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DEPARTMENT OF TRANSPORTATION

PENNDOT OFFICE OF PLANNING

Bureau of Planning and Research

2018 RESEARCH SYMPOSIUM

Proceedings

February 2019

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DEPARTMENT OF TRANSPORTATION

EXECUTIVE SUMMARY

The 2018 Pennsylvania Department of Transportation (PennDOT) Research Symposium was held on September 27-28, 2018 in Harrisburg, Pennsylvania. The event provided an opportunity for PennDOT and Federal Highway Administration (FHWA) staff to hear from university researchers on current research projects and ideas for research that could help PennDOT meet its strategic goals.

On Day One, the symposium featured an opening session, six breakout sessions with a total of 26 presentations from six universities, and a "research fair" including a poster session and information booths. Day Two included time for PennDOT and FHWA staff to discuss what they heard on Day One and to identify potential research projects for PennDOT's 2019-2020 Research Program. Based on discussion held at the symposium, PennDOT identified 26 potential research projects in five topic areas for consideration for the 2019-2020 Research Program. This research varies from the use of advanced imaging for asset management, bridge resiliency, and improvements in materials, to self-enforcing highways and coordination of traffic controls with connected and autonomous vehicles.

This report highlights the key elements from the symposium including the following sections:

- Background/Event Overview
- Opening Session Summary
- Breakout Session Summary
- Next Steps

Detailed information can be found in the appendix.

BACKGROUND/EVENT OVERVIEW

The 2018 Research Symposium built upon a 2015 event hosted by the Pennsylvania Consortium of Transportation Universities (PaCTU) consisting of 10 Pennsylvania engineering universities. The PaCTU event offered an opportunity for attendees to identify top transportation issues and to discuss how emerging technologies and research might present solutions. From the successful outcomes of the PaCTU event and the need for collaboration between PennDOT and university researchers, PennDOT's Research Division and FHWA decided to conduct a similar, but more strategic event for collaboration.

PennDOT's Research Program Management Section established a steering committee to identify the event's goals and objectives, potential format and themes as well as outcomes and next steps. The steering committee determined the event should bring PennDOT and university researchers together to talk about research gaps and new research ideas that address PennDOT's strategic planning needs.

PennDOT identified a moderator and panel of subject matter experts for each session. Each moderator developed a list of problem statements and questions for the universities to use to guide their presentations (included as Appendix A).

Day Two included time for PennDOT and FHWA staff to discuss what they heard on Day One and to identify potential research projects for PennDOT's 2019-2020 Research Program. A summary of the potential research projects is included under Next Steps.

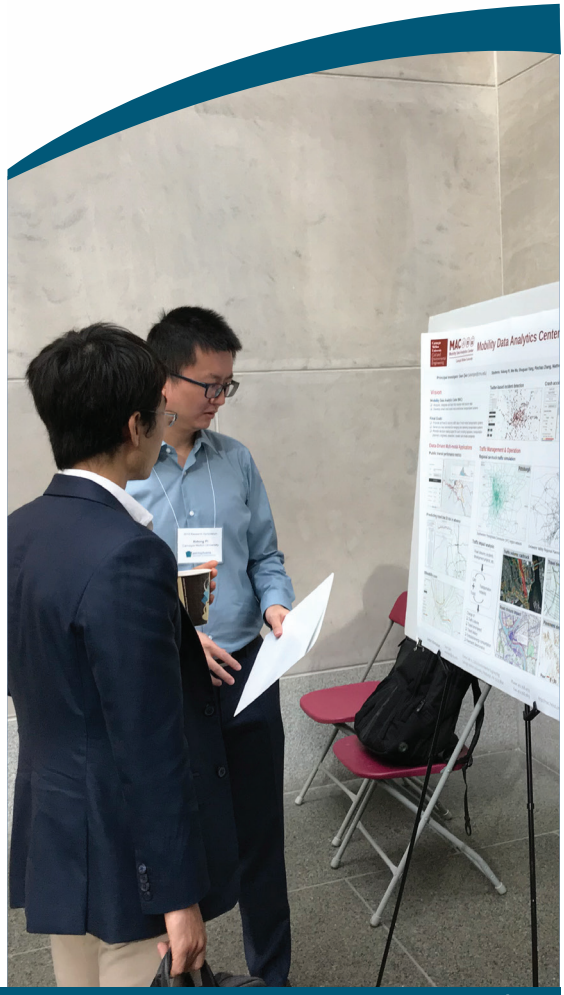
The following universities presented during the symposium:

- Carnegie Mellon University,
- Drexel University,
- Lehigh University,
- The Pennsylvania State University,
- University of Pittsburgh, and
- Temple University.

The symposium included over 40 university representatives and over 80 transportation subject matter experts (see Appendix B for a full list of the attendees). The event agenda is included as Appendix C.

The symposium format included concurrent sessions separated into six transportation themes based on the risk assessment developed in collaboration between PennDOT and FHWA:

- Asset Management
- Bridges
- Multimodal
- Pavement and Materials
- Safety
- Traffic Operations and Connected and Automated Vehicles



OPENING SESSION SUMMARY

The Opening Session was held at the Pennsylvania State Museum with presentations from PennDOT and FHWA leadership.

Doug Zimmerman, Research Division Manager for the Bureau of Planning and Research, welcomed the attendees and reviewed the agenda for the day.

Jim Ritzman, Deputy Secretary for Planning, spoke to the attendees about the benefits of the PennDOT Research Program and how this event was designed to expand upon the PaCTU event held in 2015. He discussed how this event will help shape the future of PennDOT research and ultimately transportation in Pennsylvania.

This event will help shape the future of PennDOT research and ultimately transportation in Pennsylvania.

Jim Ritzman, Deputy Secretary for Planning

George McAuley, Deputy Secretary for Highway Administration, discussed the importance of research projects being implementable. Researchers need to consider timelines and actions for deployment so that successful projects may be implemented quickly to help PennDOT stay current with the changing transportation needs and expectations.

Karyn Vandervoort, Program Management Analyst for FHWA, spoke to the attendees about the need for successful collaboration between the research universities, PennDOT and FHWA in order to be able to stay current with the changing transportation dynamics and technology. She also spoke to the need to develop a “research roadmap” that will help PennDOT identify research projects over the next 5-10 years, and allow the agency to meet its strategic goals. Multiple research projects over multiple years may build on one another to meet the identified goals.

BREAKOUT SESSION SUMMARY

Details from each breakout session, including the problem statements and an overview of the presentations, are included on the following pages. Each session had a moderator and a panel of subject matter experts who were in attendance to hear presentations and offer questions to the presenters.

Asset Management Session

Moderator: Mike Long, PennDOT, Chief, Asset Management Division

Panel Members:

- Halley Cole, PennDOT, Chief, Pavement Management Unit
- Justin Bruner, PennDOT, Chief, Bridge Asset Management
- Tracy Mausteller, PennDOT District 3, District Pavement Manager
- Kristin Mulkerin, PennDOT, Transportation Planning Manager
- Lou Ruzzi, PennDOT District 11, Senior Civil Engineer Manager
- Larry Shifflet, PennDOT, Bureau Director, Program Development and Management

Presentations Summary:

Julie Drzymalski, Ph.D., PEM, from **Drexel University**, presented on improving multi-objective decision analysis for cross-asset resource allocation. Ms. Drzymalski discussed the steps to cross-asset resource allocation including using an analytical hierarchy process (AHP) and an analytical network process (ANP). Using AHP and ANP will provide a more realistic picture of costs and benefits, higher return on investment by better utilizing funds, easier comparison and ranking of dissimilar projects, and the ability to do performance-based optimization rather than siloed planning. Ms. Drzymalski discussed evaluating and scaling mixed measures using Bayesian Modeling and how PennDOT could use this method for combining and weighting qualitative and quantitative performance measures.

Problem Statement:

If PA does not develop guidance and tools to support prioritization of infrastructure projects, then it will be difficult to ensure long-term optimization of the transportation system and there is an increased potential for inefficient utilization of available transportation funding (refer to Appendix A for the Questions and Discussion Points).

