TrańSearch

DELAWARE CENTER FOR TRANSPORTATION

YOUR MAIN RESOURCE FOR TRANSPORTATION EDUCATION, RESEARCH & TECHNOLOGY TRANSFER

WINTER 2017 VOL. 17, NO. 1

Dare to be first.





Delaware Center for Transportation

Department of Civil and Environmental Engineering

> 355 DuPont Hall Newark, DE 19716

P: 302-831-1446 F: 302-831-0674 www.ce.udel.edu/dct

Looking for the table of contents?

Use the interactive bookmark bar it's on the upper left of your Adobe Acrobat window.

Message from the Director



As many of you are no doubt aware, the Delaware Center of Transportation's primary goal is to serve as a resource to the Delaware Department of Transportation (DeIDOT), other state

DOT's, local transportation agencies and transportation-related federal organizations. Through collaboration between civil and environmental engineers and policy scientists, the center supports research, development and educational activities to address transportation needs.

As noted in our last newsletter, this past summer marked a significant transition in leadership for the DCT, with the stepping down of Professor Ardeshir Faghri, who has served as the Director for the Center for the last 19 years. During that time, the Center grew significantly and flourished under Arde's tireless efforts and visionary leadership. As a faculty colleague of Arde's here at the University of Delaware for the last ten years, I have witnessed firsthand the dedication that he brought to the job, and now that I have had a few months in his shoes, I can appreciate ten-fold the many tasks that are involved with managing such an active center while juggling the myriad of other duties that are associated with a professor's typical teaching, research, and service activities.

So Arde, thank you on behalf of everyone that has worked for or with the DCT for the past 19 years. We will miss your leadership, but I am reassured in that your door is right down that hall, and I have no doubt that you will continue to contribute in many ways to the activities of the DCT. The timing of this first newsletter also marks a very significant transition period for the federal government. With a new President in office, a significant shake-up of the executive branch underway, and sweeping executive orders leaving the President's desk on a daily basis, it is clear that the new administration wants to affect rapid change. The political alignment of the executive branch with the legislative branch of our government for the first time in many years also portends the passage of new laws that will no doubt affect the daily lives of many Americans in an even more significant fashion in the years to come.

Despite the fierce debate that is currently underway on many issues, it is clear that the crumbling of our nation's infrastructure is one of the few issues that both Republicans and Democrats can agree on. The recent nomination of Elaine Chao as the 18th United States Secretary of Transportation via a 93-6 vote will also bring new leadership and vision in this area, and it is my hope that an organized and effective approach towards rebuilding our nation's transportation infrastructure for the future will create many benefits for the U.S.'s economy and its citizens.

More locally for the DCT, we are particularly pleased to announce that Professor Allan Zarembski will be leading UD's effort as a member of the University Transportation Center on Improving Rail Transportation Infrastructure Sustainability and Durability. This UTC is led by University of Nevada, Las Vegas and also involves Virginia Polytechnic Institute and State University. There is also so much other good news to share, from our recent railroad big data conference, the activities of the Delmarva Freight Working Group, and the many successful research activities of our faculty, staff, students, and partners from government and industry. I encourage you to read more about all of our efforts in the following pages.

RR BIG DATA

ARTICLE BY DIANE KUKICH PHOTOS BY EVAN KRAPE

Conference addresses big data in railroad maintenance planning

More than 150 representatives of the railway and academic communities turned out for the 2016 Big Data in Railroad Maintenance Planning Conference at the University of Delaware on Dec. 15-16.

The third annual conference was chaired by Allan Zarembski, professor of civil and environmental engineering, and presented by the UD Railroad Engineering and Safety Program, the UD Big Data Center, and UD Professional Engineering Outreach.

"One of our goals is to come up with usable and practical results from the mountain of data that's now available to railroad engineers and others charged with keeping our railroads and transit systems safe and efficient," said Zarembski, an internationally recognized expert in railway track engineering, derailment analysis, wheel-rail interaction, and rail problems and maintenance including rail inspection and grinding.





Conference presentations covered a range of topics, including applications and case studies, big data analysis techniques, maintenance strategies, risk management, automated inspection technologies and asset management.

The focus was on making more effective use of the growing volume of inspection and other data now available to railway engineering managers to help them make their rail systems safer, more efficient and more productive.

"Specifically, we wanted to bring to bear the new emerging science of data analytics to address and analyze this high volume of data, which can be as much as several terabytes of data per day for a single major railroad, to convert this data to useable information," Zarembski said.

Railway engineering at UD

Tripp Shenton, chair of UD's Department of Civil and Environmental Engineering, said that the department has witnessed tremendous interest in this area, and he provided some highlights of UD's railroad engineering program, which was established in 2012:

- Four research-based master's students are completing or have completed their degrees, and four students are currently working on doctoral degrees.
- Close to 200 undergraduate and graduate students have taken UD's railway engineering courses, all of which are electives.
- Zarembski is teaching not only four courses at UD but also summer classes at Technion-Israel Institute of Technology, as well as a number of online courses that reach students across the world.
- UD is a partner, along with Virginia Tech, on a Tier 1 University Transportation Center (UTC) program recently awarded to the University of Nevada at Las Vegas for "Improving Rail Transportation Infrastructure Sustainability and Durability" (see section at the end of this article for more details).

Keynote presentation

Lisa Stabler, president of the Transportation Technology Center Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads, delivered the keynote address, "Big Data in the Rail Industry."

Headquartered in Pueblo,

Colorado, TTCI conducts research

and testing on its extensive network of track facilities and in its state-of-the-art laboratory facilities.

With degrees in both mathematics and engineering, Stabler is an expert in quality management, quality engineering and reliability engineering. After providing a brief overview of TTCI, Stabler used statistics about ice cream consumption and drowning to make a point about turning data into useful information.

"As ice cream consumption increases so does your risk of death by drowning," she said. "But our understanding of the



world gives us the insight to know that it doesn't make sense to say you can reduce your risk of drowning by avoiding ice cream."

Most of us can figure out that the data on ice cream and drowning appear to be correlated only because we eat more ice cream and swim more when the weather is warm — there is no real cause and effect at work.

But what happens when the data reflect more complex phenomena?

Stabler shared several concerns that arise in working with big data: understanding the quality of data is critical; big data doesn't necessarily mean that the final results use all of the data; big data can have factors that are confounded or correlated over time, or auto-correlated; and, finally, many analyses will find statistical significance due entirely to the large sample size.

She said that it's important both to understand statistical analysis and to have practical knowledge of the issues being examined in order to avoid spurious associations.

"You can have a mountain of data, but you need analysis techniques to turn it into usable information," she added. "Huge computers don't change basic statistics – your experiments still have to be well designed."

She finished with a real-world example in which the meticulous use and analysis of big data resulted in an important rule change aimed at improving safety of railway operations in North America.

"We used our knowledge of statistics as well as the expertise of our engineers at TTCI to reduce risk for the industry," she said.

About the railway UTC

The consortium funded by the University Transportation Center program recently awarded to the University of Nevada at Las Vegas will develop advanced approaches for managing big data that results from high-tech inspection systems to improve the performance and maintenance of critical railway components and infrastructure, explore new materials and technologies for maintaining and re-conditioning rail surfaces and monitoring key rails components, and provide guidelines for the more rigorous demands of high-speed rail infrastructure by bringing together global knowledge with the geological and topological information of the railway location.

Among UD's research activities will be the integration of a new generation of inspection technology with track degradation analysis and maintenance planning and the use of data analytics to develop improved planning and forecasting tools for railroad infrastructure.

Additional activities will include education and workforce development, such as developing and enhancing accredited degree-granting programs, and technology transfer to develop partnerships across sectors and move research into practice.

The \$1.4 million grant is one of 35 five-year grants awarded to lead consortia under the UTC program, and the only rail focused grant.

The U.S. Department of Transportation received a total of 212 applications, the largest number submitted in the history of the UTC Program. UTC consortia are selected to advance research and education programs that address critical transportation challenges facing the nation.

One of the largest annual gathering of transportation professionals and researchers just concluded. The Transportation Research Board (TRB) annual meeting, scheduled from January 8th through January 12th in Washington, DC had a theme this year as Transportation Innovation: Leading the Way in an Era of Rapid Change. Among the many policy makers, administrators, practitioners, and representatives of government and industry was a contingent from the University of Delaware.

This year, two graduate students made presentations: Silvia Galvan-Nunez and Ali Alsahli. Silvia was a participant in Session 274. As an attendee at the Annual Interuniversity Symposium on Infrastructure Management (AISIM)

Transportation Research Board 96th Annual Meeting

January 8-12, 2017 • Washington, D.C.

held in June at Oklahoma State University, Silvia's poster titled, "Assessing Uncertainty of Track Geometry Degradation Based on Evolutionary Markov Chain Monte Carlo," was selected as a best presentation so was offered an opportunity to present at TRB.

Ali is a doctoral student working with Allan Zarembski, and was a presenter in Session 598 with a poster entitled, "Field Validation of Inspection Gauges for Wheel Climb Safety at Switch Points."

