



UNIVERSITY OF
MARYLAND

National Transportation Center



**Program Progress Performance Report for
University Transportation Centers**



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TABLE OF CONTENTS

- 1. Program Information..... ii
- 2. Accomplishments..... 1
 - 2.A. What are the major goals of the program?..... 1
 - 2.B. What was accomplished under these Goals?..... 1
 - 2.C. How have the results been disseminated?..... 5
 - 2.D. What do you plan to do during the next reporting period to accomplish the goals?..... 6
- 3. Products 7
 - 3.A. Journal Publications..... 7
 - 3.B. Books or other non-periodical, one-time publications 8
 - 3.C. Other publications, conference papers and presentations 8
 - 3.D. Website(s) or other Internet site(s) 9
 - 3.E. Technologies or techniques 9
 - 3.F. Outreach activities 10
 - 3.G. Courses and workshops 10
 - 3.H. Inventions, patent applications, and/or licenses..... 10
 - 3.I. Seminars and other events 10
 - 3.J. Other Products..... 11
- 4. Participants and Other Collaborating Organizations..... 11
 - 4.A. What organizations have been involved as partners? 11
- 5. Impact 12
 - 5.A. What is the impact on the development of the principal discipline(s) of the program?..... 12
 - 5.B. What is the impact on other disciplines?..... 14
 - 5.B. What is the impact on other disciplines?..... 14
 - 5.C. What is the impact on the development of transportation workforce development? 14
 - 5.D. What is the impact on physical, institutional and information resources at the university or other partner institutions?..... 15
 - 5.E. What is the impact on technology transfer? 15
 - 5.F. What is the impact on society beyond science and technology? 16
 - 5.G. Additional impacts..... 17
- 6. Changes/Problems..... 17
 - 6.A. Changes in approach and reasons for change 17
 - 6.B. Actual or anticipated problems or delays and actions or plans to resolve them..... 17
 - 6.C. Other changes..... 17
- 7. Special Reporting Requirements..... 17



1. PROGRAM INFORMATION

Program Progress Performance Report for National Transportation Centers

U.S Department of Transportation

Office of the Assistant Secretary for Research and Technology (OST-R)

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Program

National Center for Strategic Transportation Policies, Investments and Decisions

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2. ACCOMPLISHMENTS

2.A. WHAT ARE THE MAJOR GOALS OF THE PROGRAM?

The National Center for Strategic Transportation Policies, Investments and Decisions at the University of Maryland, a national University Transportation Center, was founded in 2013 focusing on the U.S. Department of Transportation (DOT) strategic goal of “Economic Competitiveness”. The center focuses on research, education, and technology transfer activities that can lead to: (1) Freight efficiency for domestic shipping and for our international land, air, and sea ports; (2) Highway congestion mitigation with multi-modal strategies; and (3) Smart investments in intercity passenger travel facilities such as high speed rail. Major center activities are as following:

- **Advanced & Applied Research Promoting Economic Competitiveness**
Our research activities are multimodal/intermodal and multidisciplinary in scope, with the aims of addressing nationally and regionally significant transportation issues pertinent to economic competitiveness and providing practice-ready solutions.
- **Education, Workforce Development, Technology Transfer, & Diversity**
The consortium is committed to providing high-quality transportation education and workforce development programs for a broad and diverse audience. Center’s efforts will support the development of a critical transportation knowledge base and a transportation workforce that is prepared to design, deploy, operate, and maintain the complex transportation systems of the future.

2.B. WHAT WAS ACCOMPLISHED UNDER THESE GOALS?

In total, 49 research projects were posted to Transportation Research Board (TRB) Research in Progress (RiP) database and 10 education/technology transfer projects were posted to the NTC@Maryland website as requested by OST-R. All funded projects in the Round 1 (2013-2014) will be completed within one year with Quarterly Progress Reports submitted every three months and Final Reports submitted by their end dates. All funded projects in the Round 2 (2014-2015) projects began on January 1, 2015 or will begin on June 1, 2015. Project progress forms and project brief information pages can be found at <http://ntc.umd.edu/research/projects> and <http://ntc.umd.edu/education/education-t2>. More details of those projects can be found from the TRB RiP site at <https://rip.trb.org/> (Please enter the contract ID “DTRT13-G-UTC30” as the Keyword, then click Submit).

2.B.i. Research on Topics Relevant to Economic Competitiveness

Domestic/U.S.-Related Freight Efficiency and Reliability

- **Combining Different Data Sources to Predict Origin-Destinations and Flow Patterns for Trucks in Large Networks** [\[PDF\]](#)
A model was developed to adaptively change the search space while matching vehicles based on axle spacing attributes. The model was then tested on the manually matched vehicle pairs. It was found that incorporating external travel time information (e.g., INRIX) improved the accuracy of the re-identification algorithm significantly.
- **Efficiency and Reliability in Freight Transportation Systems (UMD and NCSU)** [\[PDF1\]](#), [\[PDF2\]](#)
Several methods were formulated for analyzing and optimizing various aspects of freight logistics, including design of networks and schedules, optimization of slack times within schedules and real-time dispatching decisions applicable when some connecting vehicles were late in arriving at the transfer terminals. A particular method for improving the reliability of intermodal and intramodal transfers of freight among vehicles at hub terminals was developed.
- **Ex-Post Value for Money Analysis of Public Private Partnerships (P3) in freight transportation infrastructure** [\[PDF\]](#)
Tasks associated with this project included: (1) data collection of mega transportation projects for the past 15 years; (2) preliminary analysis of cost and time performance between P3 and conventional projects; (3) data collection on the Presidio Parkway projects; and (4) preliminary analysis of ex-post



VfM on the Presidio Parkway project. The research team is developing the analytical framework from case studies.

- **Identification of Potentially Hazardous Roadway Network Locations Using Microscopic Observational Vehicle Data and Macroscopically Modeled Reaction Time** [\[PDF\]](#)
NTC@Maryland researchers conducted to (1) select study locations in North Carolina and Louisiana (criteria for site selection included maximizing the availability of continuously collected infrastructure based data such as the fixed location road side sensors along Raleigh-area freeway); and (2) assemble crash rate data for study locations.
- **Multi-layered Integrated Urban Freight Delivery Network – Phase I: Identification of Policy Preferences based on Qualitative and Conjoint Analyses** [\[PDF\]](#)
NTC@Maryland researchers conducted an extensive review of case studies on alternative freight demand management strategies planned or implemented in European countries. In-depth interviews were made with a Baltimore County planner who was involved in a vision plan for redeveloping Sparrows Point, a former still mill site, into a complex of freight logistics facilities.
- **Quantification of System-wide Life Cycle Benefits of Recycled Materials in Highways** [\[PDF\]](#)
Based upon the literature search and the discussion with the member DOTs, NTC@Maryland researchers (1) started developing data sheets on each material covering the nature and engineering properties of the material and their environmental suitability; (2) started communicating with agencies for collection of data on unit greenhouse gas emission reductions, energy, and water consumption reductions provided by use of each recycled material; and (3) searched for the most appropriate cost database for each material.