Sean Qian, Ph.D., from the Mobility Data Analytics Center at **Carnegie Mellon University**, presented on data-driven roadway asset management. He discussed smart decision-making using high-resolution simulation and data to understand the cost/benefits and optimal scheduling for retrofits. The presentation also reviewed Twitter-based incident detection with five categories of tweets including accidents, roadwork, hazards/weather, events and obstacle vehicles. **Christoph Mertz, Ph.D.**, from **Carnegie Mellon University**, presented on using smartphone data for asset management. Windshield-mounted smartphones can be used to detect road cracks/other roadway features. Object detection, classification, and 3D reconstruction are now standard computer vision tools. They can be used to analyze large amounts of video and images as input for asset management systems.

Laura Toran, Ph.D., and **Erica McKenzie, Ph.D.**, from **Temple University**, presented on assessing and improving stormwater management practices. As part of the I-95 reconstruction project, PennDOT is installing stormwater infiltration basins adjacent to the highway corridor. Researchers from Temple and Villanova Universities are conducting research to improve the effectiveness of the basins. The team is looking into the low plant survival rates trying to identify the best species to use for flooding and salt tolerance, and identifying other methods to mitigate contaminants.

Kostas Papakonstantinou, Ph.D., from the Larson Transportation Institute at **The Pennsylvania State University (Penn State)**, presented on infrastructure condition data collection. Penn State faculty have several ongoing research projects that deal with infrastructure data collection. One project included the visual inspection of bridge decks, data collection for the bridge decks and development of a database. The results showed the effect of multiple variables on the sojourn times at each condition rating and included the development of deterioration curves. The presentation also reviewed models for pavement crack initiation and pavement friction degradation.

Bridge Session

Moderator: Kristin Langer, PennDOT, Assistant Chief Bridge Engineer

Panel Members:

- Tim Carre, PennDOT, Assistant Chief Bridge Engineer
- Ralph DeStefano, PennDOT District 12, Senior Civil Engineer Manager
- Li Guozhou, PennDOT, Assistant Chief Bridge Engineer
- Jeremy Hughes, PennDOT District 12, Senior Civil Engineer Manager
- Bill Koller, PennDOT District 1, Senior Civil Engineer Manager
- Jim Long, PennDOT, Section Chief, Bureau of Maintenance and Operations
- Tom Macioce, PennDOT, Chief, Bridge Design and Technology Division

Presentations Summary:

Max Stephens, Ph.D., presented on advanced civil infrastructure bridge research at the **University of Pittsburgh**. The presentation gave an overview of past and current projects, future research directions, faculty research expertise and experience, and experimental capabilities. Past projects included fiber-reinforced concrete in bridge superstructures, concrete filled steel tube (CFST) columns and connections, and performance modeling tools for CFST bridges. Current projects included performance of highway bridges subjected to sequential seismic and tsunami hazards, strengthening of slender bracing using fiberglass reinforced plastic, and rapid concrete repair and rehabilitation methods using internal curing. Pending PennDOT projects discussed included corrosion repair strategies for steel bridges using high performance and traditional materials and data management, mining, and inference for bridge monitoring.

Problem Statement:

If the number of statewide bridges - including local bridges - rated as poor condition increase, then investments may have to be reprioritized and asset management will not be achieved (refer to Appendix A for the Questions and Discussion Points).

Gordon Warn, Ph.D., presented on bridge research at **The Pennsylvania State University**. The presentation provided insight into the bridge management technology used to locate, track, and repair cracking in bridge decks. The presentation outlined data-driven deterioration prediction methods as well as exploring cost-effectiveness of remediation techniques. New technologies were presented including hybrid fiber reinforced polymer concrete and glass fiber reinforced polymer reinforcement in concrete. The presentation included summaries of the current PennDOT design loads and permit vehicles, superload vehicles and railroads, as well as an example project of how the Everett Railroad Bridge was load rated in real time with weatherproof wireless sensors. The effects of channel stability on roadway hydraulic structures in Texas was discussed along with research and modeling of vehicular crashes into structures. The presentation closed with a summary of the facilities used to support safety research at the Pennsylvania Transportation Institute, including the shake table testing facility and their recent designation as a proving ground for autonomous driving.

Spencer Quiel, Ph.D., P.E., presented on bridge research capabilities and projects at **Lehigh University**. The presentation introduced the Advanced Technology for Large Structural Systems facility and outlined their capabilities for field and laboratory testing and simulations. The facility's capabilities include large-scale loading, compression, hydraulics, real-time in field-testing and soil-structure interaction and a furnace area used to test structures that experience fires. Current research projects for innovative structural systems were outlined including a new FlexBeam bridge system, corrugated web girders and tubular concrete-filled flange girders. Research projects discussed include investigations into the effects of hydraulic resistance on bridge foundations, axial loading of geothermal foundations and a field study of girder fracture retrofits using finite element modeling. The presentation concluded with an overview of resilience assessment technology and life-cycle risk management and sustainability.

Burcu Akinci, Ph.D., presented on smart infrastructure research at **Carnegie Mellon University**. The presentation began with a summary of the current issues faced including aging infrastructure, increasing demands, reduced resources and budgets, and the consequences of not acting to remediate these issues. The presentation outlined the need for smarter infrastructure that can monitor in real-time and give accurate, relevant data on large scales. Methods of vibration-based structural health monitoring and a comparison of direct and indirect methods were included. Examples of the instrumentation utilized and how the raw data translates into a damage diagnosis for future repairs were shown. The presentation outlined vehicle-bridge interaction systems and how they can track and record impact data to accurately predict damage location and severity. The Panhandle Bridge in Pittsburgh was an example of the technology being implemented to test the accuracy of the instrumentation and models. The presentation introduced micro aerial vehicles (MAV) as an option to view, inspect, and model structures remotely and in real-time. The MAV's can be used to create detailed point-cloud models of structures, which can give an accurate, instantaneous view of structures and virtually allow structure inspection. The presentation closed with an outline of a framework for prioritizing investments in bridge lifting and a summary of the societal and economic costs associated with low-clearance structures.

Noemi Bonessio, Ph.D., presented on structural health monitoring (SHM) and new materials for bridges at **Temple University**. The presentation began with a summary of new applications of SHM technologies including vibration-based modeling and its uses in multi-directional damage assessment. The presentation introduced the Damage Identification Isolated Bridges (DIIB) Program developed by the University of California San Diego, which can visualize acceleration data from sensors on a structure and develop a severity index for a given event and also measure the deterioration of bridge dampers over time. Other research topics presented include the SHM of bearings, scour effects, optimization of sensor distribution and placement, and viewing SHM data in virtual reality. The presentation concluded with an overview of the research into design, manufacturing, and performance of mechanical metamaterials and newly created material architectures and how they apply to the selection of bearing and expansion joint materials.

Ivan Bartoli Ph.D., **Emin Aktan Ph.D.**, and **Yaghoob Farnam, Ph.D.**, presented on technology leveraging for highway structures at **Drexel University**. The presentation began with a discussion of the capabilities provided by multi-purpose wireless sensors including their ability to rapidly asses a bridge's condition, measure displacement, rotation, or deformation of structures, provide non-destructive evaluations, load rate structures and provide post-event safety assessments. The presentation described how the sensors are tested both in the laboratory and in the field to ensure accurate data. The presentation introduced Drexel's Advanced and Sustainable Infrastructure Materials (ASIM) Group's research into how new materials can improve resilience, durability and sustainability of infrastructure. Research topics introduced include ultra-high performance concrete, lightweight aggregate from coal combustion products, self-healing concrete and microbial damage mitigation, and snow-melting concrete.

Problem Statement:

If the highway-related user needs of multimodal modes (ports, air, rail and transit) are not properly addressed in the highway planning/programming process or project development process, performance of the movement of people and goods will be hindered or projects will be delayed (refer to Appendix A for the Questions and Discussion Points).