Mingxin Li, a research scientist at the Delaware Center for Transportation, participated at TRB in two sessions: Session 464 poster entitled, "Research of Viable Attributes and Potential to Integrate Curbside Intercity Buses," along with researchers at UD's Institute for Public Administration and Session 709 poster entitled, "Economic Feasibility Study for Pavement Monitoring using Synthetic Aperture Radar Satellite Remote Sensing: A Cost–Benefit Analysis." See article by Marcia Scott with more details related to their presentations, along with an article in the UTC insert by Sue McNeil.

University of Delaware faculty member attendees included Allan Zarembski, Nii Attoh-Okine, Jennifer McConnell, Tripp Shenton, Marcia Scott, Christopher Kelly, Jerome Lewis, James Corbett and Christopher Meehan.

FREIGHT PLANNING

ARTICLE BY ANNA KELEHER PHOTOS COURTESY OF PABLO MCCONNIE-SAAD

FREIGHT STAKEHOLDERS DISCUSS PARTNERSHIPS FOR ECONOMIC DEVELOPMENT

Every day, freight and goods move up and down the Northeast Corridor on their way to manufacturers, stores, and consumers. The shared recognition of the economic importance of the freight and goods that originate from, pass through, or end up in Delaware recently brought 40 representatives from trucking and logistics companies, academia, agribusiness, and state and local government to Dover.

"Freight and the global economy are tightly coupled," James Corbett, professor of marine science and policy in UD's College of Earth, Ocean, & Environment, told the audience December 13.

UD's Institute for Public Administration (IPA) partnered with the Delaware Department of Transportation (DelDOT), the Salisbury/Wicomico Metropolitan Planning Organization (MPO), and the Wilmington Area Planning Council (WILMAPCO) to plan the Delmarva Winter Freight Meeting, which was hosted by the Dover/Kent County MPO. These organizations comprise the Delmarva Freight Working Group, which coordinates freight planning and research activities across the region.



James Corbett, Professor of Marine Science and Policy in UD's College of Earth, Ocean, & Environment, points out the relationship between freight activity and GDP



James Corbett addresses the Delmarva Winter Freight Meeting

"Estimated conservatively, freight and goods movement is a billion dollar industry in Delaware, and that's before accounting for the critical role it plays in supporting other economic sectors such as Delaware's multi-billion dollar agriculture and poultry processing industry," said Troy Mix, IPA policy scientist and the moderator of the meeting. "The Freight Working Group plays a key role in encouraging publicprivate partnerships to support Delaware's freight and good movements industry."

Public and private industry players present

James Corbett, the keynote speaker, presented research suggesting that the post-recession period has been characterized by experimentation in freight delivery models prompting renewed considerations of where to locate manufacturing and distribution facilities, how to route, time, and bundle shipments, and whether to ship by land, sea, or air. Corbett stressed the ripple effects of freight and logistics investments, citing one potential scenario that would see the recent Panama Canal expansion stress ports and roadways along the U.S. East Coast with more traffic, leaving harmful emissions in its wake.

Rich Clair, chief operating officer at Trinity Logistics, a \$370 million freight shipping and logistics solutions provider based in Seaford, spoke about the rapid growth of his company and plans for continued growth. In particular, Trinity Logistics is aiming to more than triple its revenue from Less-Than-Truckload (LTL) shipping in the coming years, while providing customers of all sizes with access to cloud-based, technology solutions that afford them with more information about and control over their supply chains.

The Federal Highway Administration's Lindsay Donnellon outlined the 2015 Fixing America's Surface Transportation Act, also known as the FAST Act, and its implications for state's freight plans and funding opportunities. Stephanie Johnson of DelDOT spoke about human trafficking awareness, with DelDOT's Tim Snow reporting on a study of supply chains serving Delmarva's agriculture industry.

During a networking and poster session, participants learned about potential freight planning projects and studies in Delaware and voted on which projects the state should prioritize.

Opportunities for Delmarva freight

"We are bridging the gap between the providers of the freight transportation system and the users of the system," said Daniel Blevins, principal planner at WILMAPCO, emphasizing the opportunity that the meeting provided for networking between public and private sector representatives. The DelDOT's Mike DuRoss agreed, saying, "This forum is vital to continuing and enhancing our partnerships with the freight transportation communities."

Blevins also noted that the geography of the Delmarva Peninsula necessitates strong coordination between Delaware, Maryland, and Virginia freight communities.

Future freight meetings

The Delmarva Freight Working Group has organized events annually since 2013, with information on the most recent and previous meetings available on WILMAPCO's website. UD's IPA began coordinating the activities of the Working Group in 2016 as part of an ongoing planning and research partnership funded by DelDOT. IPA and the Working Group have begun planning for the 2017 Delmarva Freight Summit.

IPA Presents Transportation-Policy Research at NECoPA

Researchers from the Institute for Public Administration (IPA) at the University of Delaware presented on several transportation-policy topics at the Northeast Conference for Public Administration (NECoPA) held in Harrisburg, Pennsylvania in November 2016. The conference was co-hosted by the American Society for Public Administration's (ASPA) Central Pennsylvania Chapter and Penn State Harrisburg. In keeping with the theme of *Public Administration in the Era of Collaboration*, IPA staff and students presented on diverse research topics, including:

- Utilizing GIS Story Maps to Engage Citizens in Planning for Complete Communities in Delaware -Savannah Edwards (MPA '17)
- Delaware's Paratransit Policy and the Need for Innovation Eli Turkel (PhD '19)
- Evaluating the State of Mobility Management and Specialized Transportation Coordination in Delaware policy scientists Julia O'Hanlon and Marcia Scott, Jessica Stump (MPA '17), and Evan Miller (MPA '17)



IPA's Angie Kline, Marcia Scott, Savannah Edwards, Jessica Stump, Julia O'Hanlon, Evan Miller, and Eli Turkel at the Northeast Conference for Public Administration.

ENGINEERING INTERNS GET CLOSE-UP LOOK AT US 301 PROJECT CORRIDOR

David Litz and Eric Van Assen entered the summer of 2016 knowing nothing about heavy construction, but by the end of the year, they had a much better handle on what it takes to build a highway. Students of environmental engineering and civil engineering, respectively, Dave and Eric were selected to gather video and still images during Delaware Department of Transportation's (DelDOT) US 301 Corridor project and edit the materials into a series of short instructional videos to illustrate DelDOT's Standard Specifications for Road and Bridge Construction.

Escorted through the corridor by Ken Cimino, the Public Outreach Coordinator for the project, they quickly found themselves rut deep in dirt, dust, and mud and learning fast the people, equipment, techniques, and jargon of a large heavy construction job. Ken has not only ensured that they got as close to the action as needed and talked with on-site personnel, he has helped them understand aspects of the project so that they can better prepare final deliverables for DelDOT.

As the summer progressed and turned into fall, Dave and Eric saw the dominance of dirt operations, silt and storm water ponds, and other environmental best management practices begin to yield to some of the structural aspects, including the start of several bridges, a large box culvert, and an arch culvert.

Gradually, Dave and Eric became fluent in the language of the Standard Specifications, including clearing and grubbing, excavation and embankment, aggregate bases, bituminous paving, cast-in-place concrete, precast concrete, bridge elements, box culverts, pipes, piles, MSE walls, erosion and sediment controls, storm water BMPs, and all the materials, techniques, equipment, and logistics that go with it.

In addition to Ken Cimino, Dave and Eric have benefited greatly from a host of contractor personnel, inspectors, resident engineers, and other personnel from the project team that have been generous with their time and often enthusiastic in explaining the aspects of the project they know best. The first of their short videos are now in final review with DelDOT personnel and they will serve as the model for what are anticipated to be hundreds of short videos, each covering a small, digestible piece of the Standard Specifications.









THE RIGHT FIT FOR SAFETY

Worker Safety is an essential priority for the transportation industry and, collectively, we haven't always made the best choices when procuring safety equipment and personal protective equipment. Employees often avoid wearing retroreflective vests, hard hats, gloves, steel-toe boots, or safety glasses. Transportation workers are exposed to a wide array of safety hazards, from vehicles on the roadways to overhead objects to sharp edges to flying debris or dust. Depending upon the dangers that may be encountered, the appropriate equipment should be thoughtfully determined and there are a lot more choices than many of us realize.

For personal protective equipment (PPE), good fit and comfort can be the difference between the equipment being effective or not, being worn or not, and being used properly or not. For example, many safety vests available on the market today are vastly more comfortable than in years past, with mesh material and venting common. If employees are resisting wearing vests, it may be time to consider another style that is more comfortable, more compatible with other apparel they are wearing at various times of the year, and the right sizes for different employees. Employees may need a different size vest in the winter to go over their bulky work jackets, assuming those jackets aren't retroreflective themselves. And remember that vests should be a minimum of ANSI/ISEA 107-2004 Performance Class 2 (Class 3 for flaggers and for nighttime work).

