



UNIVERSITY OF
MARYLAND

National Transportation Center

Program Progress Performance Report for University Transportation Centers

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Prepared for:
**Office of the Assistant Secretary for Research and Technology (OST-R)
U.S. DEPARTMENT OF TRANSPORTATION**



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1. PROGRAM INFORMATION

Program Progress Performance Report for National Transportation Centers

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

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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 University of Maryland (UMD) consortium includes: Arizona State University (ASU), Louisiana State University (LSU), Morgan State University (MSU), North Carolina State University (NCSSU), Old Dominion University (ODU) and the University of New Orleans.

National Transportation Center (NTC) @ Maryland aims to promote strategic transportation policies, investment, and decisions that bring lasting and equitable economic benefits to the U.S. and its citizens. NTC is concerned with the integrated operations and planning of all modes serving the nation’s passenger and freight transportation system, including the institutional issues associated with their management and investments. A balanced multi-modal approach will be used that considers freight and passenger travel mobility, reliability, and sustainability, as well as system operations during periods of both recurring and non-recurring incidents, including response to major emergencies. The modes in this theme include highway, transit, rail, and inter-modal interfaces including ports, terminals and airports. In particular, 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?

The NTC Program Progress Performance Report (PPPR) Information Forms were sent out to Associate Directors and NTC Researchers in August, 2014, filled out by all P.I.s from member universities, and collected by the NTC Assistant Directors by September 17, 2014. In total, 26 research/education/T2 projects were both posted to Transportation Research Board (TRB) Research in Progress (RiP) database and the NTC website as requested by OST-R. All funded project in the 2014 round will be completed within one year with Quarterly Progress Reports submitted every three months and Final Reports submitted by December 3, 2014. Project progress forms of the Round-1 projects can be downloaded <http://ntc.umd.edu/research/projects>. More details of those projects can be seen 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

NTC organizes research activities in three major research topic areas – Domestic and U.S.-related International Freight Efficiency and Reliability, Congestion Mitigation with Multi-Modal Strategies, and Smart and Strategic Investments in High Speed Rail – to directly support the U.S. DOT strategic goal of Economic Competitiveness with consideration for other related strategic goals such as Safety and



Sustainable Environment. Our research activities are multimodal/intermodal and multidisciplinary in scope. Based on the three research focusing areas of the center, faculties and research staff reported progress of a number of representative research projects in each domain. As shown in the followings, these projects cover a wide spectrum of transportation related topics including congestion mitigation, travel time reliability, climate change, work zone safety, connected vehicles and freight logistics, etc.

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

- **Combining Different Data Sources to Predict Origin-Destinations and Flow Patterns for Trucks in Large Networks** [\[PDF\]](#)

NTC researchers have coordinated with Virginia Department of Transportation (VDOT) so that per-vehicle data were collected at four continuous count sites along I-64 in the Hampton Roads. Data spanning several weeks have been collected by VDOT and made available to Dr. Mecit Cetin at ODU. The second dataset came from WIM sites across Oregon and contained both vehicle specific data as well as unique tag/transponder numbers for a subset of trucks. Both datasets are being prepared for algorithm development and testing.

- **Efficiency and Reliability in Freight Transportation Systems (UMD and NCSU)** [\[PDF1\]](#), [\[PDF2\]](#)

NTC researchers developed a modeling framework and some specific component models for optimizing freight transportation systems, with emphasis on operations at transfer terminals. UMD conducted a comprehensive review of the freight efficiency and reliability research area and developed a model for analyzing transfer terminal operations and optimizing the dispatching of vehicles from such terminals. NCSU completed simulation models of routes with stochastic segment travel times. Also, simulation models were prepared of multi-stop tours in which the segment travel times and load-unload times were stochastic. Performance metrics were identified and assessed for the simulation models.

- **Impact of Freight Movement Trends on Highway Pavement Infrastructure** [\[PDF\]](#)

NTC researchers investigated the impacts of national freight traffic trends and projections on the pavement infrastructure. National databases and literature have been reviewed to prioritize routes and segments. Development of correlations between traffic volume, loads, and composition is underway.