Mulitmodal Session

Moderator: Angela Watson, PennDOT, Manager, Multimodal Projects

Panel Members:

- Elizabeth Bonini, PennDOT, Director, Office of PennPorts and Rail
- Roy Gothie, PennDOT, Statewide Bicycle and Pedestrian Coordinator
- Anthony McCloskey, PennDOT, Bureau Director, Aviation
- Stephen Panko, PennDOT, Planning Manager, Bureau of Rail Freight
- Denise Soisson, PennDOT, Manager, Port Programs
- Michael Sorbo, PennDOT, Bureau Director, Bureau of Rail Freight
- Danielle Spila, PennDOT, Bureau Director, Public Transportation

Presentations Summary:

Keith Johnson presented on multimodal transportation research capabilities at the **University of Pittsburgh's** Center for Sustainable Transportation Infrastructure. The presentation highlighted recent and current projects including determining the air quality benefits of the bike share system in Pittsburgh and evaluating bicycle, pedestrian, transit and economic data collection needs and measures of effectiveness. Additional research presented included identifying impediments and solutions to sidewalk project implementation and developing a methodology to incorporate transit, pedestrian, and bicycle design features into projects during the planning and design phases. **Alex Labrinidis, Ph.D.**, from the **University of Pittsburgh** presented on the Pitt Smart Living Project, and is working to develop a multimodal trip planning mobile app that builds a marketplace around multimodal mobility.

Ilgin Guler, Ph.D., presented on multimodal research at the Larson Transportation Institute, part of **The Pennsylvania State University**. The presentation included discussion of providing non-traditional bus priority, transit signal priority (TSP) for connected vehicles and buses, optimizing TSP along an arterial, impacts of bus stops on surrounding traffic and using data to predict transit system performance. Additional topics presented included best practices for multimodal transportation modeling, analysis of demand and supply of real-time transit information systems, adoption of innovative vehicle technologies, freight performance measures, pedestrian and bicycle safety performance functions, and enhancing pedestrian volume estimation.

Lee Branstetter, Ph.D., presented on The Block Center for Technology and Society Future of Work Initiative at **Carnegie Mellon University**. He discussed ridesharing companies and policymakers working together. Policymakers could enact regulatory changes that benefit ridesharing companies and in return the companies could provide heavily discounted or free ridesharing coupons. These coupons could be used to improve access to jobs for low-income residents. **Stan Caldwell**, **Carnegie Mellon University**, discussed prospective job loss from automated trucks and using game theory and machine learning for a peer-to-peer ridesharing platform. **Stephen Quick, FAIA, LEED AP**, **Carnegie Mellon University**, presented on highway corridor design and autonomous vehicles.

Pavement and Materials Session

Moderator: Joseph Robinson, PennDOT, Chief Materials Engineer

Panel Members:

- Pat Baer, PennDOT, Unit Manager, Bureau of Project Delivery
- Garth Bridenbaugh, PennDOT, Civil Engineer Manager, Bureau of Project Delivery
- Neal Fannin, PennDOT, Pavement Materials Engineer, Bureau of Project Delivery
- Steve Koser, PennDOT, Section Chief, Bureau of Maintenance and Operations
- Lydia Peddicord, PennDOT, Unit Chief, Bureau of Project Delivery
- Tim Ramirez, PennDOT, Engineer of Tests, Bureau of Project Delivery

Presentations Summary:

Christoph Mertz, Ph.D., from the Robotics Institute, presented on pavement monitoring with smartphones at **Carnegie Mellon University**. The presentation addressed smartphones mounted on windshields of any vehicle that regularly drives in the city, such as police vehicles, buses, maintenance vehicles, etc. The program would be able to use computer vision and machine learning to scan a road segment and identify possible indicators such as debris on the road, color changes in soil or pooling water to identify potential road cracking. As a result of multiple data sets coming in from this program, a distress map could be constructed indicating where road damage was most severe. Current projects include collecting data in several Pittsburgh neighborhoods for three-dimensional reconstructions from roadway images.

Problem Statement:

If PennDOT material specification, policies and test requirements are not expedited over current timelines, then there is an increased potential for poor pavement performance and asset management goals will not be achieved (refer to Appendix A for the Questions and Discussion Points).

Ahmed Faheem, Ph.D., presented on research activities at the Sustainable Pavement Technology Research Laboratory at **Temple University**. The presentation addressed the possible solutions for poor pavement performance in conjunction with achieving asset management goals. Target areas addressed included the effects of Warm Mix Asphalt low mixing and compaction temperatures on mixes with Recycled Asphalt Pavement and the development of an anti-oxidant additive as asphalt mixtures enhancer. Additional items discussed include the evaluation of construction QC/QA activities and impacts on pavement long term performance including factors like pavement design elements, material production, construction placement, and overall pavement performance and pavement monitoring through automated and affordable road condition surveys using cell phones.

Yaghoob Farnam, Ph.D., presented on advanced materials for enhancing resilience, durability, and sustainability of transportation infrastructure at **Drexel University**. Dr. Farnam's presentation focused on the need to improve the resilience, durability and sustainability of civil infrastructure materials. The presentation asserted that designing pavement to better withstand a combination of salt damage and freeze-thaw conditions will improve the lifespan of the materials used in transportation infrastructure. Four potential solutions were offered for these enhancements: snow-melting concrete, self-healing concrete, recycled lightweight aggregate for internal curing and the use of ultra-high-performance concrete.

Farshad Rajabipour, Ph.D., and **Mansour Solaimanian, Ph.D.**, presented on research on pavements and materials at **The Pennsylvania State University**. The presentation gave an overview of recent and current areas of research including enhanced moisture damage, reflection cracking in asphalt pavements, reclaimed asphalt pavement (RAP) characterization through impact resonance testing, performance enhancement using fibers and new polymers, RAP binder blending using atomic force microscopy, bio-asphalt, material characterization and pavement performance evaluation, alternative concrete pozzolans (fly ash), alkali-silica reaction and foam air entrainment. Additional areas of research included concrete pavement condition assessment and overlay design, evaluation of geotextile separation to prevent migration of subgrade fines into subbase, and use of Sensing Mechanism and Real Time Pavement Monitoring Systems.

Lev Khazanovich, Ph.D., **Julie Vandenbossche, Ph.D., MS, BSCE**, and **Steve Sachs, Ph.D.**, presented on Pavement Research at the **University of Pittsburgh**. They discussed advancements to extend performance life of pavement including thin high-performance overlays to avoid pavement reconstruction under overpasses and long-life repairs through material compatibility. Nondestructive assessment of hot mix asphalt compaction uniformity and nondestructive assessment of concrete pavement uniformity were examined to address construction inspections. Quantitative non-destructive detection of durability issues in concrete pavements was discussed as a method to better detect and predict pavement failures.

Safety Session

Moderator: Gavin Gray, PennDOT, Chief, Highway Safety Section

Panel Members:

- Marcus Cramer, PennDOT District 1, Senior Civil Engineer Supervisor
- Tom Glass, PennDOT, Transportation Planning Manager, Bureau of Maintenance and Operations
- Jason Hershok, PennDOT, Traffic Control Specialist Manager
- Bill Houpt, PennDOT District 3, Safety Engineer
- Ashwin Patel, PennDOT District 6, Senior Civil Engineer Manager

Presentations Summary:

Eric Donnell, Ph.D., P.E., presented on traffic safety research at **The Pennsylvania State University**. Their focus was data driven safety approaches including how visibility and ability to read road signs are increased when using a clearview based font rather than the existing conditions described in the Manual on Uniform Traffic Control Devices. Also discussed were retro reflectivity in pavement markings, work zone safety drum and panel colors, speed management, and roadside safety through connected and autonomous vehicles that can detect and monitor pavement conditions, including lane markers and steer-by-wire systems that can measure road friction levels.