Congestion Mitigation with Multi-Modal Strategies

- **Advanced Volatility Models for Improving Travel Time Prediction** [\[PDF\]](#)
NTC@Maryland researchers aimed to identify and model uncertainties associated with travel time prediction and developed models for short term forecasting of the traffic state. The prediction interval represented likeliness of capturing true value of the future travel time.
- **Behavioral Study for Managed Lane Pricing with Refund Option** [\[PDF\]](#)
During this reporting period, researchers (1) performed full-scale survey deployment, and a total of 2274 responses were received; (2) performed descriptive analysis and identified potential behavioral models; (3) scheduled to deliver final report by the end of March 2015. The results showed that a refund option could be a strategy to make HOT lanes more appealing to the general public, although further analysis was needed to evaluate the significance of the impact.
- **Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications** [\[PDF\]](#)
This project produced an innovative system for protection of intersection dilemma zone. The proposed system, after extensive simulation experiments, was adopted by Maryland State Highway administration (MSHA) and in the process of deploying at two high-speed intersections. Through the promising results produced from this study, NTC@Maryland researchers had convinced SHA engineers of the potential of integrating traditional engineering work with advanced technologies to significantly improve traffic safety.
- **Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator** [\[PDF\]](#)
NTC@Maryland researchers developed a driving simulator-based test bed for connected vehicles research in the areas of operation and safety. The SimCreator proprietary software was used to (1) manipulate the properties of the ambient traffic; (2) create a new vehicle type to represent connected vehicles; and (3) identify the traffic parameters that can be transmitted from the connected vehicles.
- **Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications** [\[PDF\]](#)
The project started in February 2015. NTC@Maryland researchers started literature review on traffic monitoring with vehicle-to-vehicle communications. A PhD student was involved in this project.
- **Evaluating and Calibrating Emission Impacts of Traffic Management Strategies through Simplified Emission Estimation Model and Mesoscopic Dynamic Traffic Simulators** [\[PDF\]](#)
NTC@Maryland researchers used a multi-scale agent-based dynamic traffic assignment methodology (DTALite + MoveLite) to simulate time-varying traffic flow patterns within a Triangle Regional Model (TRM), NC network and accurately estimate the individual and total system cost in the transportation



network. Numerical results showed the dramatically faster computation speed than the standard MOVE-based approach. A preliminary version of the training material and user guides “Reduce Emissions and Energy Optimization” is developed at www.learning-transportation.org.

- **HOV Lane Performance Monitoring System [PDF]**
NTC@Maryland researchers made more efficient use of existing system through HOV lanes, and focused on developing an evaluation framework that combined traffic data from several sources to estimate key HOV indicators. Motivated by advancements in travel time measurement technologies, a pattern recognition algorithm for separating travel time on HOV and regular lanes collected by Bluetooth sensors was developed.
- **Minimizing Driver Errors: Detecting Unexpected Targets In Familiar Environments [PDF]**
NTC@Maryland researchers were programming the driving simulator so that data collection could be started within the next couple months. In addition, NTC@Maryland researchers continued to read the literature and developed the study design based on new research.
- **Open Toll Lanes in a Connected Vehicle Environment: Development of New Pricing Strategies for a Highly Dynamic and Distributed System [PDF]**
NTC@Maryland researchers focused on the mitigation of highway congestion through the use of multi-location auction tolling in a future environment where drivers were able to use vehicle-to-infrastructure (V2I) communication to exchange information with the toll operator. The main components of the tolling system were defined in this reporting period. The project was then split into two strands: (1) the development of analytical solutions; and (2) the development of a simulation tool to explore this potential future transportation scenario.
- **Quantifying the Effects of Manual Traffic Control on Evacuation Corridors [PDF]**
NTC@Maryland researchers completed (1) the decision choice model; (2) analysis of decision choice model results; (3) development of the manual traffic control model algorithm. The results suggested that a properly trained and experienced police officer in Baton Rouge, LA would be just as effective directing traffic in Miami Gardens FL, and vice-versa.
- **Understanding Regional Disparities in Public Transit Performance Using Realtime Transit Data [PDF]**
NTC@Maryland researchers were in the process of crafting a job posting to find a graduate research assistant at the Morgan State University.
- **Validation of Travel Time Reliability Prediction from Probe Data [PDF]**
Experimental design and data collection plans were completed. Data analysis work included (1) the Bluetooth MAC address data continually being processed and analyzed; (2) Bluetooth capture rates analyzed and compared to HERE sensor counts to verify unbiased sampling; (3) INRIX data processed to generate synthetic trajectories to allow comparison with Bluetooth travel times.
- **Vehicle Trajectory Tool (VTT): Application Pilot for AMS Test Bed [PDF]**
Major Activities that were done mainly focused on tasks 3 and 4 of the project: conduct and analyze off-line database experiments and develop and test VIV capability. Significant results included (1) off-line tests through collected high resolution vehicle trajectories by controlled field experiments; (2) developed VIV events and its threshold for giving information to driver on real time; (3) tested and evaluated predesigned VIV events' list with its thresholds.

Smart and Strategic Investments in High Speed Rail

- **Analysis of Funding Streams for Public Private Partnerships in the U.S. Transportation Sector [PDF]**
The benchmarking study was with two distinct objectives: (1) provide a comprehensive quantitative performance assessment of the cost and schedule performance for PPP transportation projects in the U.S.; (2) conduct a comprehensive analysis of funding streams to quantify the funding sources used to deliver PPP transportation projects in the U.S.
- **Long-distance Transportation Infrastructure in a Climate-constrained Future [PDF]**
NTC@Maryland researchers developed a framework for linking perturbations to electricity generation capacity to electric rail modes, in particular, high-speed rail in California. Through this work researchers were able to show how climatological and hydrological changes could impact electricity supply ultimately creating interruptions in energy supply to high-speed rail in the California corridor.



- **Quantifying and Benchmarking the Delivery Performance of U.S. Public-Private-Partnership (PPP) Transportation Projects** [\[PDF\]](#)
NTC@Maryland researchers collected and verified data through (1) professional databases; (2) publicly available sources; and (3) structured interviews with key projects constituents. The preliminary results were summarized in a technical paper submitted to the TRB. The paper presented results stemming from 25 completed PPP transportation projects. The results highlighted superior performance of PPP when compared to traditional design-bid-build delivery.
- **Revenue Management and Operations Optimization for High Speed Rail** [\[PDF\]](#)
NTC@Maryland researchers (1) studied revenue management (RM) methods and optimal operation techniques for application to the railways industry; (2) found the optimal number of passengers travelling along each leg in order to maximize the overall revenue, (3) proposed a multidisciplinary approach that used concepts and methods derived from engineering, economics, operation research, and statistics to study the economic competitiveness of the railway industry in the US.; (4) implemented in a computer program written in R the dynamic discrete choice modeling framework (5) run multiple tests on simulated data and estimated a revenue management model on real data; (6) performed intensive validation tests. Results from both simulated and real data attested that the estimation of the dynamic discrete choice model for railway RM was feasible and that results obtained were superior to static estimation.
- **U.S. National and Inter-Regional Travel Demand Analysis: Person-Level Microsimulation Model and Application to High-Speed Rail Demand Forecasting** [\[PDF\]](#)
A prototype microsimulation-based national and inter-regional passenger travel demand model for High Speed Rail demand forecasting and other national-level travel analysis was developed based on a rigorous behavioral framework in long distance travel planning, and took into account the specific attributes of the long distance travel such as low frequency, long activity duration, different sets of mode alternatives, etc. Based on the simulation results (the first two tiers of the model system), the national-level passenger OD table by travel mode and time of year is obtained.