Another example is glove choice. First, there are dozens of basic glove styles and materials, and the nature of the work can sometimes dictate a very specific glove choice. When welding or cutting, for example, general purpose gloves are not sufficiently protective. And size matters with gloves, too. Generally, if you measure your dominant hand around the fullest part of your palm (exclusive of the thumb) with a seamstress tape measure, most glove manufacturers will provide a chart that correlates that to a size (e.g., 7¹/₂"-8¹/₂" might be men's medium whereas 8¹/₂"-9¹/₂" might be women's extra-large). Some manufacturers will also show finger length size, often measured from the bottom of the palm to the tip of the middle finger. Paying a little bit more to get the right protection for the task is usually good insurance when you consider the cost of occupational injuries and making sure they're the right size can better ensure they actually get worn.



Hard hats are yet another item where there are many styles and choices and simply buying the least expensive in bulk may just ensure they spend much of their lives rolling around the bed of a pickup truck. A basic hard hat may serve the need for some employees, but the nature of their work may drive the need for a more feature-rich hat; perhaps a chin strap, a ratchet style suspension, liners for the winter, a full brim style, or so on. Remember also that hard hats should ideally comply with ANSI/ISEA Z89.1-2014, and Type 1 are designed to reduce the force of impact resulting from a blow only to the top of the head while Type II designated helmets are designed to reduce the force of impact resulting from a blow to the top or sides of the head. Class C helmets are conductive and provide no protection against contact with electrical hazards, Class G helmets are designed to reduce the danger of contact with low-voltage conductors (proof tested at 2,200 volts), while Class E helmets are designed to reduce the danger of contact with conductors at higher voltage levels and are proof tested at 20,000 volts.

Also of interest, only hard hats with the reverse donning symbol can be worn forwards or backwards while still providing the intended safety benefits.





Stepping away from PPE, a final example is highintensity rotating, flashing, oscillating, or strobe lights on vehicles (dump trucks, loaders, backhoes, mowers, trash trucks, etc.), which must be mounted on the vehicle as to be clearly visible for 360 degrees around the vehicle and must be visible from a distance of at least 3,000 feet under normal atmospheric conditions at night. The most common standard is the Society of Automotive Engineers, SAE J845, Class 1, which is the brightest level. Some vendors still cite SAE J1318, which was superseded by SAE J845; in this case, you should challenge them to demonstrate compliance with the latest standard (SAE J845) or move on to another vendor. If radio frequency interference is a concern, the Comité International Spécial des Perturbations Radio CISPR25 Class 3 or higher is what you should generally look for.

In short, when it comes to safety gear/equipment and PPE for employees, we must be good consumers and recognize that effective safety may require a little more money and perhaps a lot of questions. And if the vendor can't or won't answer questions about features or compliance with appropriate standards, maybe that's not the right vendor for your needs.

IPA PRESENTS RESEARCH OUTCOMES AT 96TH ANNUAL TRB MEETING

BY MARCIA SCOTT, IPA POLICY SCIENTIST

RESEARCHERS FROM THE INSTITUTE FOR PUBLIC ADMINISTRATION (IPA) PRESENTED RESEARCH OUTCOMES AT THE 96TH ANNUAL MEETING OF THE TRANSPORTATION RESEARCH BOARD (TRB) IN WASHINGTON, D.C. ON JANUARY 9 AND 10, 2017.



IPA's Christopher Kelly (2nd from left) and Marcia Scott (center) presented outcomes of research on integrating intercity buses in intermodal transportation facilities at the 96th Annual TRB Meeting.

Intermodal Facilities Presentation

IPA policy scientists Marcia Scott and Christopher Kelly (MPA '14) presented at Session 464, "Data and Technology for Rural and Intercity Decision Making." The presentation highlighted findings of a paper selected for inclusion in the TRB's 2017 Annual Meeting Compendium of Papers entitled, "Research of Viable Attributes and Potential to Integrate Curbside Intercity Buses in Intermodal Transportation Facilities." The paper was co-authored by Scott, Kelly, Eileen Collins (MPA '13), IPA Director Jerome R. Lewis, Ph.D., and Professor Ardeshir Faghri, Ph.D. and Scientist Mingxin Li, Ph.D., of UD's Department of Civil & Environmental Engineering. The paper may be downloaded from UD Space at *http:// udspace.udel.edu/handle/19716/19961*.

The research paper provides a synopsis of a more in-depth report, co-authored by Scott, Kelly, and Collins and published in November 2013 on, "Intermodal Transportation Facilities: Research of Viable Attributes and Potential to Integrate Curbside Intercity Buses." The research highlighted benefits of successful intermodal transportation facilities that support and enhance transit usage, promote seamless transfers among modes, provide clear access to transportation networks, maximize transportation options, and create efficiencies of shared costs and transportation infrastructure. In addition to transportation benefits, the report explored the potential for intermodal facilities to serve as centers of revitalization and hubs of economic, commercial, and mixed-used development activity.

While barriers to intermodalism exist, report findings suggest that development and investment in intermodal transportation facilities—which serve as a hub for all modes of transportation, including curbside intercity buses—will promote a more integrated and sustainable transportation system.



A poster on GIS Story Maps by IPA's Savannah Edwards (left), Marcia Scott (right), and Sarah Pragg (not pictured) was selected for display by the TRB Committee on Public Involvement.

Public Involvement Poster Presentation

IPA policy scientist Marcia Scott and public administration fellow Savannah Edwards (MPA '17) presented a poster at TRB Session 697, "Current Issues in Transportation Public." The poster was among the 25 selected for presentation by the TRB Committee on Public Involvement. Entitled "GIS Story Maps Empower and Engage Stakeholders in Planning for Complete Communities in Delaware," the 4' x 8' poster was designed by IPA policy specialist Sarah Pragg. It summarizes research, funded by the Mid-Atlantic Transportation Sustainability University Transportation Center (MATS UTC), which explores the use of GIS Story Maps to satisfy mandates for increased transparency, accountability, and public engagement in planning for transportation-efficient and sustainable places. IPA developed a series of GIS Story Maps to illustrate Delaware's complete communities planning framework that is designed to build capacity of local governments to create "attractive, inclusive, efficient, healthy & resilient places." Each Story Map conveys one of the five elements of a complete community. IPA's GIS Story Map Gallery can be viewed online at *http://arcq.is/25DcjGV*.

About TRB

The Annual Meeting of the Transportation Research Board (TRB) is a showcase for innovative thoughtleadership and research in the transportation industry. Attended by over 12,000 world-wide transportation professionals, the meeting features more than 5000 presentations in nearly 800 sessions on a range of transportation-related topics. It provides a forum for the exchange of ideas between practitioners, researchers, and policy-makers, and advances sound transportation industry practices and future research and future practice. Of the nearly 5800 papers submitted, approximately half are presented at the Annual Meeting, and about 20 percent are published in the Journal of the Transportation Research Board. University of Delaware researchers have actively conducted research and contributed to the body of knowledge around transportation issues, which is helping to inform policy, engineering best practices, and infrastructure investment decision.



A poster presented at the Annual TRB Meeting entitled, GIS Story Maps Empower and Engage Stakeholders in Planning for Complete Communities in Delaware, was designed by IPA's Sarah Pragg.

IPA AND MARSHALL UNIVERSITY'S RTI PARTNER ON RESEARCH OF SMART-GROWTH EVALUATION METHODS

BY MARCIA SCOTT, IPA POLICY SCIENTIST

Few studies have gauged causal linkages between shifting smart-growth agendas and the development of new tools to evaluate smart-growth outcomes. To bridge this gap, a research team comprising staff of the University of Delaware's Institute for Public Administration (IPA) and Delaware Center for Transportation (DCT), and Marshall University's Nick J. Rahall, II Appalachian Transportation Institute (RTI) explored factors that have both transformed the concept of smart growth and, concurrently, shaped smart growth evaluation methods and formats. Research was funded by the Mid-Atlantic Transportation Sustainability University Transportation Center (MATS UTC).

The research was conducted in two phases. A phase one report, *The Use of Smart Growth Scorecards/Assessment Tools to Advance Sustainable Land-Use Practices*, was published in June 2016 and co-authored by IPA's Marcia Scott, Philip Barnes, and William Stavru; DCT's Mingxin Li; and RTI's Sinaya Dayan, Curtis Jones, Justin Matthews, and Jeff Cragle. The results of this research reveal that both the concept of smart growth and the development and use of scorecards/assessment tools have co-evolved. Shifting state and federal legislation, leadership, political agendas, and funding have shaped the extent to which smart growth practices are implemented and evaluated at the local government level. The analysis indicates that a variety of contemporary assessment tools have been developed to provide either qualitative data and/or quantify performance on key indicators of sustainability. Transportation researchers from academia, as well as the public and private sectors, have played an important role in developing models and tools for analyzing smart-growth strategies. Travel demand models are commonly used to assess the impact of smart growth programs. Yet, considerable expertise is required to effectively utilize newer, state-of-the-practice travel forecasting models, which place them out of reach for most local jurisdictions. New assessment tools are being crafted and used to better educate and engage the public through scenario planning and the development of interactive, visualization tools. Further, digital assessment tools offer a much-needed and dynamic platform with which to satisfy mandates for increased transparency, accountability, and participatory public engagement.