Robert Tamburo, Ph.D., presented on improving safety with adaptive lighting and computer vision at **Carnegie Mellon University**. Smart headlights would offer better visibility in snow, would be able to illuminate and identify cyclists significantly faster than an average driver,

Problem Statement:

If PA does not implement safety initiatives on all public roads, and use technology and innovation, then Strategic Highway Safety Plan safety goals will not be obtained and the safety of the traveling public will not improve (refer to Appendix A for the Questions and Discussion Points).

and would significantly reduce glare; thus being safer for oncoming drivers. The technology used in headlights could also be applied to work zone lighting by making them glare free and by helping identify oncoming vehicles driving faster than posted limits. Smart intersections would be able to detect and track pedestrians and their movements, could locate vehicles, and could reconstruct vehicles from data points and show their movements in the intersection. Smart intersections could also note near collisions, unexpected pedestrian or vehicle movements, and track autonomous vehicle movements. **H. Scott Matthews, Ph.D.**, from **Carnegie Mellon University**, presented on data analytics in the connected vehicle future to revolutionize safety, emissions, and funding. The presentation focused on mechanical safety and emissions inspections for vehicles noting that the rigor of the inspections varies and are not nationally required. The presentation also suggested collecting more data from on-board diagnostics will provide better data streams down to trip level, and could provide full vehicular profiles at inspection times.

Joseph Thomas Coe, Ph.D., and **Joseph Picone, Ph.D.**, presented on the use of big data and machine learning in support of the Pennsylvania Strategic Highway Safety Plan at **Temple University**. Key subjects included highway incident detection timelines and autonomous vehicles. The presentation suggested big data is critical for transportation safety because it takes into account many contributing factors including humans, infrastructure, emergency medical services, public policy and education; has the ability to link micro and macro scales of interest; and provides data driven and evidence based best practices that result in a better allocation of resources. Highway incident detection timeline results showed machine learning systems can discover root causes if there is ample and consistent training data. Overall, the presentation asserted that increased data set integration is necessary for improvements in highway safety.

Traffic Operations and Connected and Automated Vehicles Session

Moderator: Doug Tomlinson, PennDOT, Chief, Traffic Operations

Panel Members:

- Manny Anastasiadis, PennDOT District 6, Senior Civil Engineer Supervisor
- Frank Cippel, PennDOT District 11, Assistant District Traffic Engineer
- Rich Deen, PennDOT District 8, ITS and Congestion Management Manager
- Dan Farley, PennDOT, Section Chief, Bureau of Maintenance and Operations
- Chris King, Delaware Valley Regional Planning Commission, Manager, Office of Transportation Operations
- Mark Kopko, PennDOT, Senior Civil Engineer, Bureau of Maintenance and Operations
- Joshua Spano, Southwestern Pennsylvania Commission, Transportation Planner
- Denny Prestash, PennDOT District 2, Senior Civil Engineer Supervisor

Presentations Summary:

Vikash Gayah, Ph.D., from the Larson Transportation Institute at **The Pennsylvania State University**, presented on traffic operations and connected and autonomous vehicle (CAV) technology. The program discussed using data-driven approaches and available datasets to quantify the impacts of weather on congestion and to identify unreliable corridors. Developing advanced performance metrics will help to understand and improve motorist behavior. The presenter also suggested using micro-simulation software to access transportation systems management and operations solutions. Examples of these solutions include identifying the impact of uncoordinated and coordinated ramp metering, the impact of rerouting entry ramp volumes to mitigate congestion and rear-end crashes and applying variable speed limits to improve safety. Traffic signal enhancements including network-wide impacts of adaptive signal control were discussed. The university developed passenger-based transit signal priority algorithms to minimize passenger delays and looked at types of variable message signs. The presentation also addressed recent CAV research, which includes platooning of trucks on freeways, mapping to support CAV, and reviewing enabled intersection control and implementation measures for urban environments. The presentation highlighted the test track and the PennSTART facility that will provide a testing platform for CAV.

Problem Statement:

If statewide traffic operational and congestion relief/ bottleneck strategies are not implemented, then investments will not be optimized, travel delay and traffic incidents will increase, and travel reliability performance goals will not be achieved (refer to Appendix A for the Questions and Discussion Points).

Fei Lu, Ph.D., from the **Drexel University** College of Engineering, presented on dynamic wireless charging of electric CAV to improve traffic operations. The presentation reviewed roadside challenges including the need for traffic operation improvements, traffic congestion relief and investment optimization. Solutions include improving efficiency through dynamic charging applied to CAV. Benefits include allowing more time to travel, less possibility of exposure to traffic incidents and the low maintenance cost of the wireless system. The presentation also highlighted the need to optimize the planning of the dynamic system to improve transportation efficiency and to optimize traffic operation and the charging profile.

Ding Zhao, Ph.D., from the Robotics Institute at **Carnegie Mellon University**, presented on CAV and the rigorous evaluation and verification approach including collecting data, researching the naturalistic environment, looking at the accelerated environment, and reviewing test results to identify benefits in the real world. **Sean Qian, Ph.D.**, from **Carnegie Mellon University**, presented on dynamic network analysis and real-time traffic management. He discussed smart decision-making using high-resolution simulation and data, and reviewed two network simulation models: off-line assessment and on-line traffic prediction and management. The study looked at real-time traffic management in the Philadelphia metro area. Dr. Qian reviewed a pre-planned closure for I-95 highlighting the data management techniques to show how this closure impacted traffic. The program also looked into work zone management and Twitter-based incident detection. **Stephen F. Smith** from **Carnegie Mellon University**, discussed smart traffic infrastructure for urban mobility, explaining the goal for real-time optimization of urban road networks. The advantages of this technology include optimizing signals for actual traffic on the road, coordination for networks (not just arterials), optimizing for multiple modes and scalable incremental deployment. The integration with CAV technology will provide better sensing, use of mode and route information, increased incident detection and real-time re-routing. Other topics discussed included real-time bus information and use of an app to assist pedestrians with disabilities to cross intersections.

Gary Euler and **Steve Lockwood** from the **University of Pittsburgh** presented on the Transportation Systems Management and Operations (TSMO) Capability Maturity Model (CMM), CMM assessments and CAV CMM frameworks. Mr. Euler and Mr. Lockwood explained the dimensions of capability for effective TSMO strategies including business processes, systems and technology and performance measurements. The presentation reviewed the CAV driving force for the new TSMO ecosystem. They discussed how this technology could affect the private sector and the consumer market and the challenges for state DOTs in regards to CAV infrastructure.

Benjamin Seibold from **Temple University** presented on phantom traffic jams and traffic waves explaining the uniform flow becomes inhomogeneous, in the absence of obstacles. He also presented on the traffic flow control through autonomous vehicles and the string stability of adaptive cruise control systems. Models for instabilities also apply to other situations including construction zone traffic, bus bunching, truck platooning, etc. The presentation reviewed the metro-area two-dimensional traffic flow model and the impact of moving through bottlenecks.

NEXT STEPS

Potential PennDOT Research Projects Moving Forward

Day Two of the Research Symposium brought together session moderators, panel members and PennDOT and FHWA attendees to discuss the university presentations on Day One. Moderators led discussions of the highlights from Day One to identify potential new research projects. Overall, 26 potential research project forms were completed for consideration for the 2019-2020 Research Program based on the presentations and discussion that took place as part of the Research Symposium. PennDOT's Program Management Committee will approve the 2019-2020 Research Program in March 2019. The 26 potential research projects, grouped by topic, are summarized below.

Asset Management

1. **Flood Mitigation Solutions** – This research will develop concepts and strategies to identify flood mitigation issues and solutions. These solutions could include ways to identify the underlying issue causing the flooding, identifying District solutions from repeat flooding issues, analyzing existing information (FEMA studies, etc.), and researching mitigation options and other states' best practices.

2. **Cross Asset Management Tools** – This research will develop a concept to perform cross asset management and prioritize projects affecting different assets. The concept and eventual process/system will evaluate intra-project dependency (weighing good and bad), compare values of different asset related projects, allocate cross asset resources, review optimization (performance measures weighting) to lowest life cycle cost and research the approach versus system (software agnostic).