2.B.ii. Education and Outreach

- NTC@Maryland Director, Dr. Lei Zhang, was nominated by U.S. Department of State for the 2014 APEC Science Prize for Innovation, Research and Education (ASPIRE Prize), in recognition of his commitment to excellence in scientific research in Intelligent Transportation and Sustainable Development.
- UMD graduate students: (1) Mr. Michael Maness was selected as NTC@Maryland Student of the Year; (2) Mr. Yanshuo Sun was selected as the 2015 recipient of the Electric Energy Utilization Scholarship by American Railway Engineering and Maintenance-of-Way Association (AREMA).
- **High Speed Rail Short Course** [\[PDF\]](#)
Materials for the short course were in preparation. Drafts of many of the modules have been created.
- **Master of Science in Transportation Degree Program Development** [\[PDF\]](#)
The Louisiana Board of Regents approved a new executive format Master of Science in Transportation (MST) degree at the University of New Orleans, making it the first degree of its kind in the state. The program, which will launch in the fall semester of 2015, will also be one of the first in the United States that will train students in multimodal freight and passenger transportation system.
- **NTC@Maryland Undergraduate Summer Research Program** [\[PDF\]](#)
NTC@Maryland will sponsor up to six undergraduates to work directly with UMD Transportation Engineering faculty on cutting-edge topics during the summer of 2015.
- **On-line Master of Engineering Program in Transportation Systems Engineering and Planning** [\[PDF\]](#)
The online versions of six of the courses we are currently offering on site and will be developed and we will work with the Office of Extended Studies to put the online program on the books and market it. The Program will launch in fall 2015.

2.B.iii. Technology Transfer

- NTC@Maryland) and the Center for Advanced Transportation Technology (CATT) held a symposium on January 15, 2015 to discuss emerging probe data products and applications of private sector data in planning, operations, and performance management.



- Recording of the event webcast is available for viewing at the following link: <http://vid.umd.edu/detsmediasite/Play/1a6294d88a824163b84ecd82a1c408551d>
- The Proceedings of the Symposium can be downloaded at http://www.ntc.umd.edu/sites/default/files/documents/Publications/Proceedings_1st_Probe_Data_Symposium.pdf.
- On November 6, 2014, NTC@Maryland hosted the Maryland-National Capital Park and Planning Commission (MNCPPC) from Montgomery County to transfer knowledge from past and ongoing transportation planning and modeling research at UMD.
- The UMD A. James Clark School of Engineering hosted its second annual Mpack Week, a five-day event showcasing research, education, and innovation, October 16-22, 2014, on its College Park campus. This year's Mpack Week events were focused on the theme of Disaster Resilience and the role engineers play in developing innovative solutions to help prevent, mitigate, and respond to disasters.
- New Orleans with a focus on educating and engaging community stakeholders on maritime jobs opportunities, the Board of Commissioners of the Port of New Orleans and the University of New Orleans hosted the 1st Annual Port of New Orleans Maritime Workforce Summit on October 8, 2014. Below is the link to the Highlight Video of the Port of New Orleans Maritime Workforce Summit <http://youtu.be/FWlnkY8xv1s>.
- **Autos, People and Policies (APPs): Addressing the Issues of the New Millennium [PDF]**
The research team lead by Dr. Cinzia Cirillo organized a workshop on policies and methods related to vehicle ownership and use.
- **Enhancing the Impact of the Freight Academy via Academic Collaboration [PDF]**
The NTC@Maryland collaborated with the Freight Academy by offering academic resources in curriculum development and student scholarships.
- **International Workshop on High-speed Rail Planning and Operations [PDF]**
The conference will of interest to audiences from academia, agencies (e.g. US DOT, state DOTs and highway administrations and large MPOs) and rail industrial partners, and to the transportation planning and modeling audiences in general. The conference will be held at the Arizona State University Campus, located in the Phoenix metropolitan area on October 25-27, 2015.
- **Moving Transportation Research to Practice: NTC@Maryland Webinar Series [PDF]**
NTC@Maryland researchers developed webinar agendas and overarching themes, and identified research presentations and content experts. The first webinar in the series would introduce NTC@Maryland research mission and leadership to the practitioner community, and address the overarching theme of moving research to practice.
- **Workshop on Public Private Partnerships [PDF]**
To ensure the protection of public interest and successful implementation of P3 projects, there is an urgent need to build capacity in the public agencies. The workshop serves this need by supporting knowledge exchange, stimulating collaboration, promote best practices, and explore research potential.

2.C. HOW HAVE THE RESULTS BEEN DISSEMINATED?

- NTC@Maryland released the Annual Report for Year 2014. The report can be downloaded at <http://www.ntc.umd.edu/sites/default/files/documents/Publications/2014%20Annual%20Report%20of%20National%20Transportation%20Center%20at%20Maryland.pdf>.
- NTC@Maryland plans to distribute its first quarterly electronic newsletter in June 2015. In addition to the newsletter, news items have been regularly posted on the website at http://ntc.umd.edu/news/news_archives.php.
- The *Efficiency and Reliability in Freight Transportation Systems* was discussed in two classes and in meetings with graduate students.
- The research team of the *Behavioral Study for Managed Lane Pricing with Refund Option* was in the process of contacting Maricopa Association of Governments to share the research results.
- The results of the *Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications* were disseminated through the following paths: (1) making technical presentations at annual TRB conference; (2) teaching the key system design concepts at MSHA internal workshop; and (3) transferring the knowledge to local consultants and assist them in deploying the proposed system at local hazardous intersections.



- Findings of the *HOV Lane Performance Monitoring System* were incorporated into 2014 Maryland SHA Annual Mobility Report.
- Findings of the *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* will be presented at the Human Factors and Ergonomic Society annual meeting as well as Transportation Research Boarding meeting in 2016.
- The results of *Analysis of Funding Streams for Public Private Partnerships in the U.S. Transportation Sector* were from 25 completed PPP transportation projects completed between year 1995 and 2013. Finally, the PI included the new knowledge in his graduate course on Alternative Project Delivery Methods.
- A series of technical reports of the *Long-distance Transportation Infrastructure in a Climate-constrained Future* were posted to the ASU digital repository. Results were presented at local and national workshops and conferences.
- The preliminary results of *Quantifying and Benchmarking the Delivery Performance of U.S. Public-Private-Partnership (PPP) Transportation Projects* were summarized in a technical paper presented at TRB and published by the Transportation Research Record.
- NTC@Maryland researchers organized a summer school at the University of Montreal on Dynamic Discrete Choice models.

2.D. WHAT DO YOU PLAN TO DO DURING THE NEXT REPORTING PERIOD TO ACCOMPLISH THE GOALS?

By the end of the next reporting period, all final research reports from the projects awarded in the first round are expected. The final reports can be found at the center publication page at <http://www.ntc.umd.edu/publications>.

2.D.i. Research on Topics Relevant to Economic Competitiveness

Domestic/U.S.-Related Freight Efficiency and Reliability

- Several objectives for the next period of *Efficiency and Reliability in Freight Transportation Systems* will be addressed in the next reporting period namely (1) to consider possible interrelations and correlations among vehicles arriving at or departing from transfer terminals, and (2) analyze how some system characteristics such as connectivity and slack times affect the propagation of delays in freight transportation networks, and how such delay propagation can be mitigated.
- A final analysis of P3 performance will be conducted for the *Ex-Post Value for Money Analysis of Public Private Partnerships in Freight Transportation Infrastructure*. The result will be documented for publication and dissemination to broad audience. An analytical framework of ex-Post P3 evaluation will be developed with case studies.
- For the *Identification of Potentially Hazardous Roadway Network Locations Using Microscopic Observational Vehicle Data and Macroscopically Modeled Reaction Time*, all previously collected probe-based data (high resolution GPS and i2D) will be assembled in a well-designed data base. New data collected along the routes in the selected study locations will be added as it comes available.
- NTC@Maryland researchers will reach out to Asian grocery distributors that have national networks and transfer imported products from Asia (especially from Korea and China) and obtain their data.
- *Benefits of Recycled Materials in Highways* will (1) study how each member state maintains system-wide material quantity databases; (2) determine quantities for what materials are available; (3) identify the challenges in this process and make recommendations to users on how to retrieve accurate information; (4) develop a computer-based tool that will make the necessary calculations once the system-wide material quantities are known for life cycle assessment .