- **Multi-layered Integrated Urban Freight Delivery Network – Phase I: Identification of Policy Preferences based on Qualitative and Conjoint Analyses** [\[PDF\]](#)

NTC researchers conducted an extensive review of case studies on alternative freight demand management strategies planned or implemented in European countries. We had in-depth interviews 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. In addition, we conducted an in-depth interview with a logistics manager of an Asian grocery chain that had a national network to identify the characteristics of their unique nature of the supply chain from Asia to the United States.

- **Port City Challenges** [\[PDF\]](#)

NTC researchers analyzed progress made from 2006 to date by the International Maritime Organization (IMO), International Hydrographic Organization (IHO), Corp of Engineers, United States Coast Guard, National Oceanic and Atmospheric Administration, National Weather Service, State DOTs, Radio Technical Commission for the Maritimes (RTCM) and other Maritime Industry Partners. The team met with the Corp of Engineers, NOAA and the Coast Guard to discuss implementation challenges.

Congestion Mitigation with Multi-Modal Strategies

- **Behavioral Study for Managed Lane Pricing with Refund Option** [\[PDF\]](#)

NTC researchers addressed the use of managed lane facilities as one solution to freeway congestion problems. The problem itself is a nationally and regionally significant transportation issue pertinent to economic competitiveness. The full survey to be deployed will cover the entire nation through email listings and social media, with an emphasis on the phoenix metropolitan region.



- **Congestion Mitigation Potential of Autonomous (Driverless) Vehicles: A Scenario-Based Approach** [\[PDF\]](#)

NTC researchers studied the macroscopic flow-density relationship under microscopic self-driving behavior models. This connection helped form a flow prediction mechanism to first predict bottleneck evolution along a corridor, through the an extension of Newell's 3 detector model, and further manage the performance of independently operated self-driving cars under normal and irregular conditions. A few medium-scale examples were used to show the potential of a system-wide dynamic programming-based vehicle trajectory optimization method that could coordinate the use of self-driving cars in real time, with various goals of maximizing flow capacity and minimizing energy use.

- **Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator** [\[PDF\]](#)

NTC researchers developed a driving simulator-based test bed for connected vehicle operation and safety. It included testing real time data capture applications as well as integration and interoperability of connected vehicles and highway infrastructure. A literature review was completed. A simplistic, yet realistic, network was developed using the flexible scenario creation interface of the driving simulator.

- **Evaluating and Calibrating Emission Impacts of Traffic Management Strategies through Simplified Emission Estimation Model and Mesoscopic Dynamic Traffic Simulators** [\[PDF\]](#)

NTC 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. Three strategies were successfully tested: (1) peak spreading, (2) vehicle fleet replacement, and (3) incident response with variable message signs. 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 researchers made more efficient use of existing system through HOV lanes. NTC 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.

- **Objective Decision-Making Tools for Infrastructure Investments to Combat the Impacts of Sea Level Rise** [\[PDF\]](#)

A comprehensive review of climate change effects, sea level rise (SLR), coastal flooding and their impacts on the transportation network was completed. Special emphasis was placed on understanding economic impacts, potential actions that could be taken to combat SLR effects, and tools for quantifying these impacts and such mitigative or recourse actions.

- **Open Toll Lanes in a Connected Vehicle Environment: Development of New Pricing Strategies for a Highly Dynamic and Distributed System** [\[PDF\]](#)

The mitigation of highway congestion was focused on through the use of multi-location auction tolling in a future environment where drivers are able to use vehicle-to-infrastructure (V2I) communication to exchange information with the toll operator. The main components of the tolling system were defined. The simulation was still under development in VISSIM environment. The initial analytical solutions to the scenario have been proven and analyzed.

- **Quantifying the Effects of Manual Traffic Control on Evacuation Corridors** [\[PDF\]](#)

A literature review and the video data processing were completed. Progress has been made toward developing the decision choice model and the traffic simulation models need for project completion.