A phase two report, *GIS Story Maps: A Tool to Empower and Engage Stakeholders in Planning Sustainable Places*, was published in October 2016. The study was conducted by IPA's Marcia Scott and Savannah Edwards (MPA '17), and RTI's Sinaya Dayan, Tuan Nguyen, and Jeff Cragle. The research finds that recent changes in geospatial technology offer new opportunities for use in participatory planning processes. Yet, civic tech as a movement, and public participation geographic information systems (PPGIS) as a discipline, have lagged behind the proliferation of new digital tools that can be leveraged for public engagement purposes.

The IPA and RTI research team used a case-study approach to explore the practical application of GIS Story Maps in planning for sustainable places. The case-study method provides an overview of each research team's experience using map-based storytelling, perceived effectiveness of using GIS Story Maps to convey sustainability issues, potential for using this technology to engage planning stakeholders, and lessons learned. While more research is needed,

TranSearch Winter 2017

preliminary findings suggests that online, interactive GIS Story Maps are ideal for fostering citizen engagement, providing meaningful context to complex planning topics and concepts, and empowering informed decision making on sustainability issues.

Final reports for both phases of research can found on the MATS UTC website at *www.matsutc.org/finalresearch-project1/.* RTI's GIS Story Map on "Moving Towards Sustainability in Extraction Economies of Appalachia" won third place in ESRI's 2016 International Storytelling with Maps contest in the Infrastructure, Planning, and Government category. It may be viewed at: *http://goo.gl/Bl0cpR*. IPA created a series of GIS Story Maps to illustrate implementation of complete-communities planning practices in Delaware. IPA's GIS Story Map on the Downtown Development District (DDD) program was featured in an August 2016 announcement by Delaware Governor Jack Markell about the expansion of the program and designation of five new DDDs in Delaware. This map and others may be viewed on IPA's gallery of GIS Story Maps at: *http://goo.gl/FSI6fd*.



RTI's GIS Story Map



RESEARCH

As each project is completed, a final technical report will be available on the DCT website: http://www.ce.udel.edu/dct

IRIB ONGOING STRUCTURAL HEALTH MONITORING

The Indian River Inlet Bridge represents a significant investment in infrastructure for the State of Delaware. This funding supports ongoing evaluation of the bridge and preservation of its state-of-the-art structural health monitoring system. Ending 8/31/2019

Principal Investigator: Michael Chajes and Tripp Shenton, Department of Civil and Environmental Engineering

Project Manager: Jason Arndt, Bridge Design

AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS -PILE DOWNDRAG DESIGN

The project focuses on assessment of the new AASHTO LRFD bridge design specifications for pile downdrag, and the associated implications for the design of future deep foundation projects in the state. Ending 8/31/17

Principal Investigator: Christopher Meehan, Department of Civil and Environmental Engineering

Project Manager: Jason Hastings, Bridge Design

FY15 RAIL SUPPORT FOR DELAWARE TRANSIT

The Railroad Engineering and Safety Program at the University of Delaware will provide expert technical review, research and support with regard to passenger and freight operations for the DTC. Ending 2/28/17

Principal Investigator: Allan Zarembski, Department of Civil and Environmental Engineering

Project Manager: Albert Loyola, Delaware Transit Corporation

PLANNING LEVEL ESTIMATES OF MUNICIPAL ASSETS AND THEIR MAINTENANCE

This project will develop a tool to assist with the annual cost estimate of life cycle cost of assets to municipalities. These assets include items such as pavement, signage, sidewalks, curb ramps, drainage and lighting, among others. Ending 3/31/17

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Michael DuRoss, Division of Planning

SNOW PLOW ROUTE OPTIMIZATION

The goal of this research is to develop a mathematical model for optimizing snow plow routing in order to minimize the total snow plow truck travel distance and travel times. Ending 5/4/17

Principal Investigator: Mingxin Li, Department of Civil and Environmental Engineering

Project Manager: Jason McCluskey, Materials and Opperation

FIELD MEASUREMENT OF THE DYNAMIC IMPACT FACTOR FOR BURIED CULVERTS

This research is aimed at filed investigation of the actual dynamic load effects on buried culverts. The final product is expected to be a refined methodology for estimating the impact factor for buried culverts. Ending 5/4/17

Principal Investigator: Kalehiwot Manahiloh, Department of Civil and Environmental Engineering

Project Manager: Ping Jiang, Bridge Section

INTEGRATING ZERO-VALENT IRON AND BIOCHAR AMENDMENTS IN STORMWATER

Data from a field demonstration stormwater treatment system using biofilter media amendments for removing nitrogen will be used to develop preliminary guidelines for DelDOT which will assist the agency with compliance of the Total Maximum Daily Load (TMDL) regulations for bacteria and nutrients in surface waters. Ending 5/4/17

Principal Investigators: Paul Imhoff, Daniel Cha, Pei Chiu, Julia Maresca, Department of Civil and Environmental Engineering Mingxin Guo, Delaware State University

Project Manager: Mark Harbeson, Transportation Management Center

EVALUATION OF NEW DATA SOURCES FOR PLANNING AND OPERATIONS FY16 AND FY17

This project will provide DelDOT a demonstration of what some new sources of cell phone data can provide for information and how it would be useful for both operations and planning. Ending 4/30/17.

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Michael DuRoss, Division of Planning

FY17 REGIONAL TRAVEL DEMAND MODELING SUPPORT

Assist DelDOT with developing, maintaining, applying and evaluating its travel demand forecasting model which is used not only by DelDOT but also by the state's two metropolitan planning organizations. Ending 8/31/17

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Michael DuRoss, Division of Planning

TranSearch Winter 2017

2017 DELDOT MUNICIPAL AGREEMENTS PROJECT

The goals of this project are for student interns to conduct a careful review of all known agreements that exist between DelDOT and Delaware municipalities, documenting the boundaries of the agreement and its applicability to roadways systems. Ending 12/31/17

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Karen Brittingham, Division of Planning

FALL 2016 AND SUMMER 2017 PROCESSING OF DELDOT-TMC BLUETOOTH DATA FOR TRAVEL TIME AND SPEED MEASUREMENTS

This project entails transforming raw Bluetooth data into a useable form for DelDOT and processing the data into average time and speed between sensors and comparing average speed with posted speed limit to get an indication of delay. Ending . Ending 12/31/17

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Mark Eastburn, Division of Planning

ITS SUPPORT FOR BICYCLE AND PEDESTRIAN APPLICATION DEVELOPMENT FY17

The aim of this project is on development of software tools and application that focus on the needs of pedestrians and cyclists. Ending 8/31/17

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Paul Moser, Division of Planning

Local Governments

Have you completed a Transition Plan required by

the Americans with Disabilities Act?

If not, it is essential you do so now.

Not sure what a Transition Plan is?

Contact Matt Carter (matheu@udel.edu)

at the Delaware T² Center and

let's get you started.

Enforcement is heating up and you

need to get ahead of less behind it!

On the Use of Ballast Inspection Technology for the Management of Track Substructure

ALLAN M. ZAREMBSKI, GREGORY T. GRISSOM & TODD L. EUSTON

ALLAN M. ZAREMBSKI, Ph.D., P.E., F.A.S.M.E., Hon. Mbr. AREMA, Professor of Practice and Director of Railroad Engineering and Safety Program, University of Delaware, Newark, DE, e-mail: dramz@udel.edu.

GREGORY T. GRISSOM & TODD L. EUSTON, *Georgetown Rail Equipment Company, Georgetown,*

The railroad track substructure and specifically its ballast and subballast layers play a key role in the maintenance of the stability and geometry of the track structure. However, because it traditionally has not been readily accessible below the surface of the ballast, very limited information about its conditions was available, without extensive and disruptive excavation techniques. Newgeneration inspection technology now allows for the access to significant additional information about the ballast and sub-ballast to include its extent, condition, depth, degree of fouling, and any inadequacies in the substructure layer that can lead to loss of track stability or accelerated degradation of the track structure.

PROBLEM

Ballast refers to the upper stratum or layer of the track substructure upon which the superstructure (i.e., the rails and ties) is placed (Fig. 1). It generally represents a permeable granular material(s) placed around and under the ties to promote track stability. The ballast section is a key part of the track structure. It serves several essential functions including distribution of vertical load from the bottom of the tie to the top of the subgrade, providing lateral and longitudinal restraint for the tie and track superstructure (rail, ties, and fasteners), allowing for correction of track geometry variations, facilitating drainage, providing damping for noise, vibration, and dynamic impact loads, etc. An inadequate ballast section will result in high rates of track geometry degradation in the vertical and/or lateral directions, necessitating frequent track maintenance. It can also result in more catastrophic types of failures, such as a track buckle, which can end in a derailment of a passing train. Thus, maintenance of an adequate ballast section, to include shoulders, cribs and ballast layer under the tie, is of real importance from both a maintenance and safety point of view.



Fig. 1. Ballast section (example).