Congestion Mitigation with Multi-Modal Strategies

- The *Behavioral Study for Managed Lane Pricing with Refund Option* will conclude by the end of March 2015.
- NTC@Maryland researchers will (1) work with field design contractors to complete the two proposed dilemma zone protection systems; (2) design an effective short-term and a long-term performance functions to monitoring the effectiveness of the deployed system over time; and (3) identify the potential



of extending the safety protection system to mobility advancement with information from connected vehicles.

- For the *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator*, NTC@Maryland researchers plan to (1) use the SimCreator proprietary software to manipulate the properties of the ambient traffic, create a new vehicle type to represent connected vehicles, and identify the traffic parameters that can be transmitted from the connected vehicles (2) explore the means to gather data from the connected vehicles in the ambient traffic, and synthesize information to be relayed to the driver of the driving simulator; (3) submit the final report by the end of June 2015.
- The overarching goal of the *Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications* is congestion mitigation during extreme events. NTC@Maryland researchers plan to (1) continually support and involve both graduate and undergraduate students in this project, supporting the education and workforce development goals; (2) write one refereed journal paper on the proposed study; (3) seek external support for the follow-up studies from National Science Foundation and Federal Highway Administration Exploratory Advanced Research programs. Additional research plans on congestion mitigation can be found at ntc.umd.edu.

Smart and Strategic Investments in High Speed Rail

- The research of *Revenue Management and Operations Optimization for High Speed Rail* was terminated and a final report was submitted. NTC@Maryland researchers plan to (1) write a journal publication on the results obtained; (2) present methods and results at the summer school to be held in Montreal in June 2015; (3) disseminate our results and get industrial partners involved in this effort to optimize revenue and ridership from the railway sector.
- Efforts will focus on developing a quantitative assessment of how reduced power availability and increased maintenance frequency due to extreme heat and precipitation might reduce reliability of future rail service. The quantitative assessment will include a model of rail operations, electricity consumption, and infrastructure reliance.
- NTC@Maryland researchers plan on refining the research by expanding the findings to include other electric rail systems and the implications for electricity-consuming transportation systems in general.
- NTC@Maryland researchers plan to include a continuation of the data collection efforts and analysis in order to build on the preliminary findings of this reporting period. The completed research project will be documented in an updated paper that will be submitted to an ASCE peer-reviewed archival journal.
- Ongoing and near-future research activities include increasing the database of projects to collect data from all completed U.S. PPP transportation projects. Then the results will be compared to those of international projects as well.

2.D.ii. Education and Technology Transfer

- NTC@Maryland plans to feature two clusters of projects in the spotlight newsletter for USDOT UTC programs, in addition to the previous one published at http://www.rita.dot.gov/utc/sites/rita.dot.gov.utc/files/utc_spotlights/pdf/spotlight_1114.pdf.
- NTC@Maryland plans to complete the preparation of the *High Speed Rail Short Course* material and distribute it for review and comment to a number of individuals.
- A schedule for the Webinar series will be developed along with identification of topics and speakers. A marketing strategy will be developed and implemented to advertise and broadly announce the availability of the Webinars.

3. PRODUCTS

3.A. JOURNAL PUBLICATIONS

- [1] Chokor, A., Maddex, W., El Asmar, M., Chasey, A. 2015. The rigor of negotiation: Why public private partnerships are effective. Under review by the ASCE Journal of Construction Engineering and Management.



- [2] Collins, A.J., Frydenlund, E., Robinson, R.M., Cetin, M. 2015. Exploring a toll auction mechanic enabled by vehicle-to-infrastructure technology. *Transportation Research Record: Journal of the Transportation Research Board*, in press.
- [3] Hetrakul, P., Cirillo, C. 2014. A latent class choice based model system for railway optimal pricing and seat allocation. *Transportation Research Part E*, 61(1), pp.68-83.
- [4] Hetrakul, P., Cirillo, C. 2015. Customer heterogeneity in revenue management for railways services” *Journal of Pricing and Revenue Management*, 14(1), pp. 28–49.
- [5] Nichols, A.P., Cetin, M. 2015. Evaluation of differential calibration accuracy between WIM stations using reidentified vehicles. Accepted for publication in *Transportation Research Record*.
- [6] Osman, O., Codjoe, J., Ishak, S. 2014. Impact of time-to-collision information on driving behavior in connected vehicles environments using a driving simulator test bed. *Journal of Traffic and Logistics Engineering*, Awaiting Publication.
- [7] Ramsey, D.W., El Asmar, M. 2015. An analysis of project cost and schedule performance of the entire population of PPP transportation projects in the U.S. In Preparation for the *ASCE Journal of Construction Engineering and Management*.
- [8] Ramsey, D.W., El Asmar, M. 2015. Funding streams of Design-Build-Finance-Operate-Maintain (DBFOM) Public-Private-Partnerships (PPP) in the U.S. *Transportation Sector*. In preparation for the *ASCE Journal of Construction Engineering and Management*.
- [9] Ramsey, D.W., El Asmar, M. 2015. Cost and schedule performance benchmarks of U.S. Transportation Public-Private-Partnership (PPP) projects: Preliminary findings. *Transportation Research Record*. In Press.
- [10] Stich, B. 2014. Intermodal Transportation Disruption and Reroute Simulation Framework. *Transportation Research Record: Journal of the Transportation Research Board*, 2410, 150-159.
- [11] Stich, B., Griffith, K. 2014. Federalism and transportation finance. *Public Works, Management & Policy*. Forthcoming.
- [12] Stich, B., Platt, J. 2014. The Evolution of the Section of Transportation Policy & Administration. Forthcoming.
- [13] Zhang, Y.R., Haghani, A., Zeng, X.S., 2014. Component GARCH models to account for seasonal patterns and uncertainties in travel time prediction. *IEEE Transactions on Intelligent Transportation Systems*, in press.

3.B. BOOKS OR OTHER NON-PERIODICAL, ONE-TIME PUBLICATIONS

- [1] Matthew Bartos, Mikhail Chester. 2014. *Methodology for Estimating Electricity Generation Vulnerability to Climate Change Using a Physically-based Modelling System*. Arizona State University Report No. ASU-CESEM-2014-WPS-002.

3.C. OTHER PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

- [1] Collins, A. J., Frydenlund, E., Robinson, R. M., Cetin, M. 2015. Exploring a toll auction mechanic enabled by vehicle-to-infrastructure technology. Presented at the 94th Transportation Research Board Annual Meeting, Washington, D.C., 15-2825.
- [2] Cui, Q., Liu, X., Decorla-Souza, P. 2015. Effectiveness of public private partnerships in the U.S. *Engineering Project Organization Conference*.
- [3] Lou, Y. 2015. High occupancy toll lanes with a refund option: A survey of the Phoenix-Metropolitan area. The 2015 ITE/IMSAA Arizona Spring Conference, Mesa, Arizona, February 2015.
- [4] Lou, Y. 2015. High occupancy toll lanes with a refund option: A survey of the Phoenix-Metropolitan area. The 5th Annual Graduate Research Symposium, School of Sustainable Engineering and The Built Environment, Arizona State University, March 2015.
- [5] Lou, Y. 2015. High occupancy toll lanes with a refund option: A survey of the Phoenix-Metropolitan area. The 7th International Symposium on Travel Demand Management, Tucson, Arizona, April 2015.
- [6] Lu, Y., Chen, X., Zhang, L. 2014. A national travel demand model for the U.S.: A person-based microsimulation approach. Accepted for presentation at *the 94th Transportation Research Board Annual Meeting*, Washington, D.C.
- [7] Nichols, A.P., Cetin, M. 2015. Evaluation of differential calibration accuracy between WIM stations using re-identified vehicles. *The 94th Transportation Research Board Annual Meeting*, Washington, D.C., 15-2825.