- **Validation of Travel Time Reliability Prediction from Probe Data** [\[PDF\]](#)



The preliminary project validation sites were identified. A careful analysis was conducted to ensure that sites covered provide diversity between urban and rural and geographic setting. The sites were also chosen to provide measurable travel time variability.

- **Vehicle Trajectory Tool (VTT): Application Pilot for AMS Test Bed** [\[PDF\]](#)

An existing VTT was upgraded and pilot-tested for testing the feasibility of a V-I-V system in communicating timely and spatially sensitive messages to vehicles upstream of a recurring or non-recurring bottleneck queue. Significant results included: (1) estimating the correlation between hazardous freeway sections and microscopic driving behavior; (2) developing data collection framework and fleet. More than 10 million second by second high resolution vehicle trajectories were collected.

Smart and Strategic Investments in High Speed Rail

- **Long-distance Transportation Infrastructure in a Climate-constrained Future** [\[PDF\]](#)

NTC researchers developed a structure for assessing rail vulnerability (with an emphasis on high-speed) to climate impacts. This included mapping the connection between power generation and distribution to rail lines and material profiles and design guidelines for tracks. A Transportation Seminar was developed to engage with researchers at other universities and local government officials.

- **Quantifying and Benchmarking the Delivery Performance of U.S. Public-Private-Partnership (PPP) Transportation Projects** [\[PDF\]](#)

NTC researchers collected and verified data through (1) professional databases; (2) publicly available sources; (3) structured interviews with key projects constituents. Results stemmed from 25 completed PPP transportation projects showed an average cost growth of 3.22% and an average schedule growth of 1.2%, which highlighted superior performance when compared to traditional design-bid-build delivery.

- **Revenue Management and Operations Optimization for High Speed Rail** [\[PDF\]](#)

NTC researchers (1) collected data for the analysis; (2) defined the modeling framework; (3) started the implementation of the dynamic discrete choice model that was the major methodological component of the study. Tests on simulated data attested that the estimation of the dynamic discrete choice model for railway revenue management 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. Furthermore, the model is implemented in our developed micro-simulation platform which simulates each individual's yearly long distance activities and travel in the U.S. 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 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.

Dr. Lei Zhang and Mr. Mark Franz were invited to join Maryland Governor Martin O'Malley's Opportunity Roundtable Discussion in Annapolis, MD on July 14, 2014. The event, hosted by the Governor and StateStat Program Director Mr. Mark Power, focused on innovative data-based and performance-driven management tools for government agencies and how opportunities for citizens and businesses could be created with more efficient government processes.



NTC co-sponsored the 5th TRB Conference on Innovations in Travel Modeling (ITM) during April 27-30, 2014, in Baltimore, MD. NTC Director Dr. Lei Zhang served as the conference co-chair and spoke at the opening session. This conference series is the premier forum for sharing the latest developments in travel modeling, networking with fellow professionals, and identifying research and implementation challenges and issues associated with deploying cutting-edge computational methods to meet evolving planning context. NTC was the local host of this prestigious academic conference and an exhibitor. Members of the melding community exchanged information on promising modeling methods to address emerging policy questions, such as congestion mitigation, sustainable urban development, high speed rail, transportation planning, and economic development.

UMD graduate students: (1) Chenfeng Xiong was awarded the 2nd prize winner of student paper award of the 2014 Transportation Research Forum (TRF) Annual Meeting; (2) Eirini Kastrouni has been selected as a winner for ARTBA's Women Leaders in Transportation Design & Construction Council's Future Industry Spotlight Award for her outstanding effort and contribution to the transportation construction industry; (3) Yanshuo Sun wins Louis T. Klauder Scholarship, selected by the American Public Transportation Foundation (APTF).

- **High Speed Rail Short Course** [\[PDF\]](#)

Materials for the short course were in preparation. Drafts of many of the modules have been created.

