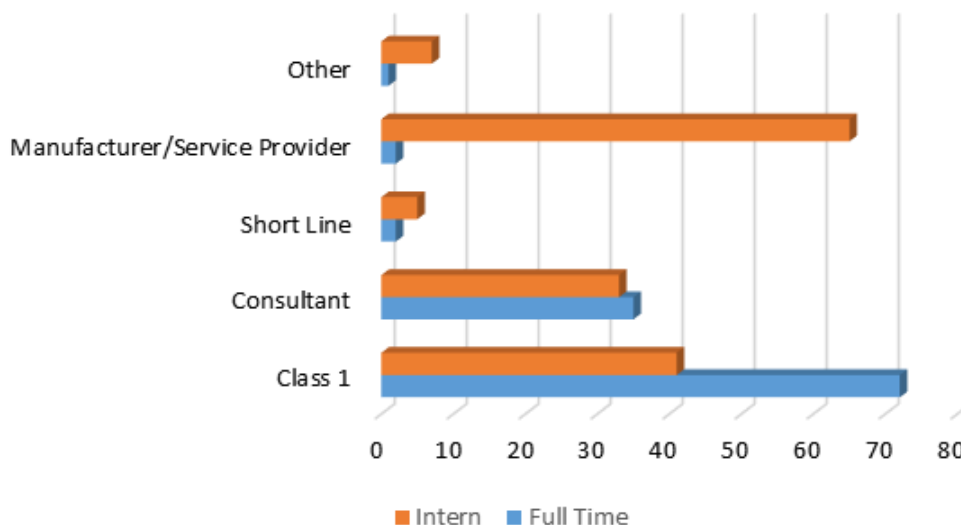


***Thank you for
your generous
support in 2015-
2016!***

Rail Industry Partners

Our industry partner, CN Railroad, continues to provide critical support for RTP. In addition to financial support, this year has seen growing participation in the undergraduate and graduate research areas. In addition, four interns from Tech worked at various positions within the CN organization over the past summer. We also recognize the support we have received from numerous other companies. Our annual events, Rail Day and Railroad Night, Michigan Rail Conference, and our summer youth program would not be possible without their participation. We continue to work with industry and REAC to improve industry visibility across our campus!

Industry New Hires and Interns since start of RTP (2008)



RTP continues to work with industry recruiters to place both interns and full time hires. Since RTP was established in 2008 we have placed over 100 full time employees in rail industry jobs, with more than 70 with the Class 1's. In the same period we have placed more than 150 students in intern or co-op positions.

SIR

Strategic Internships in Rail

We started the Strategic Internships in Railroads (SIR) partner program for interested rail industry companies in 2012. The mission of the SIR program is to create continuous and consistent internship opportunities that introduce RTP students to the rail industry environment and promote the value of RTP students to rail industry companies. Through their work, the interns actively contribute to advance company objectives and goals.

**2015-2016
Participating
SIR Companies:**





Student Intern/Co-op Highlights



Alyssa Leach & Haylee Lakenen, Railworks

- Alyssa worked on project management for the MDOT Amtrak project upgrading the line from Dearborn to Ypsilanti. She was heavily involved in measuring and calculating how far the track needed to be moved when it was being shifted to allow higher speed operations
- Haylee worked on projects in South Dakota, Nebraska, Iowa and Colorado assisting and shadowing Project Engineers. She worked alongside Foreman, Laborers and Operators to gain hands on experience at the construction level. She was also in charge of setting up road crossings for a project with Dakota Southern Railway.



John Promer, Rempres & Mario Maraccini, Via Rail Engineering

- John worked on design and construction management efforts for Rempres terminal support projects in the Chicago area and nationwide.
- Mario utilized MicroStation to design industry railroad alignments, collaborated with coworkers to keep safety and reliability the priority, developed project cost estimates, and mapped and staked sitework using GPS survey equipment.



Chet Halonen & Garrett Hutcheson, Loram Maintenance of Way

- Chet was a Mechanical Engineering Intern in Research and Development. He worked directly with engineers in the R&D department, was involved in a variety of projects throughout the summer, including work on a transit rail vacuum system, a ballast undercutter, and a handbrake tensioning system.
- Garrett did extensive work with the operation and maintenance of a Ballast Cleaner. He provided intuitive ideas on broken or malfunctioning equipment and wrote procedures for new workers to the machine.



Derek Owen & Otto Freiberg, WSP-Parsons Brinkerhoff

- Derek was involved in the Metro Blue Line Extension and Enhancement projects in the Chicago area. He used AutoCad and AutoDesk Civil 3D to assist in the preparation and submission of design packages.
- Otto worked with track layout and signaling systems in the Chicago metro area. "I was able to work with WSP| Parsons Brinckerhoff to expand my understanding of rail into the realm of signals. Throughout the internship I was able to utilize my past experience from classes as well as previous internships to better understand the difficulties and nuances of railroad signaling systems, and the massive conversion projects involved with PTC."



John Lalonde, Aaron Dean, Jackson Maslowski & Rachel Klumpp, CN

- John helped design programs to estimate rail stress under locomotive movements and operated a geometry testing load wheel to gather rail data.
- Aaron shadowed managers in the mechanical department in Homewood, IL, focusing a good deal of his time on locomotives.
- Jackson was based in Homewood, IL, working on electrical systems and signals.
- Rachel completed her second year of internship with CN, she worked in a small team on a safety-related project that brought information from several different applications into one system.

RTP Faculty & Staff



Dr. Pasi Lautala, P.E.

Dr. Lautala is the Director of the Rail Transportation Program and an Assistant Professor in the Civil and Environmental Engineering Department. For past ten years, Dr. Lautala has been one of the leaders in re-establishing rail transportation education and related research in North American universities. He's an Associate Director of Education for the NURail Consortium, one of the seven members of the State of Michigan Commission for Logistics and Supply Chain Collaboration and Vice Chair of TRB Freight Rail Committee and ASCE T&DI Rail Transportation Committee. He has created and teaches several courses in railroad engineering and is currently involved in numerous funded research projects related to railroads, multimodal transportation logistics and railway engineering education. Before his academic career, Dr. Lautala spent several years in the rail industry in the United States and Finland.



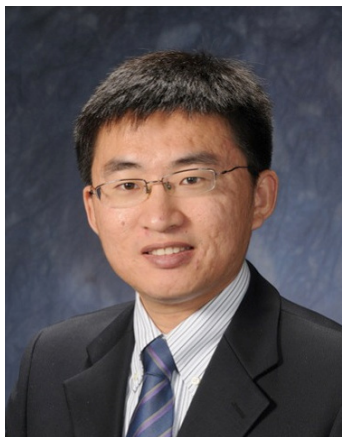
Dave Nelson, P.E.

David Nelson is our Senior Research Engineer and supports activities across the program. Dave has a BS in Civil Engineering and an MS in Mechanical Engineering which will help as we continue to push for multidisciplinary collaboration across the university. He also has an MS in teaching, including seven years of experience in primary and secondary schools. Dave's 20+ years of engineering and management experience with the US Air Force, including a tour teaching at the US Air Force Academy, and his experience from the rail related projects with Maine Department of Transportation bring a unique set of skills and experiences to our program.



Dr. Bill Sproule, P.E.

Bill Sproule is a Professor in the Department of Civil and Environmental Engineering with over 40 years of service in government, consulting, and university research and teaching in Canada and the U.S. He assisted in the development of the current Rail Transportation Program at Michigan Tech and teaches various transportation courses. He has also recently authored a book, Copper Country Streetcars. Dr. Sproule's interests include transportation planning, traffic engineering, airport planning and design, public transit, automated people movers, and consulting engineering. Canadian born and a true ice hockey fan, Bill also teaches a class titled "Hockey History and Culture". Dr. Sproule has been recognized with several awards including a Michigan Tech Distinguished Teaching Award and the ASCE Horonjeff Award.



Dr. Kuilin Zhang, P.E.

Kuilin Zhang is Assistant Professor in the Department of Civil and Environmental Engineering at Michigan Tech. Dr. Zhang received his Ph.D. degree in Transportation Systems Analysis and Planning from the Department of Civil and Environmental Engineering at Northwestern University in December 2009. After working as a Postdoctoral Fellow in the Transportation Center at Northwestern, he joined the Energy Systems Division at Argonne National Laboratory as a Postdoctoral Appointee in November 2010. He is a member of Transportation Research Board (TRB) standing committees of Transportation Network Modeling (ADB30) and Freight Transportation Planning and Logistics (AT015). He directs a high-performance computing Laboratory on Sustainable and Intelligent Transportations (SITS-Lab), and teaches transportation planning and transportation systems analysis.



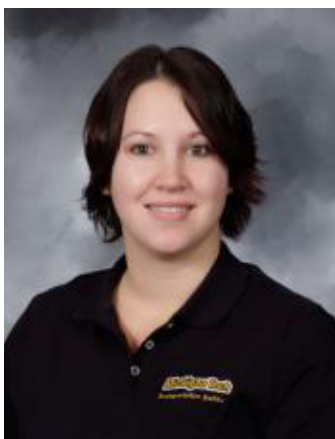
Pam Hannon

Pam Hannon is the Coordinator of the Michigan Tech Transportation Institute and supports the Rail Transportation Program through proposal development and coordination, and research project management.



Chris DelReal

Chris DelReal is a 2010 graduate of Michigan Technological University's Computer Networking and System Administration program. He now works with Michigan Tech's Tribal Technical Assistance Program as a web designer, technical advisor and code developer. Chris had a key role in the technical development of the High Speed Rail Learning System.



Amanda Kerttu

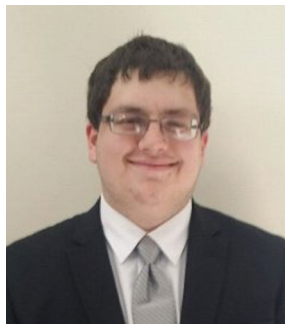
Amanda Kerttu has been working with the Eastern Tribal Technical Assistance Program at Michigan Tech as a staff associate since 2005. She is the primary contact for TTAP clients, and manages and coordinates training/events. Since 2015, Amanda has been also leading the logistics coordination for the Michigan Rail Conference and has got involved in other aspects of the RTP activities.