- [8] Park, S., Chang, G.L. 2015. Design and evaluation of an advanced dilemma zone protection system: Advanced warning sign and all-red extension. Proceedings of the Transportation Research Board 94th Annual Meeting, Washington DC.
- [9] Parr, S., Ericson, J., Wolshon, B. 2015. Human performance modeling for manual traffic control. Submitted for Presentation at the Human Factors and Ergonomic Society Annual Meeting.
- [10] Ramsey, D.W., El Asmar, M. 2015. Cost and schedule performance benchmarks of U.S. transportation Public-Private-Partnership (PPP) projects. Proceedings of the Transportation Research Board 94th Annual Meeting, Washington DC.
- [11] Ramsey, D.W., El Asmar, M. 2015. A preliminary analysis of funding streams of Design-Build-Finance-Operate-Maintain (DBFOM) Public-Private-Partnerships (PPP) in the U.S. transportation sector” Proceedings of the Engineering Project Organization Conference (EPOC), Edinburgh, Scotland, Jun. 24-26, 2015. Under Review.
- [12] Ramsey, D.W., El Asmar, M. 2014. Project cost and schedule performance of transportation public-private-partnerships. Poster in Preparation for the School of Sustainable Engineering and the Built Environment (SSEBE) Graduate Research Symposium, Arizona State University.
- [13] Ramsey, D.W., El Asmar, M. 2014. Project cost and schedule performance of transportation public-private-partnerships. Presentation at the Construction Graduate Seminar, Del E. Webb School of Construction, Arizona State University.
- [14] Song, T., Kim, S., Roupail, N., Aghdashi, B., Amaro, A., Goncalves, G. 2015. Exploring the association of crash propensity and micro-scale driver behavior. Presented at the 94th Annual Meeting of TRB (15-4991).
- [15] Zhang, Y.R., Hamed, M., Haghani, A., Mahapatra, S., Zhang, X. 2015. How data affect travel time reliability measures: Empirical study. The 94th Annual Meeting of the Transportation Research Board Compendium of Papers, Washington DC.
- [16] Zhang, Y.R., Wang, Q., Haghani, A. 2015. Innovative hybrid freeway travel time prediction method: wavelet denoising with echo state neural network and ARIMA model. The 94th Annual Meeting of the Transportation Research Board Compendium of Papers, Washington DC.
- [17] Zhou, X. 2014. Evaluating emission impact of intelligent transportation management strategies through simplified emission estimation and mesoscopic dynamic traffic simulation models. Presented in the 2014 Transportation Planning/Land Use/Air Quality Workshop, Charlotte, North Carolina;
- [18] Zhou, X., Pendyala, R. 2014. Minimum number of cars a city needs in a fully coordinated vehicle sharing system. To be presented in the Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting. San Francisco, CA, November 2014.

3.D. WEBSITE(S) OR OTHER INTERNET SITE(S)

- [1] <http://attap.umd.edu> provided up-to-date field data collection and system design progress for the *Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications*.
- [2] <http://millerhooks.umd.edu/projects/proj45.html> showed the Objective Decision-Making Tools for Transportation Infrastructure Investment to Combat the Impacts of Sea Level Rise and Climate Change on Dr. Elise Miller-Hooks’s webpage.
- [3] http://fluidsurveys.com/surveys/asutransengr/hot-refund-pretest/?TEST_DATA=&_cb=ePacVFe97i was developed as a pre-survey for the *Behavioral Study for Managed Lane Pricing with Refund Option*. Full survey: http://fluidsurveys.com/s/Refund_Option_for_Toll_Lanes/. Both the pre-survey and the final survey are developed through fluid survey.
- [4] www.learning-transportation.org was a learning document about using simulation based traffic impact analysis as training material and user guides for undergraduate and graduate students. The documents are Lesson 6.1 Understand Traffic Congestion Propagation, and Lesson 10 Reduce Emissions and Energy Optimization.

3.E. TECHNOLOGIES OR TECHNIQUES

- Techniques for analyzing route and tour-level reliability issues were created and being tested under the study of *Efficiency and Reliability in Freight Transportation* at NCSU.



- The *Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications* yielded two products: (1) Intelligent dilemma zone protection system which consisted of a dynamic all-red extension module, a wide-range traffic monitor sensor, and an advanced signal warning module; (2) integrated safety and mobility system for high-speed intersections which included a dynamic all-red extension module, a wide-range traffic monitor sensor, and dynamic variable-speed advisory module.
- The *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator* developed a preliminary driving simulator test bed by developing JavaScript coding that would enable a lead vehicle in a driving simulator generated scenario to communicate alert messages to the simulator when certain time-to-collision thresholds were reached.

Additional technologies and techniques can be viewed at ntc.umd.edu

3.F. OUTREACH ACTIVITIES

- NTC@Maryland researchers organized two internal training sessions to educate MSHA engineers and local contractors on the *Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications*.
- The *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator* received local media support and was covered by the LSU's College of Engineering (<https://www.eng.lsu.edu/news/2014/8/lsu-driving-simulators-v2v-communication-to-transform-traffic-safety/>); Business Report (<http://www.businessreport.com/article/20140811/BUSINESSREPORT0112/140819982>); NBC33 News Station (<http://www.nbc33tv.com/news/tech-corner/future-of-driving-technol>); and the LSU newspaper, The Daily Reveille (http://www.lsureveille.com/news/university-uses-driving-simulator-for-vehicle-to-vehicle-research/article_30a69c1e-8234-11e3-aba8-001a4bc6878.html);
- Associate Director, Dr. Brian Wolshon was a featured speaker for TEDxLSU which took place 02/28/2015. Associate Director of Research, Dr. Scott Parr served as the 2015 Louisiana's STEM Expo and K-12 science fair judge on 02/28/2015.
- With a focus on educating and engaging community stakeholders on maritime jobs opportunities, the Board of Commissioners of the Port of New Orleans and the University of New Orleans hosted the 1st Annual Port of New Orleans Maritime Workforce Summit October 8, 2014. Some advance coverage from some of the maritime trade publications (<http://www.professionalmariner.com/Web-Bulletin-2014/University-Port-of-New-Orleans-to-host-Maritime-Workforce-Summit/>), (<http://www.cruiseindustrynews.com/cruise-news/11699-port-of-new-orleans-co-hosts-annual-maritime-workforce-summit.html>), (<http://www.marinelink.com/news/workforce-maritime-annual378543.aspx>)
 - Additional outreach activities can be viewed at ntc.umd.edu

3.G. COURSES AND WORKSHOPS

- Summer School on "Dynamic Discrete Choice Models: Econometric Models and Operations Research Methods" that will be held at Université de Montréal (Montreal, Canada) June 10-12, 2015.
- Based on the study of the *Efficiency and Reliability in Freight Transportation Systems*, the new methods are being introduced in two graduate courses at UMD.
- The *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* was introduced in two courses CE 3600 Introduction to Traffic Engineering and CE 4600 Advance Design of Highways and Airports at LSU.
- The results of *Quantifying and Benchmarking the Delivery Performance of U.S. PPP Transportation Projects* and *Analysis of Funding Streams for Public Private Partnerships in the U.S. Transportation Sector* will be included in the PPP portion of the PI's CON551 graduate course on Alternative Project Delivery Methods.

3.H. INVENTIONS, PATENT APPLICATIONS, AND/OR LICENSES

Nothing to report this period.