2.B.iii. Technology Transfer

On August 28, 2014, the NTC portion of the open-house Advanced Transportation Technologies Day welcomed nearly 40 representatives from government, industry, academe and media to the center office during 9:30-10:30 a.m. at 1124 Glenn Martin Hall, UMD. Visitors learned about the NTC, and heard from a number of Department of Civil and Environmental Engineering faculty members how transportation engineering related to the following research topics and goals: (1) Economic Development; (2) Congestion Mitigation; (3) Freight Efficiency and Reliability; (4) Safety Improvement; (5) Emergency Preparedness; and (6) Sustainable Urban Development. See details at www.ntc.umd.edu/research/openhouse.


NTC collaborated with the I-95 Corridor Coalition Freight Academy to explore the potential of enhancing the Academy with university resources. Upon meeting with the Freight Academy coordinator, Ms. MaryGrace Parker, NTC formally submitted a technology transfer proposal with the objective of enhancing the quality and impact of the Freight Academy. The Academy was held during April 27-May 2, 2014 in New Brunswick, NJ. In accordance with the proposal tasks, NTC was actively involved in selecting the awardees of scholarships for under-represented Freight Academy nominees. In addition, NTC assisted the development and selection of the final capstone projects. NTC visited the event to assist the students in developing the problem statement and research plan for their capstone projects. This visit offered the opportunity for NTC to interact with participants and to gain first-hand experience on how the Freight Academy was operated. Finally, upon the completion of the capstone projects, NTC assisted in assessing the quality of each report.

In a related effort, NTC reached out to the I-95 Corridor Coalition Operations Academy. This training event will be held on October 7-17, 2014 in Linthicum Heights, MD. NTC sought to work with the Operations Academy to enhance the curriculum and to offer opportunities to under-represented applicants. Currently, NTC is working with representatives from the Operations Academy to assess the needs of the program and to define how NTC may assist in meeting those needs.

NTC organized a tour for the Innovations in Travel Modeling Conference attendees to visit the port of Baltimore on April 29, 2014. The group visited Dundalk Marine Terminal, which handled a variety of general cargo including autos, containers, forest products, and heavy equipment.

- **Moving Transportation Research to Practice: TPID Webinar Series** [\[PDF\]](#)

Webinar agendas and overarching themes were developed. Research presentations and content experts were identified. Plans are to identify key researchers with in the center that have projects significant progress that would be appropriate as webinar speakers. The first webinar in the series will



introduce NTC's research mission and leadership to the practitioner community, and address the overarching theme of moving research to practice. Each subsequent webinar will focus on one of the three NTC research areas. Preliminary planning has been done for the webinar series including delivery technology identification.

- **Enhancing the Impact of the Freight Academy via Academic Collaboration** [\[PDF\]](#)

This technology transfer collaboration allowed NTC to provide two program nominees from under represented regions of the US, access to one of the premier Freight Training Academy's.

2.C. HOW HAVE THE RESULTS BEEN DISSEMINATED?

NTC plans to start the Round-2 project proposal selection in October, 2014. All proposals are required to identify non-Federal matching funds in an amount equal to the funding provided by the USDOT. Projects may be one or two years in duration. However, two-year projects must be structured such that a deliverable product is provided at the end of the first year with funding for the subsequent year contingent on the successful completion of the first year's work. NTC strongly encourages proposal teams that include researchers from more than one member universities and will give funding priorities to multi-university collaborative proposals. Proposals will be first screened by NTC, then submitted to an expert panel for rigorous peer review. Every effort will be made to ensure that the expert panel is made up of individuals with a range of technical knowledge that spans the potential subject areas being proposed. The NTC Executive Committee, which consists of the Center Director and Associate Directors will make funding decisions for all proposals based on the assessments and recommendations of the review panel and available budget. The review panel will be asked to evaluate proposals using the following criteria: (1) alignment of proposed effort with center's theme; (2) quality and intellectual merit of the research proposal; (3) multi-university collaboration; (4) potential benefits to society that would result from successful completion of the work; (5) relevance of proposed effort with the national transportation agendas, including department of transportation priority areas; (6) qualifications of the investigators; (7) appropriateness of the proposed budget; (8) principal investigator's performance in prior projects; (9) likelihood the proposed work can be completed in proposed timeframe and within proposed budget; (10) use of non-federal matching funds to supplement NTC funding.