RTP Welcomes New Faculty and Staff



Hyungchul Yoon

Hyungchul Yoon is an Assistant Professor in the Department of Civil and Environmental Engineering at Michigan Tech. He received Ph.D. in civil engineering from the University of Illinois at Urbana-Champaign in 2016, focused on “Enabling Smart Cities: Post Disaster Response and Structural Health Monitoring”. His research interests include developing smart sensing technologies including smartphones and unmanned aerial vehicles (UAVs) for managing and monitoring civil infrastructure systems. Dr. Yoon has participated in multiple projects on railroads, especially to monitor railroad bridges by measuring the vibration response under in-service loads using wireless sensors and cameras attached to UAVs. Project sponsors have included the Federal Railroad Administration (FRA), American Association of Railroads (AAR), and Korea Railroad Research Institute (KRRRI).



Darian Reed

Darian is a first year Civil Engineering major. He was selected to fill a student administrative assistant position with our Rail Transportation Program, and has done an excellent job. He is also an active participant in Operation Lifesaver. As a result, we have tabbed him to help on an ongoing FRA sponsored research project on railroad grade crossings.

Darian has an extensive volunteering background, including work with the Monroe County Historical Museum and the Monroe County Relay for Life program. He has worked as an engineering intern at the Gerdau steel mill in Monroe, MI for two summers, and has picked up training and certification in a variety of Microsoft and Autodesk products.

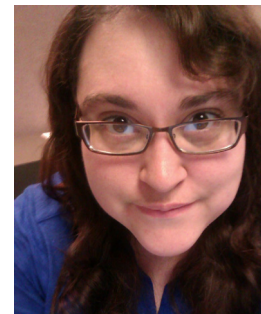


Alumni Highlights

Katie Westcott (CEE, 2010)

Engineer Special Trackwork, National Railroad Passenger Corporation (Amtrak)

I grew up in Vulcan, MI next to a Soo Line mainline, terrified of the freight trains that rolled by. I never would have imagined that years later I'd be standing just a few feet away from a high speed passenger train zooming along at 150 MPH nor that I'd enjoy making a career in the railroad industry. The summer of 2009 changed everything. On a whim, I talked to the BNSF recruiter at the Career Fair. I interned in Vancouver, WA with the Division Engineer and witnessed projects such as crossover installations, multi-track grade crossing renewal, and rail renewal programs. I worked with local Roadmasters to run the work gangs and got my first taste of track maintenance. Prior to the internship, my studies at Michigan Tech were focused towards structural design with a plan to pursue architecture post-grad. However, when I returned that fall, I elected the LS&I Railroad for my senior project and signed up for Dr. Lautala's railroad engineering course. I graduated in May 2010 and accepted a position in Amtrak's Management Associate Program.



My initial training took place in Philadelphia and my first assignment was on the New England Division where I helped run the daily maintenance activities on some of the fastest track segments in the country. I coordinated and scheduled track work, performed track and bridge inspections to ensure safe train operations and to provide smooth ride quality for passengers. In 2013, I served a short term on the Production side with the Track Laying System (TLS) consist, which replaces the entire track structure as it traverses it. I ran the gangs that operate ahead and oversaw the track laying machine (TLM) operation, ensured proper de-stressing and welding of rail, worked with ballast trains and the surfacing equipment, and handled inventory and tie supply to the TLM. That year I also assumed my current position as Engineer Special Trackwork within the Track Standards Department. I am responsible for reviewing vendor submitted plans for all special trackwork to ensure they are designed to Amtrak's standards and specifications, and to also develop and maintain standard plans. Special locations or items, such as New York's Penn Station or clothoid geometry turnouts, require site visits in order to gather specific information for me to use in new track designs or to create sketches for bid packages. With my territory spanning the country, every day there's a new challenge to tackle.

Ben Biesterveld, PE (ECE, 2006)

Project Manager II, PTC Wayside Signals, CSX Transportation, Jacksonville, FL

In all honesty, I had never considered working in the rail industry until my final year of school at Michigan Tech. Growing up in small town Wisconsin, there were railroad tracks that ran through the woods near my house, but that was the extent of my rail knowledge and interest. I had a good friend who graduated from Tech the year before me, who was hired by CSXT and I had kept in touch with him throughout my senior year. He would always call me and tell me about where he was working and what he was working on, how he enjoyed the type of work, the people, and the places he got to experience. Most notably was his involvement in rebuilding the track structure along the Gulf Coast after Hurricane Katrina hit in August 2005.



As a senior, going to the career fair in fall 2005, I stopped by the CSXT booth and was fortunate to get to interviews. A two-day (paid) trip to Jacksonville, FL sounded really good to me at the time. I graduated from Michigan Tech in spring 2006 with a degree in Electrical Engineering and have been working at CSXT ever since. Working for the railroad has been a rewarding 10 years so far. I have been able to experience all kinds of different people, projects, and visit various locations I had never been to before. I started as a Management Trainee for Signal Maintenance in Indianapolis, IN. Then I moved down to Jacksonville, FL, holding several positions in Public Projects and working on highway-rail grade crossing projects, or vehicular bridges being built over the railroad. After that I moved to Birmingham, AL and was the Supervisor for Signal Maintenance for the "Hump" Classification Yard and the surrounding main line track. Then I moved to Richmond, VA and worked again in Public Projects.

My current position is down in Jacksonville, FL at our Headquarters building. I am working on projects that are upgrading older relay based signal systems to newer microprocessor based signal systems in preparation for the federally mandated implementation of Positive Train Control (PTC). There are a lot of different departments involved in getting this new system operational which leads to the main advantage of working with rail industry and a large company like CSXT. As you can see from my personal history, there are multitude of different types of positions within the company which allows every employee to learn and gain experience.....and eventually find something that you truly enjoy.

Recent Graduate Highlights

Hamed Pouryousef (PHd, CEE, 2015)

Sharma & Associates, Inc. (SA)

Hamed Pouryousef graduated from Michigan Technological University (MTU) in spring 2015 with PhD in Civil Engineering focusing on train scheduling and capacity analysis areas using optimization and simulation models. While studying at MTU he contributed in several research projects under Dr. Pasi Lautala's supervision including development of a web-based education and training platform for high speed rail workforce in the U.S., sponsored by FRA. Hamed was also CO-Principal Investigator of "Evaluating the Use of Operational Management Techniques for Capacity Improvements on Shared-use Rail Corridors", sponsored by U.S. DOT.

After graduating from MTU, Hamed joined Sharma & Associates Inc. (SA), an engineering consulting firm with a specific focus on railroad safety, as Research Engineer. At SA, he has been primarily working on two research projects sponsored by FRA: 1) Analyzing the wayside detector systems, particularly wheel impact load detector (WILD), of one of the major commuter railroads; and 2) Implementation of Electronically Controlled Pneumatic (ECP) brake systems in the U.S. rail network.



SHARMA & ASSOCIATES, INC.

Aaron Lee (BS, CEE, 2014)

Quandel

Aaron graduated in December of 2014 and accepted a position with Quandel Consultants in Chicago, Illinois as a Project Engineer. At Quandel he has spent the majority last two years working on the ongoing corridor improvements of the Michigan Line for higher speed services of Amtrak between Chicago and Detroit. This work includes both the designs for improvement of track alignments and highway grade crossings to support train speeds of up to 110 mph. "Most recently I have been working out of Quandel's office in Kalamazoo, Michigan which allowed me to assist in construction oversight activities as well and get boots in the mud exposure to railroading from designs in MicroStation to the finished product. I have always been fascinated by trains so as soon as I found out that Michigan Tech had a rail program and that railroad engineering is still alive and booming, I focused my studies with the goal to work in the railroad industry upon graduating. During the summer of 2014 I was able to further my railroad background with an internship at TTCI in Pueblo, Colorado assisting in research for rail seat deterioration of concrete ties and other track component failure mechanisms leading to premature wear. My experience as a member of REAC and railroad classes I took have proved invaluable to me as it provided a lot opportunities both for summer internships and networking which eventually led to the job I am at today. Thus far, I enjoy my work and am excited to see where it leads me in the future!"



Mike Larson (BS, ME, 2015)

BNSF

Michael graduated from Michigan Tech in December 2015 with a Mechanical Engineering degree. Michael developed an interest in the rail industry through the Railroad Engineering and Activities Club (REAC) where he had opportunities to tour numerous railroad facilities and intern at Rail Interchange. Upon graduation, Michael accepted a Mechanical Management Trainee position with BNSF Railway. Throughout the Management Trainee program Michael attended training courses at BNSF's Technical Training Center where he learned about EMD and GE locomotives. While based at BNSF's Northtown (Minneapolis) Diesel Shop, Michael had an extensive four-month training program with craft employees to develop relationships and learn the processes and safety involved with maintaining BNSF locomotives. Michael was promoted to Mechanical Foreman I at Northtown in October where he leads craft employees to safely maintain and repair BNSF locomotives.





Graduate Students

2015-2016 Graduates

Three graduate students completed their MS degrees and their rail related research projects in 2015-2016. RTP congratulates the graduates.