3.I. SEMINARS AND OTHER EVENTS



- **NTC@Maryland Sponsored Seminar Series at UMD**

- [1] Dr. Taylor Lochrane and Mr. Cory Krause. Moving Forward at the Turner Fairbank Highway Research Center of the Federal Highway Administration. Turner-Fairbank Highway Research Center (TFHRC), February 27, 2015.
 - [2] Dr. Alex Bond. Transportation Funding and Finance in the Post-TEA Era. the Center for Transportation Leadership at the Eno Center for Transportation, February 6, 2015.
 - [3] Prof. Kato. Tokyo's Rail on the Move: Latest Discussions on Long-term Urban Rail Planning in Tokyo. Civil Engineering Department at the University of Tokyo, January 16, 2015.
 - [4] Dr. George Yannis. Traffic and Safety Data Analysis: From Correlation to Causation and Policy Support. Department of Transportation Planning and Engineering of the School of Civil Engineering at the National Technical University of Athens (NTUA), January 15, 2015.
 - [5] Dr. Mohamadreza Banihashemi. ENCE688F Highway Safety Fundamentals and Highway Safety Manual. Turner Fairbank Highway Research Center, November 20, 2014.
- Additional events can be viewed at ntc.umd.edu

- **U.S. DOT Secretary Anthony Foxx Visits NTC@Maryland Member University.**

The Institute for Transportation Research and Education (ITRE) at North Carolina State University (One of the member universities of NTC@Maryland) announced a special Transportation Founders Fund Speakers Event. Secretary Foxx was on campus on February 19, 2015 from 5-6 pm at the William and Ida Friday Institute on the NC State University Centennial Campus.

3.J. OTHER PRODUCTS

- In addition to the survey questionnaires, the *Behavioral Study for Managed Lane Pricing with Refund Option* also produced a revealed preference dataset with 2270 responses. The dataset was saved on ASU lab PCs, and might be shared per request.
- An agent-based simulation was being developed in VISSIM to analyze the behavior under the dynamic and differentiated tolling scenarios.
- The development of a manual traffic control algorithm for implementing into a traffic simulation model was completed via *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors*.
- The outcomes of *Vehicle Trajectory Tool (VTT): Application Pilot for AMS Test Bed* included (1) high resolution driving behavior database (with over 16 million second by second records); and (2) real time VIV events' list and its thresholds.
- A geospatial model of the US West was being created to identify power generation facilities that were vulnerable to climate change (either from extreme heat or stream flow change). A dataset of extreme heat forecasts for the US West was also created by the study of *Long-distance Transportation Infrastructure in a Climate-constrained Future*.

Additional products can be viewed at ntc.umd.edu

4. PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

4.A. WHAT ORGANIZATIONS HAVE BEEN INVOLVED AS PARTNERS?

Each NTC@Maryland funded project is required to have 100% match. The external organizations providing match are as the following list:

- Federal Highway Administration (FHWA), I-95 Corridor Coalition, Idmec, Technical University of Lisbon, Institute for Transportation Research and Education (ITRE), NCSU, Raleigh, NC, International Freight Forwarders & Customs Brokers Association of New Orleans, iTds, Lisbon, Portugal, Los Angeles Metro, Louisiana Transportation Research Center, Maryland State Highway Administration (MDSHA), Maryland Department of Transportation (MDOT), National Science Foundation (NSF), National Cooperative Highway Research Program (NCHRP), North Carolina Department of Transportation, (NCDOT), Port of



New Orleans, San Francisco County Transportation Authority, Strategic Highway Research Program (SHRP2), Transportation Engineering Program of UMD, University of New Orleans Transportation Institute, Valley Metro in Phoenix, Virginia Department of Transportation (VDOT)

Collaborative efforts with NTC@Maryland consortium:

- UMD, NCSU, MSU collaborated in the research of *Efficiency and Reliability in Freight Transportation Systems*. Discussions continued on how the work could be coordinated and integrated with related activities at those universities.
- University of Colorado, Boulder in the *Ex-Post Value for Money Analysis of Public Private Partnerships in Freight Transportation Infrastructure*.
- The *Behavioral Study for Managed Lane Pricing with Refund Option* was conducted by ASU School of Sustainable Engineering and The Built Environment and ASU Parking and Transit Service.
- The Psychology Department and the Gulf Coast Center for Evacuation and Transportation Resiliency at LSU

Additional collaborations can be viewed at ntc.umd.edu

5. IMPACT

5.A. WHAT IS THE IMPACT ON THE DEVELOPMENT OF THE PRINCIPAL DISCIPLINE(S) OF THE PROGRAM?

5.A.i. Research on Topics Relevant to Economic Competitiveness

Domestic/U.S.-Related Freight Efficiency and Reliability

- The developed re-identification algorithms of *Combining Different Data Sources to Predict Origin-Destinations and Flow Patterns for Trucks in Large Networks* were expected to benefit the larger community since the proposed approach improves their accuracy.
- The materials developed at NCSU relating to *Efficiency and Reliability in Freight Transportation Systems project* would (1) increase the tools and techniques available to examine freight reliability; (2) provide materials that can be used to teach people how to do freight reliability analyses; and (3) improve the ability of governmental agencies to understand the impacts on freight reliability and efficiency afforded by capital investments and operational changes.
- The key benefits of the *Identification of Potentially Hazardous Roadway Network Locations Using Microscopic Observational Vehicle Data and Macroscopically Modeled Reaction Time* included: (1) improved congestion management through more effective targeting of locations for highway safety countermeasure implementation; (2) increased cost effectiveness in highway safety improvement program investments; and (3) improved understanding of the relationships between microscopically observed and macroscopically derived driver behavior events and hazard potential.
- NTC@Maryland researchers found that there were needs of the efficient freight flow system in the Baltimore area. With the Panama Canal expansion, the more container trips in, out of, and through the region was expected. The findings of the *Multi-layered Integrated Urban Freight Delivery Network*, businesses preferences, provided guide to policy makers what plan should be implemented first.
- The outcomes of the *Quantification of System-wide Life Cycle Benefits of Recycled Materials in Highways* satisfied the enforcement of regulations that minimized risks of freight transportation to safety, reduced carbon footprints and other detriments to environmental sustainability posed by freight through use of alternative highway materials.

Congestion Mitigation with Multi-Modal Strategies

- The *Advanced Volatility Models for Improving Travel Time Prediction* used innovative data mining approaches such as advanced statistical and machine learning algorithms to study uncertainty associated with travel time prediction. The developed models helped manage traffic better and alleviate congestion



faster which resulted in economic benefits in terms of time, cost and energy savings for the users and the society as a whole.

- The *Behavioral Study for Managed Lane Pricing with Refund Option* was expected to shed more light on the implication of risks and uncertainties on managed lane users' travel behaviors. Results provided a more realistic behavioral basis for future modeling and analysis of priced MLs.
- The proposed dilemma zone protection system, after proving its effectiveness through two on-going piloting tests, fundamentally changed MSHA's design in improving intersection safety, especially on preventing the accidents caused by the existence of dilemma zones.
- The *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator* offered an opportunity for economic development by targeting improvements in the areas of traffic operation, safety, and environmental impacts.
- The *Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications* was the first step towards the envisioned transportation operation system that relied on V2V communications to support coordinated traffic operation algorithms and did not require any fixed infrastructure. The envisioned system was particularly suitable for mobility applications.
- The *HOV Lane Performance Monitoring System* introduced a unique and innovative approach for separating travel time data on HOV and general purpose lanes using a pattern recognition and clustering algorithm.
- Tolling lanes and HOV lanes had long been used as mechanisms to relieve traffic congestion as well as a mechanism to generate funds to build new facilities to further reduce congestion. The analytical models provided an understanding of how a private toll operator might use the derived tolling mechanism to maximize profit and thus appropriate policy could be put in place to ensure that other goals of the toll (i.e., reduction of congestion) were also met.
- The results of *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* led to innovative ways to manage evacuation corridors. Over the long term this research would incrementally advance the state of practice in improving the movement of traffic with evacuation corridors, and the state-of-knowledge making it possible to improve traffic management practices in the future.
- The discipline of transportation moved from infrastructure based traveler information (VMS, HAR) to in-vehicle messaging from the infrastructure or other vehicles. This research of the *Vehicle Trajectory Tool* paved the way for understanding the impact of and response to this type of messaging.