Traditionally, ballast section is inspected as part of the regular weekly or bi-weekly walking (or slow speed) track inspection activity where the inspector will note any locations with inadequate ballast sections. As such, it is a subjective inspection process, where the inspector visually evaluates the condition of the ballast and any locations where the ballast section is inadequate. This subjective process usually results in the reporting of locations with significant deficiencies (e.g., missing or small shoulders, open cribs, etc.), but locations with less than obvious deficiencies are often overlooked. Thus, while locations where standing water or "pumping" of mud or other contaminants are visible, they can be readily detected by the inspector. However, where they do not make it to the surface, they are generally "invisible" to the inspector.

SOLUTION

New-generation inspection technologies now allow for the access to significant additional information about the ballast and subballast to include its extent, condition, depth, degree of fouling, and any inadequacies in the substructure layer that can lead to loss of track stability or accelerated degradation of the track structure. These include such newly introduced inspection technologies as LIDAR for measurement of the ballast profile, ground penetrating radar inspection for ballast depth deficiency, and other related inspection technologies such as cone penetrometer and track modulus measurement.

METHODOLOGY

LIDAR

LIDAR represents a new inspection technology being applied in the railroad industry to measure and map the ballast profile. LIDAR which stands for LIght Detection And Ranging, or Laser Imaging Detection And Ranging uses optical remote sensing technology that can measure the distance to, or other properties of, targets by illuminating the target with laser light and analyzing the backscattered light. LIDAR technology has specifically been applied in the railroad industry in measuring and mapping the surface of the track, and in particular, the ballast profile of the track structure. A photograph of this inspection vehicle is shown in *Fig.2a*.

The result of this LIDAR ballast profile analysis is a report that defines missing ballast (to include shoulder and crib ballast) per length of track. This report is presented in both tabular and graphical form (*Fig. 2b*). This is also defined in terms of how many total cars of ballast are required per mile together with the exact start and stop locations, which is also used to generate an output file that serves as an automated input file for an automated ballast delivery system. This LIDAR inspection system can be utilized as a stand-alone tool, as part of a ballast delivery planning program or alternatively as a means to collect the necessary information to automate the ballast delivery using state of the art ballast delivery trains.



(a) GREX ballast saver ballast profile inspection vehicle



(b) LIDAR ballast profile image: deficient ballast zones in red

Fig. 2. LIDAR ballast profile inspection vehicle and image.

Ground Penetrating Radar

Inspection of the ballast and sub-ballast layer and associated measurement of the depth of the ballast layer are being performed using Ground penetrating radar (GPR) which allows for the mapping of the ballast section beneath the cross-tie, and the specific measurement of the condition of and depth of ballast to the top of the subgrade. GPR systems have been mounted on hy-rail vehicles such as shown in Fig. 3 to image the subsurface of the track and to map the ballast and top of the subgrade sections of the track structure. The unit shown in *Fig. 3* has three GPR units positioned to measure the center and outside sections of the ballast.



Fig. 3. Photo of hy-rail mounted GPR unit.

APPLICATION

The analysis of the LIDAR ballast profile output data is illustrated in Fig. 4 where digitized LIDAR data is overlaid onto an idealized track structure representing the top of tie, the shoulders, and the shoulder slope. The ideal ballast cross-section is defined by the user railroad and can differ from railroad to railroad as well as from track location to track location. Calculation of missing ballast below the bottom of the tie is likewise performed using an overlay of the GPR measured bottom of the ballast (top of subgrade) and the railroad defined idealized ballast depth (which again can vary as a function of location, particularly for areas of poor or weak subgrade material). For each of the six zones, the difference between the idealized ballast section (as defined by the railroad for that track location) and the actual ballast section (as measured from the LIDAR-based profile and GPR-based depth of ballast) is calculated and then summed to get the missing ballast area for the defined cross-section.

TECHNICAL BENEFITS

An adequate ballast section beneath the tie will reduce the level of vertical dynamic loading from the bottom of the tie to the top of the subgrade, thus reducing the vertical degradation of the track structure and its geometry (surface or profile, cross-level, twist, warp, etc.). It will also serve to provide dynamic attenuation and damping of the wheel/rail loads, to include impact loading such as from wheel flats, engine burns or other discontinuities at the wheel/rail interface. Likewise, proper and adequate ballast shoulders and cribs provide lateral and longitudinal resistance to movement of the track superstructure, reducing the lateral degradation of the track geometry (alignment).

A new generation of nondestructive inspection technologies such as the LIDARbased ballast saver inspection system for profile measurement and GPR for ballast depth measurement provides good information about ballast profile and depth and can be used to determine the amount of missing ballast as well as the condition of the ballast itself. This includes determination of where and how much ballast should be placed, such as ballast at end of ties (shoulders), under ties, and in cribs. Used together, they can provide significant additional information about the condition of the ballast and the steps needed to bring this condition up to standard.

TranSearch Winter 2017

These ballast (and subgrade) condition measurement techniques supplement and complement the traditional track geometry car measurements which provide information about ballast (and subgrade) condition only indirectly. This in turn allows for better decision making on track substructure maintenance to include options for cleaning or replacing the ballast, improving drainage, or simply adding ballast to increase the depth of the ballast layer. This further allows track maintenance engineers to identify and correct the root cause of track degradation problems, rather than just simply correcting the symptoms, as they appear, by tamping and related track geometry corrective actions.



Fig. 4. Digitized LIDAR ballast profile with ideal profile overlay.

The mission of the Delaware Center for Transportation is to improve the movement of people, goods, and ideas, and be viewed as a valuable resource for transportation-related issues and challenges within the state, the mid-Atlantic region and beyond.

Delaware Center for Transportation Staff

Christopher Meehan, Ellen Pletz, Business Administrator I Director cmeehan@udel.edu ebourett@udel.edu Jerome Lewis,

Associate Director jlewis@udel.edu

Matheu Carter,

T² Engineer matheu@udel.edu **Director UTC** smcneil@udel.edu

Sue McNeil,

Earl Rusty Lee, T² Program Coordinator elee@udel.edu

Mingxin Li Scientist Imx@udel.edu

Sandra Wolfe, **Event Coordinator** sandiw@udel.edu

The University of Delaware does not discriminate on the basis of race, color, national origin, sex, disability, religion, age, veteran status, gender identity or expression, or sexual orientation, or any other characteristic protected by applicable law in its employment, educational programs and activities, admissions policies, and scholarship and loan programs as required by Title IX of the Educational Amendments of 1972, the Americans with Disabilities Act of 1990, Section 504 of the Rehabilitation Act of 1973, Title VII of the Civil Rights Act of 1964, and other applicable statutes and University policies. The University of Delaware also prohibits unlawful harassment including sexual harassment and sexual violence. Inquiries or complaints may be addressed to:

Susan L. Groff, Ed. D. Director, Institutional Equity & Title IX Coordinator 305 Hullihen Hall Newark, DE 19716 (302) 831-8063 titleixcoordinator@udel.edu

For complaints related to Section 504 of the Rehabilitation Act of 1973 and/or the Americans with Disabilities Act, please contact: Anne L. Jannarone, M.Ed., Ed.S. Director, Office of Disability Support Services Alison Hall, Suite 130. Newark, DE 19716 (302) 831-4643 OR contact the U.S. Department of Education - Office for Civil Rights (https://wdcrobcolp01.ed.gov/CFAPPS/OCR/contactus.cfm).

UTC NEWS INSERT

RESILIENCY OF TRANSPORTATION CORRIDORS

PUBLISHED BY THE UD UNIVERSITY TRANSPORTATION CENTER

Dare to be first.



University Transportation Center

Department of Civil & Environmental Engineering

355 DuPont Hall Newark, DE 19716

P: 302-831-1446 F: 302-831-0674 www.ce.udel.edu/dct

Director and Managing Editor Sue McNeil

Design University Printing

Director's Message

In early December Secretary Foxx announced the 2016 University Transportation Centers. Congratulations to friends and colleagues who are part of one or more of the thirty-two UTCs (see *https://www.transportation.gov/briefing-room/ dot15016*.) In particular, congratulations to our colleague Dr. Allan Zarembski. Dr. Zarembski is leading University of Delaware's effort as a member of the University Transportation Center on Improving Rail Transportation Infrastructure Sustainability and Durability. This UTC is led by University of Nevada, Las Vegas and also involves Virginia Polytechnic Institute and State University.

While we are disappointed that the other proposals submitted by University of Delaware were not successful, we are pursuing other opportunities. For example, University of Delaware is a participant in the Center of Advanced Infrastructure and Transportation (CAIT) at Rutgers team as a US DOT Beyond Traffic Innovation Center (BTIC). These centers will build on the recently released *Beyond Traffic* report (see *https://www.transportation.gov/briefing-room/secretary-foxx-releases-beyond-traffic-2045-final-report-future-transportation.*)

In the meantime, our ongoing projects are making progress, papers are appearing in journals and presentations are being made based on these ongoing projects and recently completed projects, and our students continue to win scholarships. These activities are highlighted in this newsletter as well as recent and upcoming brown bag seminars and other presentations.