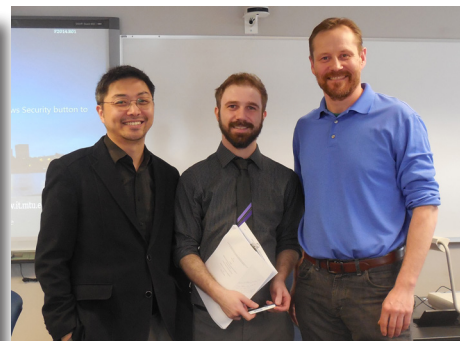
Priscilla Addison

MS in Geological Engineering
Rail Embankment Stabilization Needs on the Hudson Bay Railway



Sumanth Kalluri

MS in Civil and Environmental Engineering
Comparative Life Cycle Assessment of Road and Multimodal Transportation Options - A Case Study of Copperwood Project



Steven Landry

MS in Cognitive and Learning Sciences
Getting Active with Passive Crossings: Investigating the Efficacy of In-Vehicle Auditory Alerts for Rail Road Crossings

Continuing Graduate Students

Sanpil Ko

PhD Candidate, Civil Engineering
Advisor: Dr. Pasi Lautala

Sanpil received his B.Sc. and MS degree in Seoul, South Korea and majored in the department of Transportation and Logistics. He worked at Korea Railroad Corporation (KORAIL) after graduation. This experience lead him to pursue additional studies in transportation and railroad research. Sangpil is currently working with the PIRE Biomass project, funded by NSF.

Karl Warsinski

PhD Candidate, Materials Science & Engineering

Advisor: Dr. Paul Sanders

Karl earned B.S. degrees in both Materials Science and Engineering and Civil Engineering at Michigan Tech before continuing to graduate school to focus on metal casting. His early graduate work ranged from heavy section ductile iron casting to production of Ductile Iron from high purity components. Karl is currently working on "Austempered Ductile Iron (ADI) for Railroad Wheels", funded by NURail. His Ph.D. thesis concentrates

on the stability of the ausferrite microstructure under elevated service temperatures like those experienced by railroad wheels during on-tread braking.

Hanieh Deilamsalehy

PhD Candidate, Electrical Engineering
Advisor: Dr. Timothy Havens

Hanieh Deilamsalehy received her B.Sc. and MS degree in Tehran, Iran in Electrical Engineering and became familiar with Image Processing and Machine Learning methods during her masters program. After beginning her PhD at Michigan Technological University she was introduced to the rail program at Tech and decided to use those methods to implement an automated method for railway wheel defect detection.

Michigan Tech University. After two years in the rail industry he returned back to Michigan Tech for fall, 2016 to start his PhD studies related to grade crossing safety.

Soumith Oduru

MS Candidate, Civil Engineering
Advisor: Dr. Pasi Lautala

Soumith received his BS in Civil Engineering from Osmania University in Hyderabad, India and has been involved in the RTP since his arrival at Michigan Tech. Soumith is currently working on his MS research related to the life cycle analysis of alternative transportation options for the Eagle Mine in Marquette.

New Graduate Students

Modeste Muhire

PhD Candidate, Civil Engineering
Advisor: Dr. Pasi Lautala

Modeste received his BS degree in Civil Engineering from California Baptist University in May 2012 and his MS from

Undergrad Researcher

Aaron Dean

Aaron Dean is a junior in the Mechanical Engineering - Engineering Mechanics Department. Aaron has been working with RTP since his freshman year. For the past year he has concentrated on developing methods for analysis of the Naturalistic Driving Study data at grade crossings.

Graduate Student Research Highlights

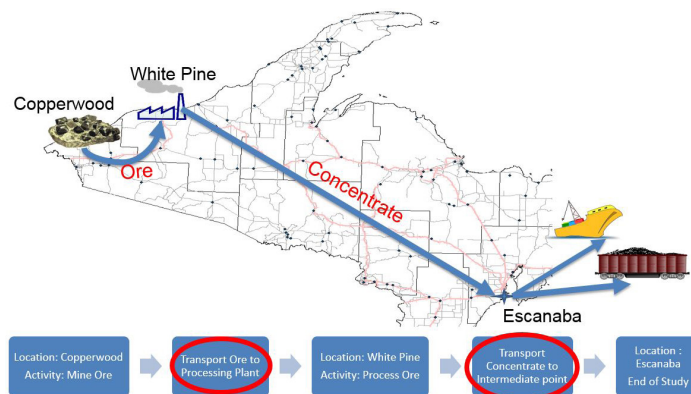
Sumanth Kalluri

Comparative Life Cycle Assessment of Road and Multi-Modal Transportation Options - A Case Study of Copper-Wood Project

This project uses a case study to assess the environmental impacts (emissions) of different transportation options for transporting ore between a planned mine and a processing plant, and concentrate from the processing plant to an intermediate location (Escanaba, MI). The ore transportation options include truck only option and two multimodal (truck-rail) options, while the concentrate transportation options include truck only, rail only and one multimodal (truck-rail) option.

Environmental impact assessment is done for several different mine lives through Life Cycle Assessment (LCA) using SimaPro Version 8 software. It covers all aspects related to the construction, operation, and maintenance (stages) of transportation infrastructure and equipment required for the project. The end of life stage was excluded from the analysis.

The output of the LCA is provided in the overall Global Warming Potential (GWP) in terms of kilogram equivalents of CO₂ (kg CO₂eq) and the emissions generated by each transportation option are compared on the basis of one ton (US ton) of ore/concentrate transported. The resulting emissions are also converted into economic values, so they can be included in the overall economic analysis. Overall, the results suggest that multimodal options generate the lowest emissions among all alternatives, for both ore and concentrate transportation. Operations stage accounts for the majority of the emissions for all six options, regardless of the life of the mine, but there are large differences in the operational emission quantities from truck only vs. multimodal options. Infrastructure emissions can also be significant, mainly in cases that combine extensive new infrastructure construction/upgrades and relatively short mine lives.



Ore/concentrate movements for LCA analysis

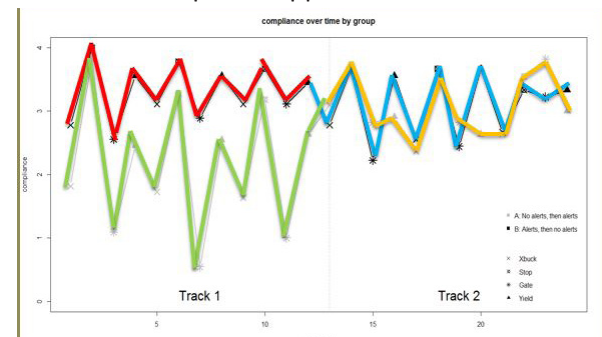
Steve Landry

Getting Active With Passive Crossings: Investigating the Efficacy of In-Vehicle Auditory Alerts for Rail Road Crossings

To increase safety at railroad (RR) crossings, experts are turning towards warning devices that can be applied to all crossings with minimal cost. In-vehicle auditory alerts (IVAA) offer potential to remedy many of the human factor issues related to crossing safety in a cost effective manner.

This thesis presents a series of experiments used to design and test an IVAA system for grade level RR crossings. Study 1 collected subjective data on a pool of potential types of in-vehicle auditory alerts from 31 undergraduate student participants. The type of IVAA was varied along a number of dimensions (pitch, repetition, wave shape, wording, voice, etc.). In addition, a pilot study was conducted to calibrate the simulated driving scenario featuring multiple RR crossings and a compliance behavior coding procedure. Compliance behavior was operationalized as an amount of visual scanning and pedal depression.

Study 2 had 20 undergraduate student participants drive in a medium fidelity driving simulator featuring four types of RR crossings, with and without IVAA warnings on approaching crossings, designed based on Study 1 outcomes. Results suggest that IVAA not only inform and remind drivers of how to comply at RR crossings, but also have a lasting effect on driver behavior after the IVAA is no longer presented (Figure below). Overall, compliance scores were highest among combination RR crossing visual warnings, such as crossbucks featuring STOP or YIELD signs and the lowest for crossbucks alone and active gates in the off position. IVAA had the largest impact on compliance scores at crossbucks and gates. The discussion includes implications for designing IVAA systems for RR crossings, and the potential implementation of prototype systems as a smartphone application.



Above: compliance score output

Right: driver simulator scene





Student Activities

Railroad Engineering & Activities Club (REAC)



The Railroad Engineering & Activities Club (REAC) was conceived in 2005, and in 2006 it was chartered as the first ever AREMA Student Chapter. Throughout the years, REAC has worked to connect university students with the rail industry like never before. It has been an outstanding gateway by providing excellent opportunities for those students interested in pursuing a career in rail and as outlined in the next paragraphs, the REAC has had a truly productive and memorable year.

The main goals of REAC are to connect students with the industry and to make the industry visible on campus. To help us meet our goals, REAC, along with RTP, presented Railroad Night XI and the 2nd Annual Rail Day & Expo, described in more detail on next page. Having this type of event right on Michigan Tech campus gives our students unparalleled opportunity to see and converse with true industry professionals and real equipment, not to mention the recruitment opportunities. As part of our preparation to the event and related University Career Fair, we also invited a staff member from the Michigan Tech Career Services to come to our October General Business Meeting and talk about building the perfect resume in preparation for our fall Career Fair.

Our monthly club meetings have been packed with great speakers throughout the year and in October, students from REAC attended the Railway Interchange 2015 in Minneapolis. Attending the Annual AREMA Conferences has been an excellent opportunity for students to learn more about the industry and the different type of companies and professionals involved. In the fall, students from REAC also volunteered their time to help out at the local Quincy Mine Hoist Association (QMHA) in Hancock, Michigan. The QMHA is in the process of restoring an older steam locomotive and tracks needed to be built so the locomotive could be moved and stored indoors for the winter. Students who participated had the opportunity to learn how to lay ties and spike rail, similar to how it is done in the industry.

The spring semester brought more industry-related presentations that were well received from the likes of Derek Yu of Alstom, Phil Pasterak from Parsons Brinckerhoff, Dr. Brad Howard of New York Air Brake, and Martita Mullen from CN Railway. Also in the spring, REAC took their annual spring field trip to the Chicago Area to tour the Nordco, Inc. plant in Oak Creek, WI, the EMD Manufacturing Plant in La Grange, IL, and the CN Railway Headquarters in Homewood, IL. These industry sponsored field trips are irreplaceable ways to provide experiences and insight to students interested in pursuing a career in the industry.