Smart and Strategic Investments in High Speed Rail

- The impact of the *Analysis of Funding Streams for Public Private Partnerships in the U.S. Transportation Sector* was to provide a comprehensive analysis of the performance and funding sources of all PPP projects in the U.S. transportation sector. This research advances the state of knowledge in project delivery systems of infrastructure.
- Findings of the *Long-distance Transportation Infrastructure in a Climate-constrained Future* helped lay the initial groundwork for how transportation infrastructure providers and operators should think about a climate constrained future.
- The findings from the *Quantifying and Benchmarking the Delivery Performance of U.S. PPP* made an important impact on the performance of PPP projects had not been quantified in a scientific manner and this effort helped public agencies assess whether leveraging private funds and delivering transportation projects non-traditionally resulted in a better allocation of time and money resources.
- The *Revenue Management and Operations Optimization for High Speed Rail* developed a dynamic framework for discrete choice modeling on finite horizon, which extended existing static framework that were largely used in a number of different disciplines (Impact on theory advancement).
- The *U.S. National and Inter-Regional Travel Demand Analysis: Person-Level Microsimulation Model and Application to High-Speed Rail Demand Forecasting* represented the first attempt to develop a microsimulation-based national long-distance travel demand for high speed rail and national travel analysis. The developed model system helped researchers and decision makers in development and quantitative evaluation of national transportation policies.

5.A.ii. Education and Technology Transfer



- The *High Speed Rail Short Course*, once developed, would have an impact on the level of understanding about high speed rail that existed within the transportation discipline.
- Webinars series of *Moving Transportation Research to Practice* broadly disseminated research findings to the research community and beyond. Results enhanced academic pursuits by expanding knowledge in the specified research areas.
- The collaboration of NTC@Maryland with the Freight Academy provided the opportunity for two students from underrepresented regions to participate in the Academy. As result, they took their improved knowledge back to their agencies while promoting the expertise and impact of NTC@Maryland.

5.B. WHAT IS THE IMPACT ON OTHER DISCIPLINES?

NTC@Maryland projects had impact on other fields of transportation such as traffic engineering and reliability analysis.

- The study of *Multi-layered Integrated Urban Freight Delivery Network* employed conjoint analysis that was widely used in marketing research. While conjoint analysis simulated individual choice behavior by mimicking a real world market, this method was been well accepted.
- The research of *Efficiency and Reliability in Freight Transportation Systems* was applicable to public transportation systems and airline networks. The tools and techniques had an impact on logistics practice as well as enterprise management.
- The *Impact of Freight Movement Trends on Highway Pavement Infrastructure* impacted disciplines focusing on national, regional, mega-regional, and local planning.
- Engineers in DOTs and other State agencies were more amenable to using recycled materials if their properties and overall benefits were clearly defined via the *Quantification of System-wide Life Cycle Benefits of Recycled Materials in Highways*.
- By developing the *Advanced Volatility Models for Improving Travel Time Prediction*, more efficient traffic management benefit private sector transportation companies such as urban delivery, trucking and logistics firms to manage their fleet in a more efficient and economical way.
- The findings of the *Behavioral Study for Managed Lane Pricing with Refund Option* regarding managed lane users' risk-taking behaviors had an impact on behavioral sciences.
- The propose dilemma zone protection system, Type-II, offered the potential to integrating traffic safety with mobility which was often in completion of priority on selection of field deployment projects for arterial traffic improvement.

Additional impacts on other disciplines can be viewed at ntc.umd.edu

5.C. WHAT IS THE IMPACT ON THE DEVELOPMENT OF TRANSPORTATION WORKFORCE DEVELOPMENT?

- The dissemination of research outcomes and publications from the *Advanced Volatility Models for Improving Travel Time Prediction* helped in developing a more informed and better educated workforce.
- The research of *Behavioral Study for Managed Lane Pricing with Refund Option* supported one thesis-based master student at ASU, and two undergraduate students. The pre-survey was deployed through ASU's School of Sustainable Engineering and The Built Environment email list, exposing faculty, staff, and students who were not in the field of transportation engineering.
- The research of *Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications* supported one PhD student at ASU.
- Through the graduate courses taught related to the *Open Toll Lanes in a Connected Vehicle Environment*, the students obtained the skills necessary to engage in the transportation community and workforce, especially in the area of Modeling and Simulation.
- The research of *Understanding Regional Disparities in Public Transit Performance Using Realtime Transit Data* provided one student with approximately 20 hrs of work per week. Data was incorporated into class materials. The project helped agencies identify deficiencies in their transit system, and helped them to provide more equitable transit service.
- Significant impact, as the field was moving more into the electric/ computer science field, and less on brick and mortar and concrete. The *Vehicle Trajectory Tool* would have an impact on the way people taught transportation.



- NTC@Maryland researchers included the new knowledge in the graduate course on Alternative Project Delivery Methods (CON 551) to educate the next generation of engineers and builders on the state of knowledge in PPP methods and performance.
- The methods, data and results of the *Revenue Management and Operations Optimization for High Speed Rail* were part of the classes that the PI regularly taught at the UMD: ENCE 688G Survey Methods in Transportation and ENCE 688L Advances in Transportation Demand Analysis. Moreover a new class in under development at the UMD, which was mainly based on the new techniques developed: ENCE 688L Computational methods for transportation demand analysis. Related courses were presented at the University of Taiwan and at the KTH in Stockholm where she taught a class of 60 PhD students from different European universities.

Additional impacts on workforce development can be viewed at ntc.umd.edu

5.D. WHAT IS THE IMPACT ON PHYSICAL, INSTITUTIONAL AND INFORMATION RESOURCES AT THE UNIVERSITY OR OTHER PARTNER INSTITUTIONS?

- In the freight research area, NTC@Maryland helped ODU receive valuable datasets (e.g., per-vehicle data from traffic sensors) from VDOT. It helps define new information resources (databases etc.) for quantifying the cost-benefits of recycled materials in highway construction.
- To researchers and public sector practitioners, the availability of any freight data was appreciated so much. The data to be collected as part of the *Multi-layered Integrated Urban Freight Delivery Network* by in-depth interviews and conjoint survey became precious resources to researchers and practitioners.
- The software developed by the *Understanding Regional Disparities in Public Transit Performance Using Realtime Transit Data* generated the realtime/static comparison database available online.
- The *Vehicle Trajectory Tool* provided (1) an extensive database of second by second equipped vehicle trajectories synchronized in time and space as they traverse freeway/arterial facilities over a period of six months; and (2) a demonstration of VIV concepts and messages in near real time, and an assessment of their effectiveness.

5.E. WHAT IS THE IMPACT ON TECHNOLOGY TRANSFER?