NTC plans to distribute its first quarterly electronic newsletter in October 2014. 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* has been discussed in two classes and in meetings with graduate students. So far, the literature review working paper has been shared by NCSU with the companion team at UMD. It has received very positive reviews.

Findings of the *HOV Lane Performance Monitoring System* are being incorporated into 2014 Maryland SHA Annual Mobility Report.

The pre-survey of the *Behavioral Study for Managed Lane Pricing with Refund Option* has been deployed through ASU's School of Sustainable Engineering and The Built Environment email list, reaching out to faculty, staff, and students who were not in the field of transportation engineering.

A series of technical reports of the *Long-distance Transportation Infrastructure in a Climate-constrained Future* have been posted to the ASU digital repository. Results were presented at local and national workshops and conferences.

In addition, NTC researchers plan to disseminate the results nationally (1) through online graduate classes and conference presentations; (2) at conferences and seminars, and intend to make available software and models developed to all interested parties.



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, final research reports from the projects awarded in the first round are expected. The reports will be made available to the website and significant results will be included in the newsletter. NTC will continue sponsoring seminars by inviting nationally and internationally recognized experts in the fields relevant to the center theme. During the next period, seminars will be broadcasted on the web and also recorded to reach out to off-campus audience.

NTC is currently working with local partners such as the Maryland DOT, Maryland SHA, and the DC DOT to establish joint student internship programs.

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

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

The vehicle re-identification algorithms will be developed and applied to the VDOT data, in order to combine different data sources to predict origin-destinations and flow patterns for trucks in large networks.

The main activities planned for the next period of *Efficiency and Reliability in Freight Transportation Systems* are (1) improving the dispatching model developed to date; (2) extending the analysis framework to consider the planning and scheduling of vehicle flows; (3) analyzing the propagation of delays in logistic systems under various circumstances; (4) submitting to a journal at least one paper document this work; and (5) developing and testing models that consider the multi-vehicle stochastic routing and scheduling problem.

Develop the necessary correlations between traffic volume, load, and composition; gather pavement design information, predict pavement performance of the prioritized sections, and begin to develop the map of freight impacts on highway infrastructure, for the *Impact of Freight Movement Trends on Highway Pavement Infrastructure*.

Identify a broader group of businesses and conduct a stated preference survey of alternative freight delivery strategies. The survey will be designed on the basis of the conjoint analysis framework that is a widely used marketing analysis methodology. The conjoint analysis will yield businesses preferences by analyzing their decision making behavior based on trade-offs among alternatives. The outcome from the *Multi-layered Integrated Urban Freight Delivery Network* is expected to give us more accurate preference structures of businesses than previous studies that used a simple Likert scale based survey or multi-criteria analysis.

Congestion Mitigation with Multi-Modal Strategies

Scheduled activities for the next period of the *Behavioral Study for Managed Lane Pricing with Refund Option* include the full deployment of survey, and preliminary behavioral modeling. The full-survey will be deployed through local government agencies, professional organizations, ASU mailing lists, and social networks. This will bring the issue to a broader general-public audience, enhancing public understanding and increasing interest.

Complete and analyze the simulation model for the *Open Toll Lanes in a Connected Vehicle Environment*. Further developments of the analytical solution will also be derived. The development of a practical data-collection game will be investigated as well.

For the *Validation of Travel Time Reliability Prediction from Probe Data*, NTC researchers plan to (1) complete the selection of project validation sites (routes), experimental design and data collection plan; (2) begin data collection; (3) develop FREEVAL models for the project study routes; (4) calibrate and validate the FREEVAL base model travel times; (5) begin the task of validating the scenario generation and travel time performance under non-recurring congestion.