REAC continues to grow and to make the industry visible on campus. Next year, we will be celebrating our 10th Anniversary as the first AREMA Student Chapter, and we are looking forward to another great year. We are already making travel plans to attend the 2016 AREMA Conference in Orlando and are getting excited for the next Railroad Night XII. We are the future of railroading and it is our hope and goal that more students will come to realize that as well.

Aaron Dean

REAC President



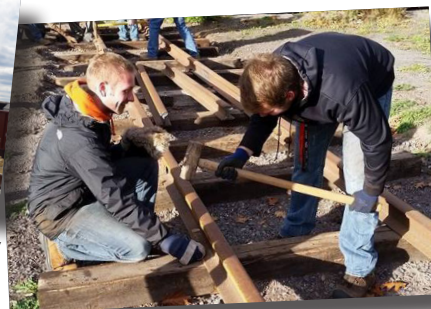
Chicago Field Trip 2015



AREMA Conference 2015



Outdoor displays at Railway Interchange 2015



Volunteering at Quincy Mine Hoist

RTP/REAC Safety Culture

Safety is the first priority in the rail industry and both RTP and REAC aim to lead by example with regards to safety here on campus. Before every rail related class period, or any REAC organized meeting or event, REAC students conduct a safety briefing. These briefings are similar to those that the railroads conduct for work crews before any assigned job or task. This process has been recognized by the University and in the fall, students from REAC were invited by the Provost to give a safety briefing during an academic forum. Aaron Dean (President) and Derek Owen (VP) gave a detailed safety briefing in front of numerous university faculty and staff. As part of a new safety campaign throughout campus, the Occupational Safety and Health Services at Michigan Tech is interested in how the railroad uses various safety protocols to mitigate risk in emergency situations. The presentation by Aaron and Derek spurred much needed conversation between concerned faculty and staff. A week later, Aaron and Derek were once again invited to present, only this time it was for the University Board of Trustees. This was an excellent opportunity to share their knowledge of safety with the primary decision makers on campus. The presentation was well received by the Board and all in attendance. REAC hopes that the Board will realize the need to prioritize safety and emergency preparedness on campus so that we can all work together to make Michigan Tech a safe environment for everyone.

11th Annual Rail Night & 2nd Annual Rail Day Expo

October 20, 2015

On October 20th, seventeen rail industry companies from Class 1 freight railroads to engineering consultants and manufacturers sponsored the 2nd Annual Rail Day/Expo. The day featured a morning poster session highlighting student and faculty rail research at Tech, an industry recruitment Expo with technology demonstrations, industry panel discussion, and the Railroad Night XI. Nearly 200 students from various disciplines participated in the different events throughout the day and Railroad Night XI brought together over 130 students, faculty, administration and community members to network, discuss rail transportation and to learn from latest policy issues from our Keynote Speaker, Art Guzzetti. Overall, the event was deemed a great success, and the Rail Transportation Program/Railroad Engineering Activities Club have already started the early planning activities for the 3rd Annual Rail Day/Expo in 2016.



**Keynote Speaker: Arthur Guzzetti,
Vice President- Policy, American Public
Transportation Association (APTA)**



GS Engineers discuss locomotive access with students



CN representatives at Rail Day



Youth Activity Highlights

6th Annual Rail & Intermodal Transportation Summer Youth Program

July 17 - 23, 2016

In July, the Michigan Tech Rail Transportation Program successfully held The 7th annual Summer Youth Program in Rail and Intermodal Transportation. The program invited a group of young students to take place in a week full of educational field trips and engaging hands-on activities, all centered around the rail industry and its connections to other transportation modes. Students learned about track structure, built scale model track sections, discussed high speed rail in the US and worldwide, and even used a PC based railroad simulator to get a feel for operating a locomotive! On top of that, the group got to tour the LS&I facilities in and near Marquette; the BNSF railyards, the Midwest Energy Coal Terminal, and the Halvor Lines trucking terminal in Superior, WI; and a train derailment site and the fascinating Lake Superior RR Museum in Duluth, MN. The program created a week of memories for this group of high school students!

SYP 2016 Field Trip Schedule

- Monday: the Lake Superior and Ishpeming Railroad started the field trips with a tour of the Eagle Mills Yard and the LS&I maintenance facilities
- Tuesday: traveled to Superior Wisconsin and met with UW Superior staff
- Wednesday: toured the BNSF 28th Street Yard & facilities. Visited a train derailment site in Duluth, MN. Then toured the Midwest Energy Coal Terminal in Superior
- Thursday: Visited the Halvor Lines trucking terminal and Lake Superior RR Museum in Duluth, then returned to Houghton
- Friday: Visited the Lake Linden and Torch Lake Railroad



Midwest Energy Coal Terminal



Halvor Lines Trucking Terminal

"I'd recommend both the Summer Youth Program and the Rail Program itself here at Michigan Tech to anybody interested in railroad transportation."

-Alex Christmas

**2016 SYP
Program Sponsors:**



Students watching trains
at N21st St. Bridge
in Superior, WI



BNSF Railyard



UW-Superior Campus



Past Summer Youth Program Students Advance in Studies

Sean Pengelly - SYP 2010

Sean developed an early interest in trains and by middle school had decided to pursue a civil engineering program, with a focus on railroading. During the spring of 2010 Sean and his parents discovered the Michigan Tech Rail and Intermodal Transportation Summer Youth Program, and decided to visit Tech for the week. According to Sean, "The week I spent there at Michigan Tech's campus learning about the professional railroad industry and education/career opportunities grew my interest and passion even more. It was the field visits that first gave me the opportunity to get up close with rail infrastructure in a professional manner. Connecting with Pasi was huge, since I could see his passion for the industry and his passion for education."

Sean stayed in contact with the Tech rail program during the next few years, and eventually decided to apply to the university. "The SYP was a major influencing factor on my decision to attend Michigan Tech. For the two years I was there, I was able to immediately step into a roll with RTP based on the connections I made at the SYP two years prior". After two years at Michigan Tech, Sean was able to follow his dream in cross country running and transferred to UIUC, while working in their Rail Program.



Alex Christmas - SYP 2015

Alex grew up in a family that supported his passion for railroading. His interest started almost before he learned to walk. In 2011 he started an online series of rail videos through his own YouTube channel. As he shot more train video, his interest grew. He lived in a region with a strong rail fan base, and used connections developed there to get to know engineers, conductors, and yardmasters in his area. The more he learned, the more questions he had!

Alex first heard about the railroad program at Michigan Tech through his father around the 9th grade in high school. During his junior year in high school he applied to the Michigan Tech Rail and Intermodal Transportation program, planning to use it both as a opportunity to learn more about Tech, and to learn more about the rail industry. And it turned out to be a great experience. In his words, "Over that week in the summer of 2015, our group toured Cliff's Mining and Railroad operations near Marquette, visited trucking, shipping and rail operations around the Twin Ports in Duluth-Superior. The time in campus also allowed us to get a feel for Tech. After the week was over, there was no question that Michigan Tech was my top pick for College." A short time later he was filling out his application, and started school here at Tech in the fall of 2016. He has already made a mark for himself in the RTP, having been elected to serve as secretary of the Railroad Engineering and Activities Club.

Student & Youth Other Events

October 2015

October 17, 2015: 13 REAC student members met up at the Quincy Mine and Hoist to organize a large pile of wooden cross ties and lay some more track next to the old Quincy Mine round house.

February 2016

February 16, 2016: Spring Career Fair and Railroad Night. REAC sponsored an information session featuring rail industry companies.

March 2016



March 17, 2016: REAC Students Derek Owen and Aaron Dean manned a table at the Stem Festival, Thursday, March 17.

May 2016

May 8-9, 2016: Construction Career Days. Dave Nelson supported the Civil Engineering Booth at Construction Career Days, in Howell, MI. 1700 students from 150 schools participated.

June 2016

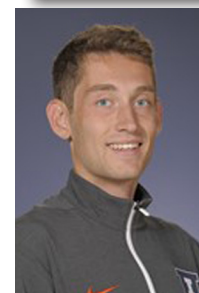
June 28, 2016: RTP Booth at Engineering Scholars Program (ESP) and Women In Computer Science (WICS) Tech Expo, 186 high school students in MUB Ballroom

July 2016

July 15, 2016: Design a Sustainable Future Teacher Institute - Pasi presented teachers with ideas on how to incorporate transportation (and its sustainability) in their education

July 17-23, 2016: Summer Youth Program, see article on previous page.

July 19, 2016: NTSI Rail Transportation Presentation - Pasi presented a rail overview to students