> Sue McNeil Professor, Department of Civil & Environmental Engineering

ransearch

Highlights from Selected Recent and Ongoing CAIT at UD Projects

Over the past five years twenty seven projects, seventeen funded as part of the Tier 1 grants and another ten as part of the National UTC (as shown in Tables 1 and 2), have been funded at UD as part of the CAIT consortium. Reports have been submitted for twenty of these projects, another two reports are in preparation and four projects are still ongoing. Recent accomplishments are documents below. Papers, webinars and presentations disseminating completed research are also continuing and are listed in this newsletter.

Tier 1 UTC Projects

While this grant has ended, researchers continue to finalize reports, and build on and disseminate the results of their research from already completed studies. Recently completed reports include:

• McNeil, Sue, Joseph Trainor, Alex Greer, Israt Jahan and Kelsey Mininger, "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy," December, 2016.

• Roda, Andres, Ali Maher, and Sue McNeil, "Life Cycle Cost Reduction Road Map," October 2016.

 Herning, Gordana, Ali Maher and Sue McNeil,
"Collaborative Proposal on Resilience: Definitions, Measurement, Tools and Research Opportunities," August 2016.

• Gong, Jie, K. Heaslip, S. McNeil, F. Farzan and S. Brink, "Big Data: Opportunities and Challenges in Asset Management (collaborative project)," August 2016.



Table 1 Tier 1 UTC Projects

Title	Dates	Principal Investigators
Better State-of-Good-Repair Indicators for the Transportation Performance Index	September 1, 2012 - January 31, 2014	Sue McNeil
Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges	September 1, 2012- January 31, 2014	Thomas Schumacher and Jennifer McConnell
Mathematical and Experimental Investigations of Modeling, Simulation and Experiment to Promote the Life-Cycle of Polymer Modified Asphalt	September 1, 2012 - January 31, 2014	Pam Cook and Nii Attoh-Okine
Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses	September 1, 2012 - January 31, 2014	Nii Attoh-Okine
Multi-Sensor Sheets Based on Large-Area Electronics for Advanced Structural Health Monitoring of Civil Infrastructure	January 1, 2013 - December 31, 2013	Thomas Schumacher
Evaluation of Biotechnologies for Flexible Pavement Applications	June 1, 2013 - May 30, 2014	Nii Attoh-Okine
Enhancing Removal in Stormwater Treatment Facilities for Transportation	January 1, 2014 - December 31, 2014	Pei Chiu and Paul Imhoff
Big Data: Opportunities and Challenges in Asset Management	April 1, 2013 - August 31, 2014	Sue McNeil
Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy	September 1, 2013 - August 31, 2014	Sue McNeil and Joseph Trainor
Guidelines for embedment length of carbon fiber reinforced polymer (CFRP) strips in near surface mount (NSM) retrofitted concrete structures.	January 1, 2014 - December 31, 2014	Nakul Ramanna
Exploration of Video-Based Structural Health Monitoring Techniques	September 1, 2013 - August 31, 2014	Thomas Schumacher
Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network	September 1, 2013 - August 31, 2014	B.J. DeCoursey
Asphalt: Rheology and strengthening through polymer binders	January 1, 2014 - December 31, 2014	Pam Cook and Nii Attoh-Okine
Biochar as a Rechargeable Geobattery to Promote Nitrogen Removal in Stormwater from Roadways	September 1, 2015 - December 31, 2015	Pei Chiu and Paul Imhoff
Cookbook for Rheological Models – Asphalt Binders	September 1, 2015 - December 31, 2015	Nii Attoh-Okine and Pam Cook
Tracking Housing Recovery in Sea Bright, NJ and the Relationship to Infrastructure Renewal	September 1, 2015 - December 31, 2015	Sue McNeil and Joseph Trainor



Table 2 National UTC Projects

Title	Principal Investigators	Dates
Bridge Retrofit or Replacement Decisions: Tools to assess Sustainability and aid Decision-making	Abigail Clarke-Sather and Thomas Schumacher	January 1, 2015- December 30, 2015
Using information at different spatial scales to estimate demand to support asset management decision making (started September 1, 2014)	Sue McNeil and Joseph Trainer	September 1, 2014 – August 31, 2015
Satellite Assessment and Monitoring for Pavement Management (started September 1, 2014)	Arde Faghri and Mingxin Li	September 1, 2014 – August 31, 2015
Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure	Jennifer McConnell	February 1, 2016 – January 31, 2017
Lean Construction Applications for Bridge Inspection	Abigail Clarke-Sather and Jennifer McConnell	February 1, 2016 – August 31, 2017
Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)	Chris Meehan	September 1, 2015 – August 31, 2018
Sustainable Geotextiles for Transportation Applications from Recycled Textiles	Abigail Clarke-Sather and Chris Meehan	September 1, 2016 – August 31, 2018
Reducing Stormwater Runoff Volumes with Biochar Addition to Highway Soils	Paul Imhoff and Julia Maresca	September 1, 2016 – June 30, 2018
Experimental evaluation of the engineering behavior of soil-biochar mixture as a roadway construction material	Kalehiwot Nega Manahiloh	September 1, 2016 – August 31, 2018
Collaborative Proposal: The Connection Between State of Good Repair and Resilience: Measures for Pavements and Bridges	Sue McNeil and Rusty Lee	September 1, 2016 – December 30, 2017



Bridge Retrofit or Replacement Decisions: Tools to assess Sustainability and aid Decision-making

The final report for this project was recently completed:

• Tabrizi, Arsha, and Abigail Clarke-Sather and Thomas Schumacher, "Bridge Retrofit Replacement Decisions: Tools to Assess Sustainability and Aid Decision Making," August 2016.

This research developed a methodology to describe sustainability impacts in terms of costs to owners (A), road users (B), and the environment (C). This A+B+C costing method measures the overall efficiency and sustainability of bridge repair options with lower scores representing greater efficiency. These impacts can differ between specific maintenance, rehabilitation, and replacement service operations and from normal traffic patterns. This research investigated a case study comparing different deck expansion joint rehabilitation/replacement options in the units of dollars for the expected remaining bridge life. A case-study was conducted on the full-depth replacement of the bridge's abutment expansion joint including removal of the joint's headers, armoring and in-place. sealant. Using the A+B+C costing method, the most sustainable joint maintenance program was determined for the bridge's remaining service life. It was found that an open compression seal (OCS) implemented after the full depth replacement in 2015, and replacing the OCS with a strip seal in 2030 was the most cost effective joint maintenance program at approximately \$188,000. The most expensive option would cost about \$285,000, approximately 52% more. For each joint maintenance program considered - the owner costs ranged between 10-15%, the societal costs ranged between 80-90%, while the environmental costs ranged between 2.6 and 2.7%. Environmental impacts only considered

air emissions and likely underestimated other (e.g. water and soil emissions) environmental costs of joint replacement. We are preparing journal articles for the Journal of Infrastructure Systems (sustainability costing method) and Journal of Bridge Engineering (bridge joint replacement case study) from this research.

Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure

Work on the project "Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure" began in September, 2016. Potential agencies in each of the climates have been identified. Historical NBI data from these agencies has also been reviewed.

Lean Construction Applications for Bridge Inspection

Currently, researchers are in the process of shadowing routine bridge inspection work of inspection crews both in the office and on site at bridges. They have shadowed 8 bridges' routine inspection work including pre-stressed box girder, steel girder, culverts, reinforced concrete slab and timber multi span bridges. Data collected includes a time log of all activities occurring during the inspection of the bridges. Bridge inspection activities have been defined as: review of previous documents in preparation for inspection (document review); mobilization of equipment and personnel to the site; inspection time including the time spent on visual assessment, measurement, note taking, and photographs for each bridge element; demobilization, and reporting (documentation). Preliminary findings from this research suggest that the process of documentation, computer data entry needed for reporting to the National Bridge Inventory, takes nearly twice as long as on-site inspection of bridges.



Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)

Field data collection on this project has continued, with automated field data collection for the west abutment occurring on a 10-minute cycle and manual data collection for the east abutment happening approximately every 2 weeks. Numerous sensor readings related to GRS-IBS performance have been collected, including measurements of GRS abutment wall facing displacement, pore water pressure, total pressure, strain, temperature, volumetric water content, and foundation deflection readings. In general, the sensors have indicated little change in their values over this time period, indicating relatively successful structure performance. These sensors will continue to be monitored over the course of the next year. Site visits will continue to be made on a biweekly basis, with additional visits being made as appropriate after storm events or other unusual loading conditions. To date, no obvious visual problems have been observed with the structure. In the future, within the next year or so, plans are being made to have publications in the following areas: geotextile strain gauge calibration, live load testing of a constructed GRS-IBS, applied bearing pressure on a GRS-IBS, and long term performance of a GRS-IBS.

Sustainable Geotextiles for Transportation Applications from Recycled Textiles

Goodwill of Delaware and Delaware County has delivered two payloads or 625 items of discarded clothing for us to evaluate the material properties of. Two undergraduate researchers have characterized the clothing by material type. The undergraduates are in the process of determining total weights and total square feet of each material type available in order to compare with transit application needs for square feet.