3. **Performance Modeling Validation** – This research will develop and use alternate methods to evaluate and validate PennDOT's bridge and pavement performance models for use in asset management. The project will evaluate the data collection schedules and intervals to determine the sensitivity and impact to performance models.

4. **Advanced Asset Imaging** – This research will develop software to stitch multiple images together to quantify and track long-term movement of retaining walls, slope slides or other slow moving features.

Bridges

1. **Microbial Concrete Sealer** – This research will measure the applicability and effectiveness of microbial sealer in preventing deterioration of deck and parapet concrete. This project will determine what types of products can be obtained, determine if there are any safety issues surrounding their use, perform lab testing to determine if there is any negative effect of properties (including skid resistance) and test in the field.

2. **Bridge Resiliency in Rain Events** – This research will document the increased flow rates, re-evaluate Hydrologic and Hydraulic studies, research backfill materials and research foundation design.

3. **Internal Curing with Fine Light Weight Aggregates (FLWA) Created from Fly Ash** – This research will analyze and test potential alternatives to current FLWA's, using previously unsuitable fly ash. The proposed new material has the potential to contain heavy metals and testing for deterioration and release of these potential hazards must be addressed. The material, if found to be stable after partial deterioration, would then be tested to assess its potential as an alternate to current FLWA's.

4. **Serviceability of Staged Bridges** – FHWA's Serviceability Limits and Economical Steel Bridge Design gives a formula for calculation of bridge vibration flexural strain. However, the report does not supply thresholds to when strain is acceptable. This research would set thresholds when phased construction is warranted.

5. **Remote Sensing with Unmanned Aerial Vehicles (UAV) for Structural Inspections** – This research will investigate remote sensing technologies for use in conjunction with UAV for structural inspections of bridges, high mast light poles, and retaining walls. The research will identify and evaluate the feasibility and benefits of technologies including high definition photography/video, LiDAR, infrared thermography, point clouds, 3D models and maps, and augmented reality. The research will also identify and evaluate interface and integration with PennDOT's Bridge Management System and other Bridge Information Models.

Multimodal

There were no potential research projects obtained from the Research Symposium for the multimodal topic.

Pavement and Materials

1. **Evaluation of Out of Specification Fly Ash for Use in Concrete** – For the past 5 to 10 years there have been sporadic shortages of fly ash for use in concrete. This research will look at the possible use of out of specification fly ash in concrete, and will identify what can be added to concrete to accommodate the out of specification fly ash and what modifications can be made to the fly ash.

2. **Long Life Concrete Repairs** – This research will improve the existing patching material specifications to account for compatibility and quality of patching material. A guide will be developed to help Districts determine what materials to use where and when.

3. **Feasibility of Combining Computer Data to Evaluate Material Performance** – Currently material (aggregates, asphalt and cement) used on PennDOT projects cannot be electronically tracked back to the roadway section or bridge that the materials were placed on. This inability is affecting the ability of PennDOT to evaluate the effectiveness of improvements made to specifications and standards. This research will explore the feasibility of connecting all of PennDOT's separate computer systems (RMS, eCAMMS, CMS, BMS) to be able to retrieve useful data to evaluate roadway and bridge material performance in a rational unbiased way.

4. **Evaluating Options for Maintaining Skid Resistance of Concrete Pavements in Pennsylvania** – This research will continue previous research and establish a basis for specification limits for aggregates and mitigation techniques to maintain acceptable skid resistance levels in concrete pavements.

5. **Evaluating Testing, Protocols, and Limits for Asphalt Rejuvenating Agents in Pennsylvania** – This research will establish the testing, protocols and specification limits needed in order to allow the use of rejuvenators in asphalt paving materials.

Safety

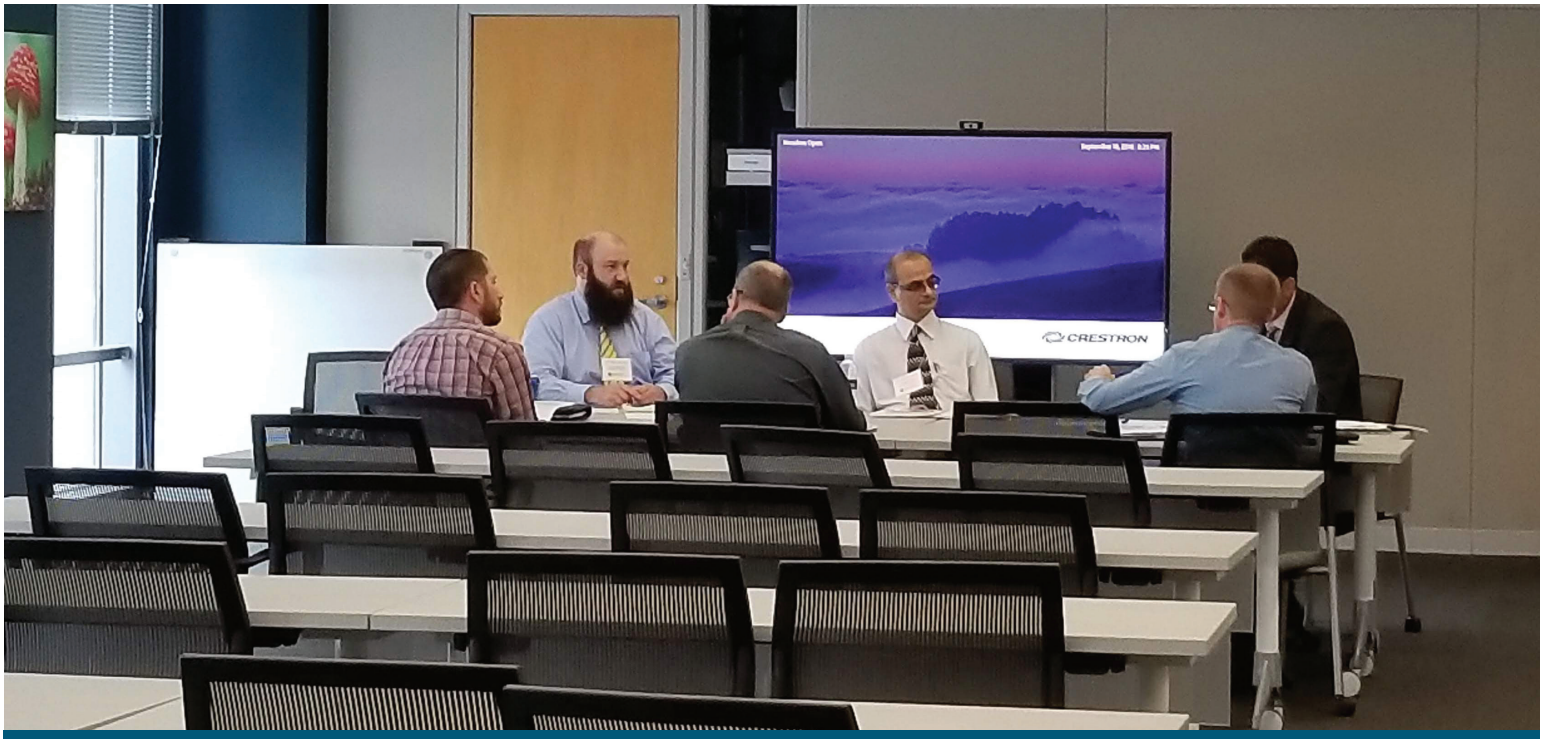
1. **Behavioral Safety** – This research will marry analysis of PennDOT crash data and behavioral sciences to determine appropriate safety countermeasures that truly affect the driver. This will also include the best way to communicate these issues to the public to assist in changing motorist behavior.

2. **Machine Learning Safety Analysis** – This research will investigate the utilization of complex algorithms to access large volumes of data that could lead to safety countermeasures, which PennDOT technical staff may not be aware of through routine investigation.