Sean Pengelly



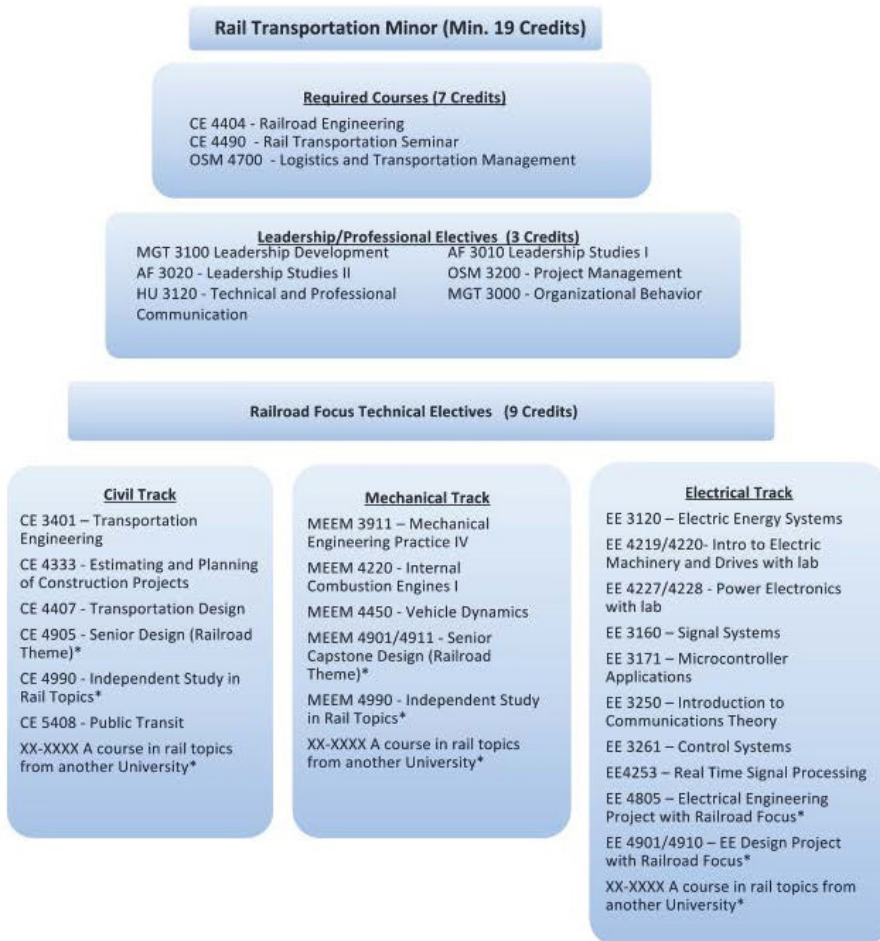
Alex Christmas



New Educational Opportunities in Rail

Rail Transportation Minor

In spring 2016, the University Senate approved Rail Transportation minor as part of the University offerings. This minor is targeted to Michigan Tech students from various disciplines with interests in the rail transportation industry. The mix of discipline specific and multi-disciplinary class requirements provide students with the basic skills and background necessary to rapidly become effective specialists and leaders in the industry. In addition to the courses in rail transportation and engineering, students also learn logistics, management, leadership, and/or communications skills to meet the demands of rail industry careers. In addition to civil engineering and business needs, the industry is increasingly looking for graduates with the technical expertise needed for their signal and communications systems (including IT systems), and the background to handle the latest developments in mechanical systems, including locomotive engines. The Minor is initially setup for student from Civil, Electrical and Mechanical Engineering departments, but future additions will be considered based on the level of student interest. Figure below presents the course setup for the Rail Transportation Minor.



Scholarship Winners

Each year the RTP offers internal scholarships funded by industry partners and students compete for AREMA scholarships including Michigan Tech Alum AREMA Scholarships. In 2015-2016, Michigan Tech students received over \$10,000 in rail Scholarships.

AREMA Scholarships

Kelsey Abbott	ME	Michigan Tech Alumni Scholarship
Alexandra Lakenen	CE	Michigan Tech Alumni Scholarship
Otto Freiberg	CE	Michigan Tech Alumni Scholarship
Derek Owen	CE	Light Density & Short Line Railways Scholarship, CN

CN US Scholarship Program

Rachel Klumpp	BM
Taylor Wiegand	CE

Internal Scholarships from RTP and Industry

Aaron Dean	ME	CN Railroad Scholarship
Derek Owen	CE	CN Railroad Scholarship

**Congratulations to
all the winners!**



Publications/Conferences

Journal Publications

- Deilamsalehy, H. Havens, T., Lautala P., Medici, E., Davis, J., An Automatic Method for Detecting Train Car Wheel Flat Spots and Hot Bearings Using Thermal Imagery, *Journal of Rail and Rapid Transit* (2016) DOI: 10.1177/0954409716638703
- Pouryousef, H., Lautala P., Watkins, D., Development of hybrid optimization of train schedules model for N-track rail corridors, *Transportation Research Part C*. (2016) 67:169-192, doi:10.1016/j.trc.2016.02.008

Conference Papers / Presentations

- Lautala, P., Jeon, M., Landry, S., Nelson, D., Dean, A., Driver Behavior at Highway-Rail Grade Crossings Using Naturalistic Driving Study Data and Driving Simulators, *American Railway Engineering and Maintenance of Way Association (AREMA) 2016 Annual Conference*, Orlando, FL, August 28-31, 2016
- Nelson, D., Lautala, P., Dean, A., Harnessing Undergraduate Students as Rail Industry Technology Developers/Problem-Solvers, *American Railway Engineering and Maintenance of Way Association (AREMA) 2016 Annual Conference*, Orlando, FL, August 28-31, 2016
- Landry, S., Jeon, M., Lautala, P., Nelson, D., Design and Evaluation of In-Vehicle Auditory Alerts for Railroad Crossings, *Global Level Crossing Safety and Trespass Symposium (GLXS)*, Helsinki, Finland, June 12-16, 2016
- Nelson, D., Lautala, P., Jeon, M., Driver Behavior at Level Crossings Using Naturalistic Driving Study Data, *Global Level Crossing Safety and Trespass Symposium (GLXS)*, Helsinki, Finland, June 12-16, 2016
- Pouryousef, H., Lautala, P., Hybrid Optimization of Train Schedules (HOTS) for Stop Pattern and Dwell Time Analysis, *11 th World Congress in Railway Research*, Milan, Italy, May 29 – June 2, 2016
- Addison, P., Lautala P., Oommen T., Vallos, Z., Embankment Stabilization Techniques for Railroads on Permafrost, *ASME/ASCE/IEEE 2016 Joint Rail Conference*, Columbia, SC, April 12-15, 2016
- Deilamsalehy, H. Havens, T., Lautala P., Detection of Sliding Wheels and Hot Bearings Using Wayside Thermal Cameras, *ASME/ASCE/IEEE 2016 Joint Rail Conference*, Columbia, SC, April 12-15, 2016
- Landry, S., Jeon, M., Lautala P., Nelson, D., Getting Active with Passive Crossings: Investigating the Use of In-Vehicle Auditory Alerts for Highway-Rail Grade Crossing, *ASME/ASCE/IEEE 2016 Joint Rail Conference*, Columbia, SC, April 12-15, 2016
- Kalluri, S., Lautala, P., Handler, R., Comparative Life Cycle Assessment Of Road And Multimodal Transportation Options – A Case Study Of Copperwood Mine, *Transportation Research Board 95th Annual Meeting of the National Academies*, Washington, DC, January 12-16, 2016
- Lautala, P., Dick, T., Rizos, D., Clarke, D., Toward Next Generation of Railroad Professionals – Collaboration by NURail and Rail Industry, *Railway Interchange*, Minneapolis, MN, Oct 4-7, 2015

Invited Presentations

- Michigan Tech Alumni Association, “Rejuvenating Rail Transportation in the U.S. and at Michigan Tech,” (August, 2016)
- Upper Great Plains Transportation Institute/North Dakota State University, “Railroad Careers and Programs,” “Rail/ Multimodal Research at Michigan Tech,” and “Upper Peninsula Freight (Rail) Study and Michigan Tech Rail Transportation Program,” (October, 2015)
- Peninsula Association of County Commissioners, “Rail in Michigan and the Upper Peninsula Freight (Rail) Study,” (November, 2015)
- Michigan Railroad Association, “Michigan Tech Rail Transportation Program,” (December, 2015)

RTP in the Press

- July-August, 2016, 4th Annual Michigan Rail Conference was covered by various television, radio and news outlets
- July 20, 2016- SYP in the News KBJR-TV Channel 6 (NBC) in Duluth, <http://www.northlandsnewscenter.com/news/local/Michigan-Tech-students-get-an-up-close-look-at-trains-in-Superior-387700422.html>
- April 6, 2016 – KEDA Panel Discussion - Pasi Participated as transportation expert in the breakfast panel discussion on the Upper Peninsula Infrastructure Needs for the Keweenaw Economic Development Association. Lautala's remarks were later covered by the *Daily Mining Gazette* “Rail Expert Explains UP Railroad Limitations”
- March 8, 2016 – Tom Bartlett was highlighted in UP Career Corner
- September 4, 2015- Pasi was quoted on article about Michigan Supply Chain Report <http://www.freep.com/story/news/local/2015/09/05/logistics-district-detroit-study/71783260/>



Conference Highlights

4th Annual Michigan Rail Conference

August 17-18, 2016

The 4th Annual Michigan Rail Conference took place in August at Northern Michigan University, Marquette. The conference, the first to take place in the Upper Peninsula, exceeded all expectations with a record turnout of 160 participants. The conference was led by the Michigan Tech Rail Transportation Program in cooperation with the Michigan Department of Transportation (MDOT) and National University Rail Center (NURail), all under guidance from a Conference Planning Committee.

The conference had 14 industry sponsors and it featured almost 30 presenters from the rail industry and stakeholder groups, as well as keynote speeches by Mr. Tom Baldini (on economic development in the U.P.) and Mr. Frank Patton (on the Great Lakes Basin). Technical session topics ranged from the future of rail in Michigan, to rail operations and related development in the Upper Peninsula, and plans for the Great Lakes Basin Railroad.

Almost 70 participants stayed an extra day to tour various locations in the Upper Peninsula. These included the Lundin Mining and Mineral Range Railroad operations in Humbolt, Sawyer Int'l Airport rail access and Potlatch Corporation in Gwinn, and the CN ore docks and rotary dumper and Delta Manufacturing facilities in Escanaba. Escanaba & Lake Superior (E&LS) Railroad sponsored a lunch for the field visits and provided a tour of its Escanaba car repair shops.

2015 Railway Interchange

October 2015

Pasi Lautala, David Nelson and a group of 12 REAC members attended the 2015 Railway Interchange in Minneapolis. Railway Interchange is a combined trade show organized by various rail industry trade organizations and attracts almost 10,000 participants. Michigan Tech students participated in the Quiz Bowl and poster competitions as part of the student activities. Aaron Dean and Alex Lakenen served as student interns for the Conference Operating Committee. In keeping with the rail theme, the students used the Green Line light rail to move from their hotel to the downtown conference location.

RTP also organized an alumni event for Michigan Tech's rail industry graduates at The Local in downtown Minneapolis where more than 20 alumni from across the industry joined with students for a great social event! Finally, Pasi Lautala presented a paper co-authored by Dimitris Rizos, Tyler Dick and David Clarke in the closing general session for the conference.