- The methods developed by *Combining Different Data Sources to Predict Origin-Destinations and Flow Patterns for Trucks in Large Networks* would be potentially integrated into a system being developed for field testing and deployment planned for an FHWA Small Business Innovation Research (SBIR) Phase II project.
- The findings and methods of the *Efficiency and Reliability in Freight Transportation Systems* were disseminated to professionals through the technical literature. Efforts were made to identify freight transportation operators who agreed to implement and tested the methods developed. The tools and techniques could be showcased in technology transfer activities.
- Various State DOTs planned to adopt a green materials management approach. The *Quantification of System-wide Life Cycle Benefits of Recycled Materials in Highways* directly helped the DOTs build their capacity to sustain such efforts. The successful implementation of this project could also lead toward the development of green materials registry and management at the DOTs.
- The results and the methods of *Advanced Volatility Models for Improving Travel Time Prediction* were disseminated to the traffic management personnel in various states. It helped them in developing better strategies for traffic management and congestion mitigation.
- The travel time separation algorithm developed by NTC@Maryland researchers made impacts on the existing public facility (e.g. display travel time information on the variable message sign) and other commercial services (e.g. Google Map provides travel time information) by making it possible to show travel time for HOV and other lanes separately.
- This *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* led to planning agencies adopting some portion of this research in the development/updating of their emergency traffic management plans.
- The software developed by the *Understanding Regional Disparities in Public Transit Performance Using Realtime Transit Data* facilitated more effective transit planning and evaluation.



Additional impacts on technology transfer can be viewed at ntc.umd.edu

5.F. WHAT IS THE IMPACT ON SOCIETY BEYOND SCIENCE AND TECHNOLOGY?

- Improvements in the efficiency and reliability of freight transportation improved the entire U.S. economy and, hence, the living standards throughout the U.S. They could also improve the competitiveness of the U.S. The tools and techniques had an impact on the cost of providing freight services. They also reduced manufacturing and product delivery costs.
- The *Identification of Potentially Hazardous Roadway Network Locations Using Microscopic Observational Vehicle Data and Macroscopically Modeled Reaction Time* could lead to decreased fatalities associated with traffic collisions and hazardous scenes.
- More efficient traffic management and congestion mitigation had significant societal economic and other user benefits. Economic benefits included travel time and cost reduction and reduction in energy use. Other benefits included travelers' peace of mind and reduction in the frustration levels that were due to long delays in traffic queues.
- The activities performed in the *Behavioral Study for Managed Lane Pricing with Refund Option* included a survey deployed through multiple email lists and social networks. They included ASU's School of Sustainable Engineering and The Built Environment email list, ASU's Parking and Transit Services email list, Arizona ITE and ITS Arizona mailing lists, and ADOT mailing list.
- The *Design and Implementation of a Detection, Control, and Warning System (DCWS) for Dilemma Zone Applications* (1) improved public knowledge and attitudes in preventing intersection crashes caused by dilemma zones; (2) potentially changed the behavior, practices, decision making of drivers when encountering a yellow phase at high-speed intersections; and (3) significantly reduced the rear-end collisions in a dangled-crashes at high-speed rural intersections.
- The proposed approaches of the *Distributed Traffic Monitoring and Prediction with Vehicle-to-Vehicle Communications* could open up new possibilities for a variety of transportation applications such as real-time traffic-responsive route guiding system and instant user feedback platform for dynamic value-added road pricing systems. It could enable a new paradigm of a safer, more efficient and cost-effective transportation infrastructure.
- By using V2I technology to allow drivers to bid on road tolls would produce a competitive pricing for the toll road as opposed to a pricing scheme set by the toll operator. This would also allow drivers to communicate their desire to use the toll road operators, through the bids they make, giving them input into the pricing scheme for using the toll road.
- The software developed by the *Understanding Regional Disparities in Public Transit Performance Using Realtime Transit Data* provided transparency to the level of service provided by transit providers.
- As part of the project tasks, this research team of the *Vehicle Trajectory Tool* investigated the VIV.
- The results of the *Analysis of Funding Streams for Public Private Partnerships in the U.S. Transportation Sector* determined the absolute and relative monetary contribution of private investment in PPP transportation projects. This assisted in arguments in favor of several surface transportation programs, some of which were set to expire, such as TIFIA and the Highway Trust Fund (HTF) as part of MAP-21.
- NTC@Maryland research could lead to decreased emergency evacuation times resulting in fewer fatalities associated with major disasters such as wild fires, flash floods, hurricanes, etc.
- *Long-distance Transportation Infrastructure in a Climate-constrained Future* research showed infrastructure managers how extreme heat and water could make their systems vulnerable and it was anticipated that over the coming decades this information would help guide responses to the creation of new science or the improvement of technology to maintain reliability.
- The results from the *Quantifying and Benchmarking the Delivery Performance of U.S. Public-Private-Partnership (PPP) Transportation Projects* were likely to make an impact on improving public knowledge regarding the performance of PPP projects in the U.S. In addition, the results suggest that PPP may ultimately lead to additional jobs that typically improved the social and economic conditions.
- A capable long distance travel analysis tool enabled us to better understand the long-distance travel behavior and forecast the travel patterns in the future. With the analysis tool, the decision makers or politicians would make efficient and inexpensive investments or national-level or inter-regional-level transportation policies which would have an impact on people's long distance travel.



- The *High Speed Rail Short Course* helped all members of society better understand the features of high speed rail. Much of the seminar information shared should ultimately result in transportation solutions in the U.S. that were more sustainable and positively impact the quality of life.

5.G. ADDITIONAL IMPACTS

- NTC@Maryland included a greater body of knowledge, additional well-trained transportation professionals, improved productivity due to the travel time and reliability improvements, reduced energy use and reduced environmental impacts. The tools and techniques had the potential to alter the business practices of carriers, shippers, receivers, and manufacturers.
- NTC@Maryland (1) increased understanding and awareness of the importance of freight transportation system; (2) improved methodological understanding on choice behavior by applying a marketing research methodology; (3) had students trained for freight transportation planning.
- The impact of the *Vehicle Trajectory Tool* would increase the understanding of transportation issues in the area of safety and conceptualism of transportation. By collecting a vast amount of data from i2D devices, it was expected that the body of knowledge of transportation engineering would improve.
- Broader outcomes from the *Quantifying and Benchmarking the Delivery Performance of U.S. Public-Private-Partnership (PPP)* included an increased understanding and awareness of transportation issues. Long-term impacts could include an increase in the amount of infrastructure projects delivered to the public, and a better use of resources to deliver said infrastructure.

6. CHANGES/PROBLEMS

6.A. CHANGES IN APPROACH AND REASONS FOR CHANGE

Nothing to report this period.

6.B. ACTUAL OR ANTICIPATED PROBLEMS OR DELAYS AND ACTIONS OR PLANS TO RESOLVE THEM

- An anticipated delay factor is the timing of interviews and surveys. The research team of the *Multi-layered Integrated Urban Freight Delivery Network* will try to schedule as many interviews as possible to make more progress.
- The survey development and pretesting of the *Behavioral Study for Managed Lane Pricing with Refund Option* took longer than expected during the last reporting period. During this reporting period, the team has successfully completed the survey and the exploratory data analysis.
- For *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors*, problems were encountered in calibrating and validating the traffic simulation network. The estimate time required to complete one observation was significantly underestimated. At this time, the procedure has been streamlined but it has ultimately delayed the completion of the final report.
- The research of *Vehicle Trajectory Tool* requests a 90 days no-cost extension from the current termination date of June 30, 2015 to September 30, 2015. This is primarily due to delay in receiving i2d equipment which was necessary to carry out the VIV experiments.

6.C. OTHER CHANGES

Nothing to report this period.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report this period.

The table summarizing all active NTC@Maryland funded project can be found at:
<http://ntc.umd.edu/sites/default/files/documents/Publications/NTC%202015%20Projects%20Table.pdf>