3. **Self-Enforcing Highway**s – This research will look into design characteristics that can address behavioral safety and driver performance through modifications to actual roadway designs.

4. **SMART Intersections** – This research will investigate the utilization of camera technology to document and analyze what pedestrians, bicyclists and cars are doing in intersections to more appropriately target safety countermeasures.

5. **SMART Work Zone Lighting** – This research will investigate the utilization of algorithm based smart lighting in work zones that improve safety by spot lighting driver hazards and workers in a manner that does not blind drivers during nighttime operations.



Traffic Operations and Connected and Automated Vehicles (CAV)

1. **Traffic Volumes from Probe Speed Data** – The availability of new data sources in recent years has opened up opportunities for improved traffic operations and better Transportation Systems Management and Operations (TSMO) performance metrics. The key piece of data still missing is real-time traffic volumes. Work is underway at the University of Maryland and the National Renewable Energy Laboratory to convert probe speed data into volumes. This research will investigate PennDOT roads and provide valuable information to use in various aspects of the TSMO program.

2. **Criteria for using the TSMO Toolbox** – In the early days of ITS (Intelligent Transportation Systems), PennDOT focused largely on the deployment of cameras, dynamic message signs, highway advisory radios and vehicle detectors. This research will look to advance PennDOT's TSMO program and will provide information and training to the Districts and planning partners to help them understand when to use each of these strategies, where they are most appropriate and how to successfully deploy them.

3. **Best Practices/Potential Solutions for Commercial Vehicle Navigation** – Most well-known navigation applications like Google Maps and Waze are designed for passenger vehicles. When used by commercial vehicles, it may result in trucks traveling through roadways too narrow for their vehicles, striking overhead bridges or using truck restricted roadways. This research will explore the best practices and potential solutions in place around the country to address this issue.

4. **CAV Hotspots** – Past research, such as the Pennsylvania Connected and Automated Vehicle Strategic Plan and NCHRP 20-24(112), identified activities for DOTs to ensure roadway networks are prepared for the deployment of CAV. However, due to the scale and cost of preparing infrastructure, changes will have to occur gradually over time. This research will analyze vehicle registration data, census information, industry trends and other data sets, to identify locations in Pennsylvania likely to see initial market penetration of CAV. PennDOT can use this information to target initial deployments and investments to ensure early benefits.

5. **Mapping of Work Zones for CAV** – As CAV technology progresses, the importance of high definition mapping becomes more apparent. This research will analyze and document the mapping requirements for CAVs to operate in a work zone and identify best practices of mapping methodology, with emphasis on lowering the costs and time necessary to map the roadway while maintaining the safety of personnel conducting the operation. The research will also develop recommendations for updating maps and may determine what degree of roadway change constitutes remapping, identify data housing and dissemination requirements, and document other potential data use cases.

Research Roadmap

BRIDGES
Past/Current/Future Research

Problem Statement(s)

If the number of statewide bridges - including local bridges - rated as poor condition increase, then investments may have to be reprioritized and asset management will not be achieved.

Past Projects (since 2015)

• 50 KSI (Kilopound/Square Inch) Steel H-Pile Capacity	$85,348.72
• Bridge Waterproofing Details - Phase 2	$106,175.00
• Remote Sensing for Bridge Scour Projects - Phase 3	$179,992.00
• Assessment of Current Design Loads for Permit Vehicles	$97,879.00
• Improving Spatial Precipitation Distribution Map - Analysis for Bridge Inspections and Emergency Response	$208,966.00
• Strain-Based Fatigue Crack Monitoring of Steel Bridges Using Wireless Elastometric Skin Sensors	$490,000.00
• Bridge Deck Cracking: Effects on In-Service Performance, Prevention, and Remediation	$317,073.00
SUBTOTAL	$1,485,433.72

Current Projects

• District 1 - PA Flex Beam	$299,957.55
• Environmental and Cost Effectiveness of Partially Grouted Riprap for Scour Countermeasure	$500,000.00
• MU-3 Stream Surveys - Mussels	$591,052.88
SUBTOTAL	$1,391,010.43

Future Projects

• Bridge Deck Joint Elimination	$ TBD
• Corrosion Repair Strategies for Steel Bridges Using High Performance and Traditional Materials	$ TBD
• Data Management, Mining, and Inference for Bridge Monitoring	$ TBD
• To Be Determined based on discussion at the 2018 PennDOT Research Symposium – this is your opportunity to provide ideas and input!	$ TBD
SUBTOTAL	$ TBD

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GRAND TOTAL $2,876,444.15

The Program Management Section in coordination with FHWA plans to develop a Research Roadmap, which will guide PennDOT's research over the next 5 to 10 years. PennDOT will use this roadmap to document past and current research projects, as well as, establish research goals and objectives that will help meet strategic goals. The roadmap will help PennDOT to identify research projects that may serve as incremental steps to meet its overall research goals.

APPENDIX A

2018 Research Symposium Strategic Themes

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2018 Research Symposium Strategic Themes – 8/28/18

Theme	Research Problem Statement	Discussion Question(s)	Subjects to Explore
Pavement and Materials	If PennDOT material specification, policies and test requirements are not expedited over current timelines, then there is an increased potential for poor pavement performance and asset management goals will not be achieved.	What advancements can be made in pavements and materials to extend performance life? How can construction inspections be improved to predict pavement failures better or earlier? What processes can be put in place to better detect or predict pavement material failures, aka, materials associated with pavements? How can the testing of pavement materials be accelerated?	• Improved inspections • Pilot projects for asphalt and concrete

Traffic Operations and Connected and Automated Vehicles	If statewide traffic operational and congestion relief/bottleneck strategies are not implemented, then investments will not be optimized, travel delay and traffic incidents will increase, and travel reliability performance goals will not be achieved.	Transportation Systems Management and Operations (TSMO) is a way to address reliability, mobility, and congestion by using various strategies rather than just trying to build our way out. Our TSMO Mission is the movement of people and goods from point A to point B as efficiently, safely, and reliably as possible. In addition, connected and automated vehicle (CAV) technologies may be a game-changer for how we manage transportation.
		
		How can TSMO solutions and CAV technologies be applied to create a less congested, more reliable road network?
			• Effects of connected and automated vehicles
			• TSMO planning at the state and regional level
			• TSMO Capability Maturity Model
			• TSMO performance metrics
			• Application of TSMO Solutions:
			  ○ Bridge De-icing
			  ○ CCTV
			  ○ Dynamic Curve Warning
			  ○ DMS
			  ○ Dynamic Rerouting
			  ○ Flex Lanes
			  ○ Freeway Service Patrols
			  ○ Integrated Corridor Management
			  ○ Junction Control
			  ○ Managed Lanes
			  ○ Queue Warning
			  ○ Ramp Metering
			  ○ Road Weather Info. Systems
			  ○ Smart Corridor Initiatives
			  ○ TIM Teams
			  ○ Traffic Incident Detection
			  ○ Traffic Management Center
			  ○ Traffic Signal Enhancements
			  ○ Transit Signal Priority
			  ○ Traveler Information
			  ○ Variable Speed Displays