2015 AREMA Conference alumni gathering

Many of the presenters gather for a group photo at the 4th Annual Michigan Rail Conference in August.

Joint Rail Conference 2016

April 12-15, 2016

Dr. Pasi Lautala and eight students from Michigan Tech attended the Joint Rail Conference in Columbia, South Carolina April 12-15. The four graduate students (Hanieh Deilamsalehy, Priscilla Addison, Steven Landry, and Sumanth Kalluri) presented their technical papers while undergraduate students presented their senior design/enterprise projects. All eight students received scholarships from ASME to attend, and Sumanth Kalluri brought home the 2016 Best Student Technical Publication award for his paper, *"Toward Integrated Life Cycle assessment and Life Cycle Cost Analysis for Road and Multimodal Transportation Alternatives – A Case Study of the Highland Copper Project."*



Sumanth Kalluri best paper award at the 2016 Joint Rail Conference

TRAC

July 12-14, 2016

In July, 2016, RTP was an integral part in organizing the Rail Academic Conference (TRAC). Pasi Lautala and David Nelson led the academic content committee for the event that combined Railway Engineering Education Symposium (REES) and National University (NURail) Annual Meeting into one event at Urbana, Illinois. The event had over eighty total participants, many of them professors with no prior experience in rail transportation/engineering.

In addition to RTP's contribution in organizing the event, it also provided content to various sessions and handled posting of pre-conference learning materials in its online Rail Learning System. Lautala moderated a session as part of the event and both Lautala and Nelson presented in the symposium. Michigan Tech had also five research posters and two RTP students, Aaron Dean and Sumanth Kalluri participated in the event. Kalluri was one of the contestants of the 3-minute thesis competition.

Guest Speakers / Visitors

January - 2016

Jan 18-19: Derek Yu, Product Solutions Engineer from Alstom - Derek Yu visited campus, presented two discussions on *"Rail Signals"* to Rail Transportation Seminar and REAC.

design project.

March 15: Ed Burkhardt, Rail World, Inc presented on *"US vs. Europe Freight railroads"* to Rail Transportation Seminar (Web conference).

March 22: Tony Hatch, ABH Consulting presented on *"Status of Rail Transportation from Investor Perspective"* to Rail Transportation Seminar (Web Conference)

March 29: Mark Duve, NS Railroad presented on *"US Locomotive Trends"* to Rail Transportation Seminar (Web Conference).

February

Feb 9: Phil Pasterak, Vice President from PB/WSP – Phil made two presentations on *"Midwest High Speed Rail Projects"* to Rail Transportation Seminar and REAC.

March

March 1: Brad Howard from New York Air Brake provided two guest lectures on *"Train Simulations and Automated Trains"* to Rail Transportation Seminar and REAC.

March 3: Ian Weiner and Troy Elbert, from CN Railway and Herzog - Visited campus to discuss CN rail materials work and dye penetrant senior

April

April 5 -6: Martita Mullen from CN visited campus and presented on *"Railroad Track and Rail Maintenance"* to Rail Transportation Seminar and REAC

Students with Pasi at the 2016 Joint Rail Conference





Other Events / Professional Development / Workshops

September - 2015

Sept 18: Lautala and Pouryousef participated in the UK Railway Study Association (RSA) inspection tour of the Michigan Corridor. They made presentations to the US railway academia rebuild effort and on Tech's railway capacity research.

September 29: REAC and RTP hosted a railroad industry information session following the Career Fair.

October - 2015

Oct 3-7: AREMA Conference and Railway Interchange (see page 20 for details)

October 13: Pasi participated in the FRA Project Delivery Conference in Washington DC.

Oct 20: 2nd Annual Rail Day and Student Expo (see page 15 for details)

Oct 31- Nov 4: Dave Nelson attended the 2015 National Grade Crossing Safety Training Conference in Arlington, Texas.

December - 2015

Dec 3: Pasi participated in a two-day management training seminar in Marquette, Michigan.

Dec 9: Tim Havens attended the Big Data in Railroad Maintenance Planning Conference at the University of Delaware.

Dec 9: Pasi presented on RTP and senior design projects to the Michigan Railroad Association membership at their winter meeting.

Dec 10: Pasi and Adam visited CN headquarters in Montreal to present on RTP activities supported by CN donations.

January - 2016

Jan 10 – 13: Pasi organized and moderated a session on "The Future of Railroad Rolling Stock" and Sumanth Kalluri present a poster "Comparative Life Cycle Assessment of Road and Multimodal Transportation Options" at the TRB Annual Meeting

Jan 28-30: Dave and 14 Senior Design students visited LSRC railyard in Saginaw to preview work requirements for senior design projects.

February - 2016

Feb 16: REAC and RTP hosted a railroad industry information session following the Career Fair.

Feb 25-27: Dave attended AREMA Committee 24 Meeting in Fort Worth, Texas.

March - 2016

March 31 – April 2: REAC Spring Field Visit (see page 14 for details)

April - 2016

April 6: Pasi participated as a transportation expert in a breakfast panel discussion on the Upper Peninsula Infrastructure Needs for the Keweenaw Economic Development Association. His remarks were later covered by the Daily Mining Gazette article, "Rail Expert Explains UP Railroad Limitations."

May - 2016

May 5-6: Pasi met with MDOT representatives to discuss ongoing rail projects.

May 15-18: Pasi and Sangpil Ko participated in the PIRE Annual Meeting in Tabasco, Mexico. Sangpil also presented a poster in the NSF PIRE Program Event in Washington, D.C.

May 29 - June 1: Hamed presented a poster, "Hybrid

Optimization of Train Schedules (HOTS) for Stop Pattern and Dwell Time Analysis" and participated in the 2nd Talent Workshop during the World Congress on Railway Research

June - 2016

June 13 - 15: Pasi gave two presentations on grade crossing research at Tech during the Global Level Crossing Safety and Trespass Prevention Symposium 2016

July - 2016

July 12 - 14: TRAC (REES and NURail Annual Meeting) (see page 21 for details)

July 20: Pasi held a Q&A session for middle school students who watched the "Megastructures - Extreme Railway" documentary as part of their summer camp.

August - 2016

Aug 4: Pasi presented a Tech Talk "Rejuvenating Rail Transportation in the US and at Michigan Tech" to over 50 people at the 2016 Michigan Tech Alumni Reunion

Aug 17 - 18: 4th Annual Michigan Rail Conference (see page 20 for details)

National University Transportation Center

In 2012, the seven university consortium, including Michigan Tech, was awarded the first National University Rail Transportation Center (NURail) by the USDOT Research and Innovative Technology Administration (RITA). After 2013 competition, NURail also became a Tier-1 University Transportation Center. The primary objective of the NURail Center is to improve and expand rail education, research, workforce development, and technology transfer in the U.S. The grant has supported various educational and student activities and projects covered in this report. Four projects were completed in 2015-2016, two projects continue and one new project was started. Many of the projects receive (have received) complimentary funding from non-federal sources.



NURail Researchers



Tim Havens
-Assistant Professor,
Dept. of Electrical &
Computer Engineering



Thomas Oommen
-Assistant Professor,
Dept. of Geological
Engineering



Dr. Paul Sanders
-Assistant Professor,
Dept. of Material
Science & Engineering



Myoungsoon Jeon
-Assistant Professor,
Dept. of Cognitive &
Learning Sciences



Pasi Lautala
-Assistant Professor,
Civil & Environmental
Engineering

Completed NURail Projects

The 2015-2016 year saw several completed NURail projects at Michigan Tech, including:

Computer Vision and Machine Learning Method for Detection and Assessment of Wheel Anomalies Using Sensor Fusion of Thermal and Visible Spectrum Cameras (by Dr. Tim Havens): We proposed a machine learning approach that automatically detects and identifies sliding wheels in thermal and visible spectrum imagery. The process first detects and extracts the wheel and bearing region and then extracts feature descriptors of the area of interest, looking for anomalies in the wheel. The process also finds the mean temperature of the extracted bearing region to detect hot bearings if they exist. The small sample size of actual wheel images available limited progress, so simulated data was used for algorithm training purposes. A UPRR data set was then used for evaluating the algorithm. The results showed the method was able to detect 98% of the total number of simulated and real world defective wheels in addition to identifying all the normal wheels without any false alarms (see also Journal Publication on Page 19).

The Effects of Auditory Warnings and Driver Distraction on Rail Crossing Safety (by Dr. “Philart” Jeon): A promising approach to preventing train-vehicle collisions at highway-rail grade crossings is the use of in-vehicle auditory alerts (IVAA) which are possible with today’s technology. The project conducted a series of experiments to design and test an IVAA system for RR crossings starting with collection of subjective data on a pool of potential in-vehicle auditory alerts. The results were used to design a prototype IVAA crossing notification system for testing in a medium fidelity driving simulator. Results suggest that IVAA not only inform and remind drivers of how to comply at RR crossings, but also have a lasting effect on driver behavior. Compliance scores were highest among combination RR crossing visual warnings, such as crossbucks featuring STOP or YIELD signs, and lowest for crossbucks alone and active gates in the off position. Nearly 75% of the subjects reported that they would be likely to use this type of auditory warning system and would be even more likely to use it, if it contained train present/absent information.