Reducing Stormwater Runoff Volumes with Biochar Addition to Highway Soils

Sixteen field samples from the roadway test site, eight samples from the control roadway soil, and eight samples from the biochar-amended soil, have been retrieved. These field samples will be used to assess the impact of biochar on soil aggregate formation and the role of microbial activities in this process.

Collaborative Proposal: The Connection Between State of Good Repair and Resilience: Measures for Pavements and Bridges

This project is with Dr. Gordana Herning of Rutgers and MIT, and Professor Kevin Heaslip of Virginia Tech and builds on the work leading up to and including the workshop on resilience held last December. To date, the team has worked on structuring the literature review. We have also developed a brief survey, which was sent it to the advisory board, asking what DOT personnel know about resilience and how they will use the concept. The results confirmed our assessment that there are no widely understood or used methods or concepts. A preliminary case study using Prime Hook Delaware has been completed and a paper submitted to the World Conference on Managing Pavement Assets. Other case studies have been identified in collaboration with the advisory board and the supporting data is being acquired.

TranSearch

Brown Bag and Other Seminars

Three brown bag seminars were held during the fall semester. Each seminar involved faculty and graduate student and focused on an ongoing CAIT project. The seminars were as follows:

• Wednesday, October 5, 2016. Abigail Clarke-Sather, Jennifer McConnell and Emal Masoud, "Lean Construction Applications for Bridge Inspection." For a description of the project see https://cait.rutgers.edu/cait/research/lean-construction-applications-bridge-inspection

• Wednesday November 16. Chris Meehan and Tyler Poggiogalle "Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)." For more information see http://cait.rutgers.edu/cait/research/long-term-monitoring-geosynthetic-reinforced-soil-integrated-bridge-system-grs-ibs)

• Friday December 2. Jennifer McConnell and Tian Bai. "Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure." For more information see https://cait.rutgers.edu/cait/research/multi-scale-condition-and-structural-analysis-steel-bridge-infrastructure



Emal Masoud







Professor Chris Meehan and graduate student Tyler Poggiogalle



Professor Laxmi Ramasubramanian presenting "Gender Inclusive Planning for Transportation

In addition to the brown bag seminar, Professor Laxmi Ramasubramania presented a seminar on "Gender Inclusive Planning for Transportation" on October 26. The seminar was based on studio work at Hunter College looking at gender issues and incidents of harassment and violence

within the transportation system (in NYC). Dr. Laxmi Ramasubramanian is an Associate Professor of Planning and Design at Hunter College. She is a certified planner (AICP). Dr. Ramasubramanian seeks to inform and transform planning practice in order to create a just and equitable society. Specifically her research examines how the use of digital technologies such as GIS can alter social and political processes, particularly the power of individuals and institutions to create and sustain social change. Dr. Ramasubramanian is an expert in the design, implementation and evaluation of participatory planning projects that use affordable and accessible digital technologies. She is the author of Geographic Information Science and Public Participation, published by Springer-Verlag, and past-president of the University Consortium for Geographic Information Science (UCGIS), a coalition of over 70 universities.

IranSearch

Recent CAIT at UD Related Publications, Presentations, and Posters

Journal articles

Shariati, A. and Schumacher, T. (2016). Eulerian-Based Virtual Visual Sensors to Measure Dynamic Displacements of Structures. Structural Control and Health Monitoring. Online first on December 23. DOI: 10.1002/stc.1977.

Walker, K., Miller, T. H., Gupta, R., Shariati, A., and Schumacher, T. (2016). Development of Virtual Visual Sensor Applications for Wood Structural Health Monitoring. ASTM Journal of Testing and Evaluation. Vol. 46 (1). DOI: 10.1520/ JTE20160194.

Greer, A., and Brokopp Binder, S. (2016): "A Historical Assessment of Home Buyout Policy: Are We Learning or Just Failing?," Housing Policy Debate, DOI:10.1080/105 11482.2016.1245209

Binder, S. B., & Greer, A. (2016). "The devil is in the details: Linking home buyout policy, practice, and experience after hurricane Sandy." Politics and Governance, 4(4), 97-106.

Invited talks

Chu, Pei, "Black Carbon as a Redox Catalyst and Microbial Electron Storage Medium for Stormwater Pollutant Degradation." December 2016, National Kaohsiung Marine University, Taiwan.

McNeil, Sue, London, Mosi and Trimbath, Susanne. (2016)."Making connections at the state and regional level between infrastructure and economic growth : a perspective from the United States," Regional Cohesion Policies: a Comparison between Italy and United States, University of Calabria, Rende (Cosenza), October 18-19, 2016 organized by the Diparti-mento di Scienze Politiche e Sociali, University of Calabria, and sponsored by the American Studies Center of Naples.

Conference Presentations

Chiu, Pei, "Mechanisms and Applications of Biochar-Supported Microbial Transformation of Environmental Contaminants." August, 2016. The 252nd American Chemical Society (ACS) Fall National Meeting, Philadelphia, PA. Oral presentation.

Chiu, Pei, "Removal of Nitrogen and Phosphorus from Stormwater in Bioretention Cells Using Zero-Valent Iron and Biochar." August, 2016. MATS-UTC Annual Meeting, Charlottesville, VA. Poster presentation.

Schumacher, T. and Harris, D. K. (2016). "Monitoring of Concrete Bridges Using Digital Videos and Imagery." Session entitled Overview and Applications of SHM Technologies for Concrete Structures at the ACI Fall 2016 Convention. Philadelphia, PA. October 23-27.

Schumacher, T. and Shariati, A. (2016). "Estimation of Bridge Cable Forces using Virtual Visual Sensors from Digital Videos." ASNT NDE/NDT for Highways and Bridges: Structural Materials Technology. Portland, OR. August 29-31.

Tian, J., Jin, J., Saquing, J.M., Yu, Y., Chiu, P.C., Guo, M., and P.T. Imhoff (2016) "Biochar Addition to Stormwater Treatment Media for Enhanced Nitrogen Removal and Hydraulic Performance," US Biochar Initiative Biochar 2016, The Synergy of Science and Industry: Biochar's Connection to Ecology, Soil, Food and Energy, Portland. OR. Tian, J., Jin, J., Chiu, P., Guo, M., and P.T. Imhoff (2016) "The Impact of Biochar on Bioretention Nitrogen Removal and Hydrologic Performance," Fall Meeting of the American Geophysical Union.

Herning, Gordana, Andres Roda, Ali Maher, and Sue McNeil, "Resilience Considerations in Transportation Infrastructure," Symposium on Current Issues of Architecture and Construction, Armenia, November 21, 2016.

Webinars

Imhoff, P.T., Chiu, P., Maresca, J., Brown, J., Panta, S., Hegberg, C., and L. Trout, Reducing Stormwater Volume and Nutrients with Biochar, National Fish and Wildlife Foundation Chesapeake Bay Stewardship Fund Webinar, Annapolis MD, 2016.

McNeil, S., Herning, G. and Maher, A., "Resilience, Performance Measurement, and Asset Management: Connecting the Concepts," TRB Webinar: Integrating Climate Change Resilience into Transportation Asset Management, October 13, 2016.

Publication

Ozden, A., Faghri, A., Li, M., & Tabrizi, K. (2016). Evaluation of Synthetic Aperture Radar Satellite Remote Sensing for Pavement and Infrastructure Monitoring. Procedia Engineering, 145, 752-759.

Presentation and Publication

Li, M., Faghri, A., Ozden A. (2017) Economic Feasibility Study for Pavement Monitoring using Synthetic Aperture Radar Satellite Remote Sensing: A Cost– Benefit Analysis. Transportation Research Record (TRR) - Journal of Transportation Research Board. TraiSearch

Presentations

Daniel Liu, Y. (Daniel). (2016). "Integrating Resilience Concepts with Pavement Management: A Case Study in Delaware", AISIM12, Oklahoma State University, June.

Martey, Emmanuel. (2016). "Probability Analysis of Train Derailments Using Cupola Function Theory", AISIM12, Oklahoma State University, June. Silvia Galvan Nunez, Silvia. (2016). "Assessing Uncertainty of Track Geometry Degradation Based on Evolutionary Markov Chain Monte Carlo", AISIM12, Oklahoma State University, June.

Radovic, Matija. (2016). "Real Time Object Recognition Using Convolutional Neural Networks", AISIM12, Oklahoma State University, June.

Theses/Dissertations

Tabrizi, Arsha. (2016) "Sustainability Costing to Aid Bridge Management Decision Making: A Case Study on Bridge Deck Expansion Joint Replacements." Masters of Civil Engineering, Department of Civil and Environmental Engineering, University of Delaware.