2018 Research Symposium Strategic Themes – 8/28/18

Theme	Research Problem Statement	Discussion Question(s)	Subjects to Explore
Safety	If PA does not implement safety initiatives on all public roads, and use technology and innovation, then Strategic Highway Safety Plan safety goals will not be obtained and the safety of the traveling public will not improve.	If Pennsylvania does not implement safety initiatives on all public roads while using technology and innovation, then the Strategic Highway Safety Plan goals will not be met and we will not achieve the vision of Toward Zero Deaths, which aims to improve the safety of the traveling public. https://www.penndot.gov/TravelInPA/Safety/Documents/PA%20SHSP%202017-02-15%20(All%20signatures).pdf	• Utilization of Data Driven Safety to apply safety countermeasures • Collection and analytical practices for state and local roadway data as it relates to determining expected safety performance • Technologies and processes that would improve work zone safety • Improving safety culture through changed approach to communication with the public • Maximizing the effectiveness of Connected and Automated Vehicles to leverage the greatest safety potential • Mechanisms to plan for and deliver local safety projects • Testing and practices relative to dealing with the Manual for Assessing Safety Hardware
Bridges	If the number of statewide bridges - including local bridges - rated as poor condition increase, then investments may have to be reprioritized and asset management will not be achieved	What new technology for smaller bridge structures are universities researching that could help the Department and municipalities reduce the number of small, structurally deficient bridges? What research could be performed to evaluate the life span of some of the structures that utilize newer technology (i.e. GRS-IBS, UHPC, “bridge in a backpack”, or other new technology) where there are not case logs of long-term in-service use? What research could be performed to address challenges in the areas of constructability and maintainability that are unique to bridges? For example, live load translation during deck pours of phased construction projects and bridge vibration flexural strain limit. Reference Sections 5.2.3 through 5.3.2 of FHWA’s SERVICEABILITY LIMITS AND ECONOMICAL STEEL BRIDGE DESIGN Can threshold criteria/requirements be developed to assist in the design of steel bridges to check for Lateral Torsional Buckling and Global Stability during construction? What type of research project would advance exploration of extending the life of bridge materials? What new deck overlay technologies are being developed/researched/tested? (Of particular importance, UHPC deck overlay materials specification development.) Exploration of nanotechnology in concrete bridge decks to eliminate external curing.	• Bridge data collection • Bridge Management System (BMS) • Bridge prioritization software • Early deterioration detection tools • Improved inspections • Repair Methods • Design Aids • Small bridge technology

2018 Research Symposium Strategic Themes – 8/28/18

Theme	Research Problem Statement	Discussion Question(s)	Subjects to Explore
Asset Management	If PA does not develop guidance and tools to support prioritization of infrastructure projects, then it will be difficult to ensure long-term optimization of the transportation system and there is an increased potential for inefficient utilization of available transportation funding.	What new tools could assist PennDOT in managing its assets more effectively in terms of both system optimization and the efficient utilization of available transportation funding? How can we use existing data to predict and/or prevent failures of pavement materials? Are we collecting the right data? Is there something we should be collecting we are not, or something we are collecting that adds no value?	• Data collection/modeling • Project management • Software development • Allocating assets • Deterioration rates • Pavement Asset Management System • Cross-allocation for Twelve Year Program (TYP) • Tools for “cross-asset allocation” • Project performance re: TAMP • Using Fiber Reinforced Polymer (FRP) products to repair superstructure and substructure • Use of drones for bridge inspections.
Multimodal	If the highway-related user needs of multimodal modes (ports, air, rail and transit) are not properly addressed in the highway planning/programming process or project development process, performance of the movement of people and goods will be hindered or projects will be delayed.	What multi-modal advancements could be researched to improve the performance of the transportation network and insure access for all users? How can information systems be integrated across all modes?	• Performance measures and targets for non-highway modes • Technologies for transit safety • Economic impact of ports, public transportation, and aviation (statewide and local levels) • Impact of intermodal facilities for congestion reduction; including lane management to support port traffic • Wayfinding for multimodal travel options (on road and mobile technologies) • Meeting the multimodal mobility needs of Generation X • Best practices in UAS efficiencies • TNC impact on traffic congestion and public transit systems • Future transportation needs for connecting Mega regions • Best practices from other states for statewide multimodal programs (enabling legislation for funding, etc.) • Solving the labor shortage for public transit industry • Methods to improve public transportation ridership through employer-sponsored incentives • Case studies of successful Inland Ports • State oversight / regulation of shared mobility systems (bike share) – including development of revenue streams • Integrating shared mobility systems and transit

2018 Research Symposium Strategic Themes – 8/28/18

Theme	Research Problem Statement	Discussion Question(s)	Subjects to Explore
			• Use of augmented reality for vehicle safety education
Freight Management and Operations ***(Note: During the Research Symposium Freight Management and Operations will be combined with Traffic Operations and Connected and Automated Vehicles)***	If truck size and weight (TWS) enforcement does not occur, then infrastructure will deteriorate at a higher rate and result in higher risk of catastrophic failure of structures and pavements.	What truck size and weight (Truck Weight System) detection tools and activities can be explored to help protect infrastructure from premature deterioration? What coordination needs to occur between highway and other modes (ports, air, and rail) to insure the efficient movement of people and goods? What data (real-time and historic) should be shared amongst freight transportation model agencies and how can this be used to optimize freight movement and improve safety?	• Over-the-Road Trucking • Collaboration and technology for enforcement and detection (TWS, WIMs, VWIMs, other) • Rail • Ports • Innovative procurement, i.e. P3 for ports • Weight restrictions • Roadway Bonding • STAA/102” truck access (Act 31 of 2018) • Truck navigation issues (GPS)
Within each of the thematic groups identified above, the discussion at the symposium should also include: technology (automation), maintenance, quality, workforce development, new opportunities and research endeavors from the universities.			

APPENDIX B

2018 Research Symposium Attendees

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Appendix B

Research Symposium Attendees

PUBLIC SECTOR		
Anastasiadis	Emmanuel	PennDOT Engineering District 6-0
Arellano	Janice	PennDOT Bureau of Maintenance and Operations
Baer	Patricia	PennDOT Bureau of Project Delivery
Bindie	Michael	PennDOT Bureau of Planning and Research
Bonini	Elizabeth	PennDOT Multimodal Deputate
Bridenbaugh	Garth	PennDOT Bureau of Project Delivery
Bruner	Justin	PennDOT Bureau of Maintenance and Operations
Carre	Tim	PennDOT Bureau of Project Delivery
Cippel	Frank	PennDOT Engineering District 11-0
Cole	Halley	PennDOT Bureau of Maintenance and Operations
Cramer	Marcus	PennDOT Engineering District 1-0
Deen	Richard	PennDOT Engineering District 8-0
DeStefano	Ralph	PennDOT Engineering District 9-0
Fannin	Neal	PennDOT Bureau of Project Delivery
Farley	Daniel	PennDOT Bureau of Maintenance and Operations
Fenton	Sarah	PennDOT Engineering District 4-0
Ferretti	Louis	PennDOT Bureau of Planning and Research
Glass	Tom	PennDOT Bureau of Maintenance and Operations
Gothie	Roy	PennDOT Multimodal Deputate
Gray	Gavin	PennDOT Bureau of Maintenance and Operations
Heath	Karen	PennDOT Planning Deputate
Heineman	Richard	PennDOT Bureau of Maintenance and Operations
Heltebridle	Laine	PennDOT Bureau of Planning and Research
Hershock	Jason	PennDOT Bureau of Maintenance and Operations
Houpt	William	PennDOT Engineering District 3-0
Hughes	Jeremy	PennDOT Engineering District 12-0
Koller	William	PennDOT Engineering District 1-0
Kopko	Mark	PennDOT Bureau of Maintenance and Operations
Koser	Steven	PennDOT Bureau of Maintenance and Operations
Langer	Kristin	PennDOT Bureau of Project Delivery
Li	Guozhou	PennDOT Bureau of Project Delivery
Long	Jim	PennDOT Bureau of Maintenance and Operations