Rescheduling/ Timetable Optimization of Trains along the U.S. Shared-use Corridors (by Dr. Pasi Lautala): A detailed investigation was done to understand how US and Europe approach capacity analysis, and whether any benefits could be gained from cross-pollination. The resulting hybrid simulation approach combines the strengths of two commercial packages (RTC and RailSys) to analyze the trade-off between Level of Service (LOS) parameters and capacity utilization in the U.S. environment. In addition, a multi-objective linear programming (LP) model “Hybrid Optimization of Train Schedules” (HOTS) was developed to allow the application of European-based scheduling approach over the North American operational environment. The results of this approach showed substantial improvements in LOS parameters, such as reduction in total stops and dwell times. The results also confirmed the reverse relationship between LOS criteria and capacity utilization levels. The HOTS model was successful in rescheduling and compressing the timetable in multiple corridor and operational environments. The model was also capable of resolving conflicts and could reschedule trains whose routing scenarios were changed. (See also publication in Page 19)

Integrated Life Cycle Assessment (LCA) and Life Cycle Cost Analysis of Multi Modal Freight Transportation Alternatives to Copperwood Project (by Dr. Pasi Lautala): This project used a case study to assess the environmental impacts (emissions) of different transportation options for transporting ore between a planned copper mine and a processing plant, and concentrate from the processing plant to an intermediate location. Life Cycle Assessment (LCA) using SimaPro software was conducted for all aspects related to the construction, operation, and maintenance (stages) of both transportation infrastructure and equipment. Truck, rail and multimodal transportation options were considered. Overall, the results suggest that multimodal options generate the lowest emissions among all alternatives. The operations stage accounts for the majority of the emissions for all options, regardless of the life of the mine, but there are large differences in the operational emission quantities between truck only and multimodal options. The project also revealed that construction emissions can be significant, especially for short mine lives, but emissions from maintenance activities remain fairly low.

New and Continuing NURail Projects

Alloy Design and Testing of Austempered Ductile Iron for Rail Wheels (by Dr. Paul Sanders): The project that concentrates on thermodynamic stabilization of austenite by alloying is approaching its final stages. An initial trial pour was conducted in February. Several of the test bars were heat treated, and the microstructures were analyzed using image analysis software. DSC samples were extracted and tested to compare with prior samples. Further refinement of thermodynamic modelling is ongoing in preparation for additional pours, which are expected to take place this summer. A new sample pattern has been developed to make heat treatment and sample machining easier.

Rail Embankment Stabilization for Cold Climate Railroads – Case of Hudson Bay Railway (by Dr. Thomas Oommen): Degradation of permafrost conditions along the line make it essential to identify potential settlement locations so proper maintenance or embankment stabilization measures can be applied to ensure smooth and safe operations. This research sought to characterize the different permafrost degradation susceptibilities present at the study site. Track geometry exceptions were compared against remotely sensed vegetation indices to establish a relationship between track quality and vegetation density. This relationship was used as a proxy for subsurface condition verified by electrical resistivity tomography. The established relationship was then used to develop a three-level degradation susceptibility chart to indicate low, moderate and high susceptibility regions. The defined susceptibility regions can be used to better allocate the limited maintenance resources and also help inform potential long-term stabilization measures for severely affected sections.

NEW PROJECT - Life Cycle Assessment (LCA) of Ore Transportation Route/Mode Alternatives for Eagle Mine (by Dr. Pasi Lautala): This project will continue the research initiated under Copperwood Mine case study and apply similar techniques for ore transportation options at the Eagle Mine in Marquette county. It will also investigate whether a simplified LCA methodology could be applied for the analysis without jeopardizing the outcomes.



NURail Student Projects

RTP again supported three undergraduate projects. Students from electrical engineering and computer science worked on railroad wheel contamination, teams from civil and environmental engineering worked with Lake State Railway and for the first time we had students from materials science participate, working on a rail defect detection project.

Planning and Design Services for Improvements to the Lake State Railway Company (LSRC) Saginaw Yard (co-sponsored by Lake State Railway and MDOT)

Two groups of students from CEE conducted this senior design project. The fall semester groups were responsible for conceptual designs while the spring groups concentrated on providing more detail to the preferred alternatives. The project involved four main components: 1) improvements to the rail system to allow storage of a unit train; 2) drainage improvements throughout the yard complex; 3) design of a covered locomotive wash facility; and 4) site work in the rail yard and the neighboring communities to improve yard access and allow LSRC to park the previously mentioned unit train. The students successfully completed their work, developing a plan for parking a 7600 foot unit train while still maintaining yard operations. Preliminary plans for the wash facility were developed, and a viable drainage improvement program provided. Although changes in the local situation prevented implementation of the proposed unit train configuration, LSRC did begin a program to improve the yard during the summer of 2016 using many of the ideas proposed during this student project.

Locomotive
Wash Facility
Rendering



Railroad Wheel Contamination Detection (co-sponsored by Norfolk Southern Railway)

Students from electrical engineering and computer science conducted a senior design project that investigated opportunities for detecting contaminants on the train wheels during car Classification. When contaminants are present, the retarders at classification yards won't operate effectively and the cars can blow apart couplers or even derail the train. The goal of this project was to detect contaminants on the train wheels in order to avoid damage during the recoupling process. A test stand was designed and built to measure the coefficient of friction for various contaminants at varying levels of application. It was found that even a very thin film of any contaminant had a significant impact on the coefficient of friction. Machine Learning methods were used to classify contamination state with 70% test accuracy.

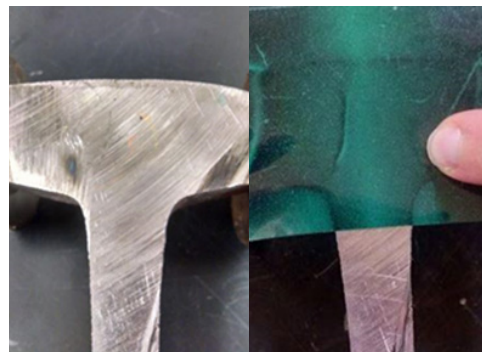
Test stand
for wheel
contamination
research



CN Railway Cold Weather Defect Detection (co-sponsored by CN)

Advanced Metalworks Enterprise (AME) with students from material science and engineering and from civil engineering conducted a study to investigate alternative methods for field testing to confirm that defective rail has been completely removed. See page 25 for more details on the project.

Hairline defect
in the head of
the rail (left)
compared
to the same
defect with
magnetic
film at room
temperature
(right)



Research Highlights

Rail Program Collaborates with CN on Research



2015-2016 was the first year for Michigan Tech to collaborate on multiple research activities with our strongest rail industry partner, CN. Both projects were related for the most valuable asset of the railroads, its steel rail. Our students worked on a project to identify alternative methods that might improve the rail management, especially in cold climates, and a research team from the Materials Science and Engineering Department took a look at the metallurgy of rail sections that had witnessed deterioration in the field. Below are summaries of each project.

Student Project: CN Railway Cold Weather Defect Detection

What started as a student project conducted by the Advanced Metalworks Enterprise (AME) at Michigan Technological University turned into an exciting internship opportunity for John LaLonde, fourth year MSE undergraduate and the leader of the project. The team was tasked to attack a challenge faced by all railroads; internal rail defects. Modern railways use ultrasonic trucks to locate these defects for removal, but once the defect has been removed, CN goes one step further to insure that the entire defect was removed with the use of dye penetrant on the cross sectional ends of the rail. However, this process can be adversely affected by weather, as cold and wet conditions can cause tests to fail.

The goal of the AME project was to create a process that could be completed reliably, in all weather, and in a shorter period of time. After testing two alternative approaches, the team decided to move on with a magnetic particle inspection process that relies on the flux created by field lines being forced to bend around a defect in a magnetized piece of material. The flake will reflect light at certain orientations and will display defects as a white line on green film (Figure on bottom, page 24).

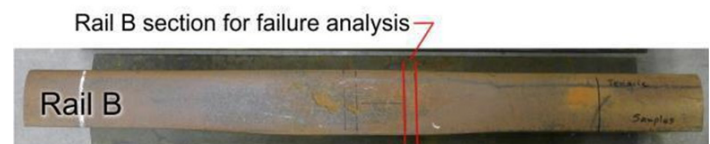
To test the new process, team used the film and a portable yoke to test 11 samples containing defects at temperatures ranging between -30°F and 40°F and found that the test performance was satisfactory throughout the temperature range. Based on the results, CN determined that the new method was worth further investigations and offered John a summer intern position to both continue the process and work in other aspects related to CN business.

"I spent almost three months with CN and worked on topics ranging from helping to design programs that would estimate the rail stresses experienced under locomotive movement to actually getting to operate a geometry testing load wheel. It was a busy, but rewarding summer. While CN is still looking into the potential implementation of our new process, being able to follow a student project in a paid internship was the best reward I could get for the work over winter. It is truly an awesome experience getting to take a project from a proof of concept with two loose magnets and a pile of iron shavings, to cold testing at 2 AM, out of the back of a pickup truck, in a Houghton snow storm, and on through field trials with CN. I can't imagine many students get that kind of experience and I am grateful to all of the students and faculty at Michigan Tech and at CN that made the project possible." -John LaLonde

CN Rail Steel Analysis

Crushed head or "flattened" head are common defects that occur on rail lines. CN Rail submitted three sections of rail that exhibit flattened head for metallurgical analysis by Michigan Tech researchers. A metallurgical analysis and testing was compared to the current standards for new rail steel. Differences in steel supplier macrostructure, cleanliness, microstructure, mechanical properties and chemical composition were documented. This was an effort to determine the root cause for "flattened head" failure on the various rail section samples. The analysis began on the macro scale and finished with microanalysis of grain size, phase types, inclusions and cracks. The analysis and procedures were based upon the CN internal document Specification for the Manufacture of Steel Rail (SMSR) and further augmented with additional microanalysis.

Macro segregation was examined for each rail section and the etched sample is shown in the figure below. While it was not possible to positively state the effect of the rail steel structure and properties on the flattened head defect in the rails supplied because the local track conditions and loading conditions were not known, it was found that Rail A was unacceptable for macro segregation, and Rail B did not meet all CN specifications (hardness, strength, inclusion %, and composition). Future research could consider Controlled (lab scale) fatigue testing of the various steel types and Investigating the potential correlation between crushed heads and local environmental/track conditions.