Rachel Chiquoine at the 2016 WTS Awards Banquet

WTS Scholarship Winner Announced

Congratulations to Rachel Chiquoine. Rachel received the Carmen E. Turner Graduate Scholarship from WTS (Womens Transportation Seminar) Philadelphia. She received the scholarships at the 2016 Awards Banquet in Philadelphia on December 8. A 2016 graduate of the MAS program in Civil Engineering and now a PhD student in the Disaster Science and Management program, Rachel received the Sylvia Alston Graduate Scholarship in 2015. Her interests include transportation infrastructure, the transportation aspects of public health, the spread of disease, and other unusual transportation contexts in disasters.

n5earch

UD Presentations at the TRB Annual Meeting

Several UD faculty, researchers, graduate students, and former students made presentations or presented posters at the 2017 Annual Meeting of the Transportation Research Board. These are:

Managing Impacts in Track Structure, Part 1 (Part 2, Session 189) Sunday 9:00 AM- 12:00 PM Workshop Influence of Track Geometry on Rail Defect Formation Allan Zarembski, University of Delaware

Sustainable Gateways: Ensuring Clean, Safe, and Reliable Port Gateways for the 21st Century Sunday 1:30 PM- 4:30 PM *Workshop* James Corbett, University of Delaware, presiding **Overview on Sustainable Gateways** James Corbett, University of Delaware

Load Rating and Load Application to Culverts and Buried Bridges

Monday 8:00 AM- 9:45 AM Lectern | Practice Ready Paper Experimental Evaluation of Dynamic Amplification Factor for Box Culverts Andrew Wells, University of Delaware Harry Shenton Kalehiwot Manahiloh, University of Delaware Gary Wenczel, University of Delaware

Annual Interuniversity Symposium on Infrastructure Management Monday 10:15 AM- 12:00 PM

Poster Assessing Uncertainty of Track Geometry Degradation Based on Evolutionary Markov Chain Monte Carlo Silvia Galvan-Nunez, University of Delaware Nii Attoh-Okine, University of Delaware

Data and Technology for Rural and Intercity Decision Making Monday 3:45 PM- 5:30 PM Lectern Research of Viable Attributes and Potential to Integrate Curbside Intercity Buses Marcia Scott, University of Delaware Christopher Kelly, University of Delaware Eileen Collins, State of Alaska Jerome Lewis, University of Delaware Ardeshir Faghri, University of Delaware Mingxin Li, University of Delaware

TRB's Rail Safety IDEA Program: Sponsoring Innovation to Improve Railroad Safety and Performance Tuesday 10:15 AM- 12:00 PM *Poster* Rail Safety Project 28: Field Validation of Inspection Gauges for Wheel Climb Safety at Switch Points Allan Zarembski, University of Delaware

Fresh Ideas for Statewide Multimodal Planning: Innovative Partnerships Toward Shared Goals Tuesday 3:45 PM- 5:30 PM Poster Delaware's Active Transportation Measures of Effectiveness: Quantifying Public Health Impacts Andrea Trabelsi, Whitman Requardt and Associates Ashley Tracy, Whitman Requardt and Associates Mike DuRoss Scott Thompson-Graves, Whitman Requardt and Associates David Racca, University of Delaware

Laura Saperstein, Delaware Department of Health and Social Services

Current Issues in Transportation Public Involvement Tuesday 3:45 PM- 5:30 PM Poster | Practice Ready Paper GIS Story Maps: A Tool to Empower and Engage Stakeholders in Planning for Complete Communities in Delaware Marcia Scott, University of Delaware

Geospatial Data Acquisition Technologies in Design and Construction Poster Tuesday 3:45 PM- 5:30 PM *Poster* | *Practice Ready Paper* Economic Feasibility Study for Pavement Monitoring using Synthetic Aperture Radar Satellite Remote Sensing: A Cost-Benefit Analysis Mingxin Li, University of Delaware Ardeshir Faghri, University of Delaware Abdulkadir Ozden, University of Delaware Yixiang Yue, Beijing Jiaotong University



Comparing Tools for Asset Management

In collaboration with the Mid-Atlantic Geospatial Transportation Users Group (MAGTUG), Delaware T2/ LTAP, CAIT at UD hosted a one-day event "Comparing Tools for Managing Infrastructure." Our objective was to provide a forum in which local and county governments can better understand what their asset management needs are and how different products address these needs. Approximately sixty participants



Brian Sovik from Data Transfer Solutions presents VueWorks (Photo Credit: Matheu Carter)

from local and county governments and consultants heard presentations and saw demonstrations from three software vendors, AssetWorks, Munilogic and VueWorks.

The day included presentations and demonstrations. The presentations are available at *https://magtug.wordpress.com/past-meeting-materials/*.



Matt Garber from Carroll Engineering demonstrates the MuniLogic software (Photo Credit: Matheu Carter)



Jim Hammond from AssetWorks demonstrates the software (Photo Credit: Matheu Carter)

TranSearch

Upcoming Spring Brown Bags and Seminars

Monday February 13, 1:25pm to 2:15pm, ISE 417, "Binomial-Distribution-Probability Modeling to Advance Transportation Risk Assessment and Resiliency Strategies," Cathleen Geiger, Department of Geography, University of Delaware and Norm Marshall, President, Smart Mobility Inc.

Abstract: Assessment of a few networked roadways and their accompanying arches, bridges, culverts, and related infrastructure can be solved directly these days with a well-posed deterministic model. But upscaling of these systems to statewide 100-year storm events quickly turns into a decision making tool which will take longer to run than the duration of the storm itself. Outlooks of such outcomes for a variety of scenarios quickly moves the problem into Monte Carlo realizations as an added factor of 100 to 1000 times more processing time. To address these needs, a probabilistic approach is taken to assess risk through vulnerabilities and criticalities that can be tailored from local infrastructure ratings. The outcome includes an integrated assessment tool for scenario testing of traffic diversions and roadway failures at local to regional scales. Application of the underlying principles can be adapted to maritime networks as well, especially given the upcoming changes in the Polar Codes set forth by the International Maritime Organization (IMO) effective 1 January 2017.

Tuesday March 7, 1:00pm to 2:00pm, Dupont Hall 341, "Toward Internet of Everything: Architectures, Standards, and Interoperability," Ram D. Sriram, Chief, Software and Systems Division, Information Technology Laboratory, National Institute of Standards and Technology

Abstract: The Internet, which has spanned several networks in a wide variety of domains, is having a significant impact on every aspect of our lives. These networks are currently being extended to have significant sensing capabilities, with the evolution of the Internet of Things (IoT). With additional control we are entering the era of Cyber-Physical Systems (CPS). In the near future the networks will go beyond physically linked computers to include multimodal-information from biological, cognitive, semantic, and social networks. This paradigm shift will involve symbiotic networks of people (social networks), smart devices, and smart phones or mobile personal computing and communication devices that will form smart net-centric systems and societies (SNSS). These devices – and the network -- will be constantly sensing, monitoring, interpreting, and controlling the environment. A key technical challenge for realizing the "Internet of Everything (IoE)" is that the network consists of things (both devices and humans) which are heterogeneous, yet need to be interoperable. In other words devices and people need to interoperate in a seamless manner. This requires the development of standard terminologies (or ontologies) which capture the meaning and relations of objects and events. Creating and testing such terminologies will aid in effective recognition and reaction in a network-centric situation awareness environment. In this talk, I will provide a unified framework for Internet of Things, Cyber-Physical Systems, and Smart Networked Systems and Societies, and then discuss the role of ontologies for interoperability. I will also describe representative projects at the National Institute of Standards and Technology.

Tuesday March 21, 1:00pm to 2:00pm, Dupont Hall 341, "IUMAT- Integrated Urban Metabolism Analytical Tool," Simi Hoque, Associate Professor, Department of Civil, Architectural and Environmental Engineering, Drexel University.

Abstract: The goal of IUMAT is to analyze the combined effects of transportation, building development, land use, water, and waste on the urban environment. We are using "metabolic" fluxes as our theoretical and analytical basis to measure how emissions and energy use are characterized across a city. The heart of the research project involves using the building as the central unit or node of analysis, from which water, waste, transportation, land use, and other fluxes can be modeled. Our model currently runs statistical analysis on residential energy demands within a city, using RECS data and the Census track.

Watch your email for other brown bags (generally Tuesdays at 1pm for the 2017 spring semester) and seminars. Proposed topics and presenters are:

- Reducing Stormwater Runoff Volumes with Biochar Addition to Highway Soils, Julia Maresca and Paul Imhoff
- Sustainable Geotextiles for Transportation Applications from Recycled Textiles, Abigail Clarke-Sather and Chris Meehan
- Experimental evaluation of the engineering behavior of soil-biochar mixture as a roadway construction material, Kalehiwot Nega Manahiloh
- The Connection between State of Good Repair and Resilience: Measures for Pavements and Bridges, Daniel Liu, Rachel Chiquoine, Rusty Lee and Sue McNeil

TranSearch

Contact Us

Want to learn more about the UTC? Watch for our new website – there will be a link from: http://www.ce.udel.edu/UTC/index.html

Want to be notified by email when UDUTC is sponsoring transportation related events? Want to be notified by about UDUTC funding opportunities or graduate fellowships?

To be added to the email distribution list, send an email to Sue McNeil (smcneil@udel.edu)