Long	Mike	PennDOT Bureau of Maintenance and Operations
Macioce	Tom	PennDOT Bureau of Project Delivery
Marshall	Adam	PennDOT Engineering District 10-0
Mausteller	Tracy	PennDOT Engineering District 3-0
McAuley, Jr.	George W.	PennDOT Highway Administration Deputate
McCloskey	Anthony	PennDOT Bureau of Aviation
Medina	Alberto	PennDOT Bureau of Project Delivery
Mulkerin	Kristin	PennDOT Center for Program Development and Management
Ndimbie	Ngani	PennDOT Policy Office
Panko	Steve	PennDOT Multimodal Deputate
Patel	Ashwin	PennDOT Engineering District 6-0
Peddicord	Lydia	PennDOT Bureau of Project Delivery
Pento	Bob	PennDOT Bureau of Maintenance and Operations
Prestash	Dennis	PennDOT Engineering District 2-0
Ramirez	Timothy	PennDOT Bureau of Project Delivery
Reilly	Christine	PennDOT Highway Administration Deputate
Rimer	Michael	PennDOT Center for Program Development and Management
Ritzman	James	PennDOT Planning Deputate
Robinson	Joseph	PennDOT Bureau of Project Delivery
Roman	Elizabeth	PennDOT Bureau of Project Delivery
Ruzzi	Louis	PennDOT Bureau of Project Delivery
Schreckengost	Ron	PennDOT Engineering District 10-0
Scott	Shelley	PennDOT Bureau of Planning and Research
Sharp	Robert	PennDOT Bureau of Public Transportation
Shifflet	Larry	PennDOT Center for Program Development and Management
Sneed	Susan	PennDOT Human Resources
Soisson	Denise	PennDOT Multimodal Deputate
Sorbo	Michael	PennDOT Bureau of Rail Freight
Sorce	Heather	PennDOT Bureau of Planning and Research
St. Clair	Daryl	PennDOT Highway Administration Deputate
Storm	Barbara Jean	PennDOT Bureau of Planning and Research
Swisher	Teresa	PennDOT Bureau of Planning and Research
Szczur	Joseph	PennDOT Engineering District 12-0
Tarson	Lisa	PennDOT Bureau of Planning and Research
Tomlinson	Doug	PennDOT Bureau of Maintenance and Operations

Walker	Anja	PennDOT Bureau of Innovations
Walter	J. Brian	PennDOT Highway Administration Deputate
Wasilchak	Robert	PennDOT Engineering District 4-0
Watson	Angela	PennDOT Multimodal Deputate
Zimmerman	Douglas	PennDOT Bureau of Planning and Research
Albert	Jen	Federal Highway Administration
Bobitz	Phillip	Federal Highway Administration
Buck	Jon	Federal Highway Administration
Lujan	Ezequiel	Federal Highway Administration
Mento	Tony	Federal Highway Administration
Sugnet	Katherine	Federal Highway Administration
Vandervoort	Karyn	Federal Highway Administration
Parker	John	Pennsylvania Turnpike Commission
Schultz	Michael	Pennsylvania Turnpike Commission
King	Chris	Delaware Valley Regional Planning Commission
Spano	Joshua	Southwestern Pennsylvania Planning Commission
Cameron	Kelsey	McCormick Taylor (event staff)
Goddard	Michelle	McCormick Taylor (event staff)
ACADEMIA		
Akinci	Burcu	Carnegie Mellon University
Branstetter	Lee G.	Carnegie Mellon University
Caldwell	Stan	Carnegie Mellon University
Matthews	Scott	Carnegie Mellon University
Mertz	Christoph	Carnegie Mellon University
Pi	Xidong	Carnegie Mellon University
Qian	Sean	Carnegie Mellon University
Quick	Stephen	Carnegie Mellon University
Smith	Stephen	Carnegie Mellon University
Tamburo	Robert	Carnegie Mellon University
Whitmore	Allanté V.	Carnegie Mellon University
Zhao	Ding	Carnegie Mellon University
Bartoli	Ivan	Drexel University
Drzymalski	Julie	Drexel University
Farnam	Yaghoob	Drexel University
Lu	Fei	Drexel University

Zhang	Hua	Drexel University
Quiel	Spencer	Lehigh University
Donnell	Eric	Pennsylvania State University
Fox	Patrick	Pennsylvania State University
Gayah	Vikash V.	Pennsylvania State University
Guler	Ilgin	Pennsylvania State University
Huang	Hai	Pennsylvania State University
Liang	Xiao	Pennsylvania State University
Papakonstantinou	Kostas	Pennsylvania State University
Piasente	Jon	Pennsylvania State University
Rajabipour	Farshad	Pennsylvania State University
Solaimanian	Mansour	Pennsylvania State University
Warn	Gordon	Pennsylvania State University
Abboud	Bechara	Temple University
Bonessio	Noemi	Temple University
Coe	Joseph	Temple University
Faheem	Ahmed	Temple University
Hosseini	Arash	Temple University
Mahvelati	Siavash	Temple University
McKenzie	Erica	Temple University
Picone	Joseph	Temple University
Seibold	Benjamin	Temple University
Toran	Laura	Temple University
Euler	Gary	University of Pittsburgh
Johnson	Keith	University of Pittsburgh
Khazanovich	Lev	University of Pittsburgh
Labrinidis	Alex	University of Pittsburgh
Lockwood	Steve	University of Pittsburgh
Sachs	Steve	University of Pittsburgh
Stephens	Max	University of Pittsburgh
Vandenbossche	Julie	University of Pittsburgh

APPENDIX C

2018 Research Symposium Agenda

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2018 Research Symposium Preliminary Agenda – DAY 1

September 27, 2018

1. **Registration** — **Keystone Building** — **7:30 AM – 8:30 AM**
2. **Research and Innovation Fair** — **Keystone Building** — **8:00 AM – 4:15 PM**
3. **Welcome –** — **PA State Museum** — **8:30 AM – 8:35 AM**
   Doug Zimmerman, PennDOT
4. **Morning Address –** — **PA State Museum** — **8:35 AM – 9:15 AM**
   Karyn Vandervoort, FHWA; Dep. Sec. Ritzman, PennDOT; Dep. Sec. McAuley, PennDOT
5. **Concurrent AM Breakout Sessions** — **Keystone Building** — **9:30 AM – 11:55 AM**

	9:30-10:10	10:25 – 11:05	11:15 -11:55	Location
Asset Management	Drexel	*Open*	Carnegie Mellon	Forest Room
Bridges	Pitt	Penn State	Lehigh	Hearing Room 2
Multimodal	*Open*	*Open*	*Open*	Meadow Room
Pavement & Materials	Carnegie Mellon	Temple	Drexel	Hearing Room 3
Safety	Penn State	Carnegie Mellon	Temple	Desert Room
Traffic Operations & Connected & Automated Vehicles	Temple	*Open*	Penn State	Hearing Room 1

6. **AM Scheduled Break** — **Keystone Building** — **10:10 AM – 10:25 AM**
7. **Networking Lunch** — **Keystone Building** — **12:10 PM – 1:10 PM**
8. **Concurrent PM Breakout Sessions** — **Keystone Building** — **1:15 PM – 3:40 PM**

	1:15 – 1:55	2:05 – 2:45	3:00 – 3:40	Location
Asset Management	Temple	*Open*	Penn State	Forest Room
Bridges	Carnegie Mellon	Temple	Drexel	Hearing Room 2
Multimodal	Pitt	Penn State	Carnegie Mellon	Desert Room
Pavement & Materials	Penn State	Pitt	*Open*	Hearing Room 3
Safety	*Open*	*Open*	*Open*	Meadow Room
Traffic Operations & Connected & Automated Vehicles	Drexel	Carnegie Mellon	Pitt	Hearing Room 1

9. **PM Scheduled Break** — **Keystone Building** — **2:45 PM – 3:00 PM**
10. **Research and Innovation Fair Closes** — **Keystone Building** — **4:00 PM**

2018 Research Symposium Preliminary Agenda – DAY 2

September 28, 2018

(PennDOT, FHWA Only)

1.	**Welcome – Doug Zimmerman**	**Hearing Room 1**	**8:30 AM – 9:00 AM**
2.	**Concurrent Breakout Sessions**		**9:00 AM – 11:00 AM**
	a. Asset Management/Bridges/Pavement & Materials – Hearing Room 1		
	b. Traffic Operations & Connected & Automated Vehicles/Safety/Multimodal – Hearing Room 2		
3.	**Break**		**10:00 – 10:15 AM**
4.	**Large Group Report Out**	**Hearing Room 1**	**11:00 – 11:50 AM**
5.	**Symposium Closing Remarks**	**Hearing Room 1**	**11:50 AM – 12:00 PM**

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