Location of rail B section examined with SEM. The location was selected at the edge of the flattened head section and included surface spalling and cracking



John LaLonde



Driver Behavior at Highway-Rail grade Crossings

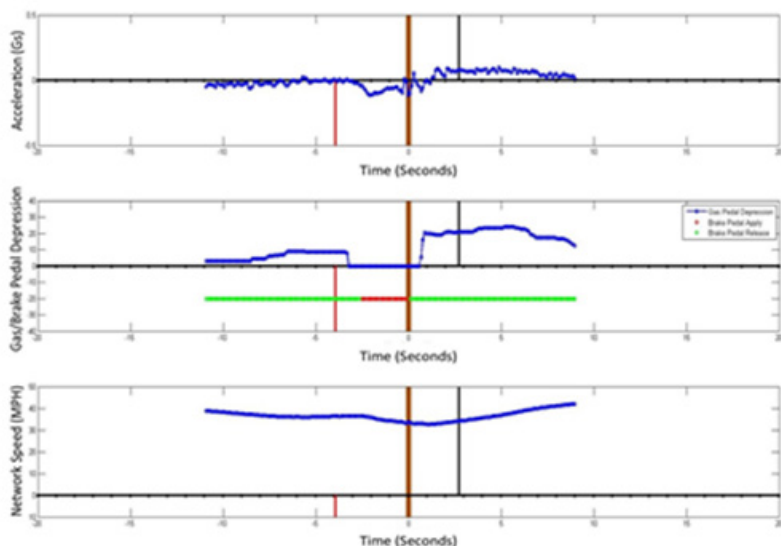
2015 finally saw us begin to gain some traction in our Grade Crossing research program. Dave Nelson was awarded a start up grant by the Michigan Tech Transportation Institute to start working with data from the Federal Highways Strategic Research Program (SHRP2) Naturalistic Driving Study (NDS). Aaron Dean took the data reduction required to analyze the NDS data and turned it into a Summer Undergraduate Research Fellowship (SURF). Philart Jeon and Steve Landry produced some excellent work using our driving simulator resources to look at driver response to auditory warnings at grade crossings (see page 13 for details). This work allowed us to secure a grant from the Federal Railroad Administration, which will expand our research over the next two years.

\$10,000 MTTI Initiative on NDS Research

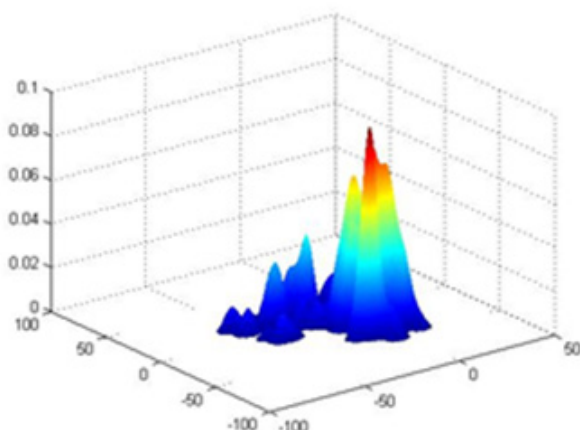
The year's activities started in May with a \$10,000 grant from MTTI. The grant was used to set up a Data Use Licensed with the NDS data enclave at Virginia Tech Transportation Institute (VTTI), and to acquire a preliminary set of data including throttle, brake, and head tracking information, as well as forward and rear video for 700 crossing traversals at 7 different crossings. This data was used to explore data reduction and processing techniques for the data, and led directly to the SURF proposal developed by Aaron.

SURF Summer 2016

Aaron Dean worked extensively on developing techniques to effectively use the head tracking data found in the NDS data set. Using the data collected under the MTTI grant he developed techniques for importing and smoothing the data. He also developed a method for comparing the machine vision data provided through the NDS with a narrative record provided by VTTI to use in verifying the validity of the machine vision data.



Above: brake and throttle results from NDS



Left: 3-D analysis of baseline conditions



Left: diagram of head tracking experiment set-up

Below: data for head tracking experiment

Objects of Interest	Head Rotation Angle (degrees)
Forward	0
Left Window/Mirror	33.69
Right Window/Mirror	-61.82
Left Windshield	14.04
Right Windshield	-45.12
Interior Object	0
Instrument Cluster	0
Cell Phone	-5
Rearview Mirror	-29.48
Center Stack	-29.48

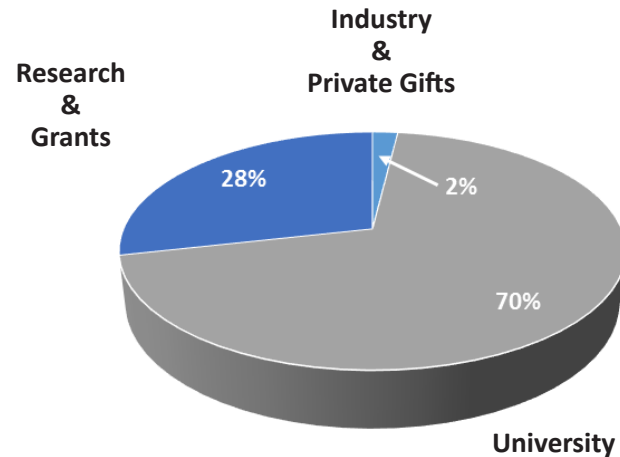


Aaron Dean

Finances

RTP Funding

Financial support for the Rail Transportation Program is received internally at Michigan Tech from the Department of Civil and Environmental Engineering (CEE). External funding consists of sponsored program research projects and contributions and gifts from industry partners and private individuals.



RTP Expenditures

Expenditures to support the rail transportation activities have been divided into several categories:

Faculty, Staff and Consultants (Research)-

Research expenses are wages, salaries, and subcontracts plus overhead charges specific to sponsored research projects.

Director and Staff (RTP)-

Rail program expenditures include director and staff salaries and other direct expenses used to support and continue development of the Rail Transportation Program.

Student Support and Activities-

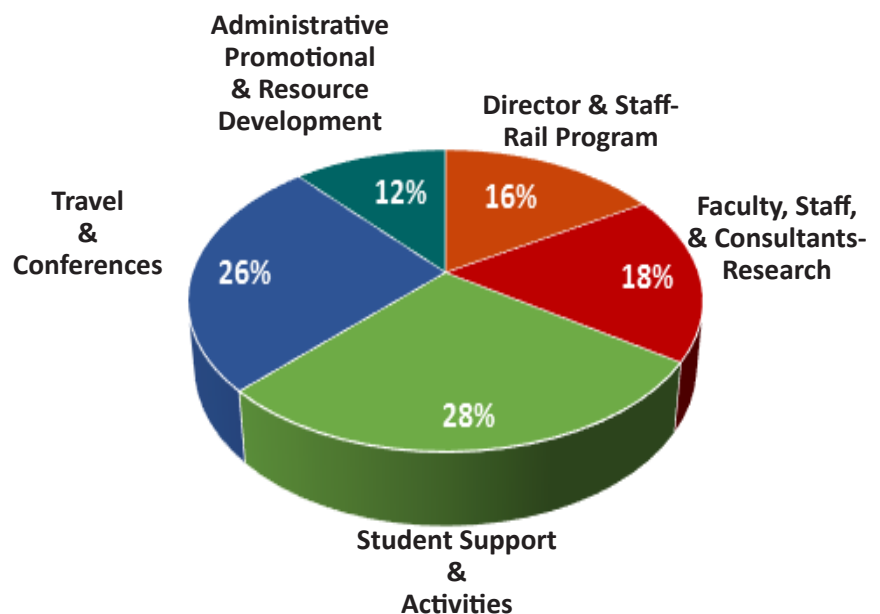
Includes direct student expenses, such as tuition and stipends, expenses for conference fees and field visits, travel, and sponsorship for student events and REAC activities.

Travel and Conferences-

Includes all non-student support for travel and participation in rail and educational conferences and meetings to facilitate the development of the rail transportation program. This includes travel expenses incurred in sponsored research projects.

Administrative, Promotional, and Resource Development-

Expenses incurred in the operation and development of the rail program, such as marketing, material development, and purchase of program resources.



About the Michigan Tech Transportation Institute

The Michigan Tech Transportation Institute will provide the operating structure, resources, recognition, and leadership, in a collaborative environment, that supports research, education, and outreach leading to sustainable solutions for transportation.

MTTI is an umbrella organization bringing together the cross-disciplinary centers and principle investigators conducting transportation related research and education initiatives that address national and global needs. Principal Investigators conduct transportation research under MTTI within six transportation focused areas:

- Transportation Structures including bridges and pavements. Other related areas include geotechnical, construction, and nanotechnology related to sensors.
- Transportation Materials including concrete, asphalt, steel, wood, and aggregates. Other related areas include construction, geotechnical, and nanotechnology related to sensors and materials.
- Transportation Systems including waterways, traffic/safety, construction, rail, air, public transportation, freight, intelligent transportation systems, vehicle infrastructure integration, nanotechnology related to sensors, and radio frequency identification devices.
- Environmental Aspects of Transportation includes environmental impacts, energy, carbon dioxide and other pollutants, fugitive dust, wildlife, flora and fauna, and carbon credits.
- Social Aspects of Transportation includes policy, planning, human factors, history, economics, and archeology.
- Transportation Technology Transfer includes all outreach, management systems, and workforce development programs.

www.mtti.mtu.edu



**Michigan
Technological
University**

Michigan Tech Transportation Institute

About Michigan Technological University

Michigan Technological University is a leading public research university, conducting research, developing new technologies, and preparing students to create the future for a prosperous and sustainable world. Michigan Tech offers more than 120 undergraduate and graduate degree programs in engineering, forestry and environmental sciences, computer sciences, technology, business and economics, natural and physical sciences, arts, humanities and social sciences.



© Copyright 2016 by Michigan Technological University.

To obtain permission to reprint any articles or graphics from the *Michigan Tech Rail Transportation 2015-2016 Annual Report* please contact the RTP at rtp@mtu.edu.

Michigan Technological University is an equal opportunity educational institution/ equal opportunity employer, which includes providing equal opportunity for protected veterans and individuals with disabilities.

www.mtu.edu



**Michigan
Technological
University**



Rail Transportation Program

Michigan Tech Transportation Institute • Michigan Technological University