NTC researcher also plan to (1) conduct and analyze off-line Database Experiments for the *Vehicle Trajectory Tool*; and (2) develop and Test V-I-V capabilities.

Finish producing software for automating tasks related to the *HOV Lane Performance Monitoring System*.

For the *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator*, NTC researchers plan to (1) develop a simplistic, yet realistic, network using the flexible scenario creation interface of the driving simulator; (2) 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; (3) 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.

By introducing the concept of shared autonomous vehicles and ride sharing, NTC researchers plan to develop a holistic optimization approach for synchronizing travel activity schedules, transportation services, and infrastructure on urban networks. The following key questions will be addressed: How many cars a city should use to support the overall transportation activity demand/desires, at different levels of coordination and pre-trip scheduling? How many parking lots and road infrastructure are required?

The work plan of *Evaluating and Calibrating Emission Impacts of Traffic Management Strategies through Simplified Emission Estimation Model and Mesoscopic Dynamic Traffic Simulators* includes (1) testing additional strategies including capacity improvements, tolling, ramp metering and work zone strategies; (2) developing additional applications, such network evacuation modeling (due to weather or special events); (3) Calibrating the simulated trajectories with second by second observations (i2d from GPS + OBD).

Complete mathematical modeling work of *Objective Decision-Making Tools for Transportation Infrastructure Investment to Combat the Impacts of Sea Level Rise and Climate Change*. Develop appropriate exact/heuristic optimization-based techniques for solution of the stochastic, bi-level program. Demonstrate how this tool can support objective, equitable, multi-attribute investment decision-making on where, when and to what level to make infrastructure investments, accounting for uncertainty in sea level rise or other flood-precipitating events, event longevity, and resulting performance effects. Prepare and apply model to a real-world based case study. Assess the performance of the developed tools and modify as found to be appropriate. Demonstrate the applicability and utility of the developed tools to decision-makers through application on the case studies. Complete and submit journal article. Given presentation at conference as planned.


For *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors*, NTC researchers plan to complete the decision choice model and traffic simulation models.

Smart and Strategic Investments in High Speed Rail

Continue data collection efforts and analysis. Present the final results from the entire population of PPP transportation projects. Phase 1 of *Quantifying and Benchmarking the Delivery Performance of U.S. PPP* fills a gap of knowledge on PPP project performance in the U.S. transportation sector, and also compares the results to those of previous research efforts studying international PPP markets.

Conducted extensive tests on real data to assess the validity of the proposed approach of *Revenue Management and Operations Optimization for High Speed Rail*. Once the modeling system is fully estimated and validated, several revenue management strategies will be tested in order to study the competitiveness of 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 researchers plan to conduct (1) cross-sample validation for model component and model improvement; (2) national-level passenger OD table completion, integrating with the stop-level simulation results; and (3) high speed rail application with the developed model system.

2.D.ii. Education and Technology Transfer

NTC plans to feature two clusters of projects in the spotlight newsletter for USDOT UTC programs.

NTC 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. Depending on the maturity of research projects, it is anticipated 2-4 webinars being conducted in the next reporting period.

For the *Enhancing the Impact of the Freight Academy via Academic Collaboration*, NTC plans to complete the review of the 2014 Capstones, and generate final report on the overall experience and lessons learned from this technology transfer.

3. PRODUCTS

3.A. JOURNAL PUBLICATIONS

- [1] Asadabadi, A., Miller-Hooks, E. 2014. An optimization-based approach to reducing the impacts of sea level rise on freight transport. In preparation for submission.
- [2] 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.
- [3] Hetrakul, P., Cirillo, C. 2014. Customer heterogeneity in revenue management for railways services” *Journal of Pricing and Revenue Management*. In press.
- [4] Osama Osman, Julius Codjoe and Sherif Ishak. 2014. Impact of time-to-collision information on driving behavior in connected vehicles environments using a driving simulator test bed. Submitted for consideration for publication and presentation at the 94th Annual Meeting of TRB. Under review.
- [5] Ramsey, D.W., El Asmar, M. 2015. Cost and schedule performance benchmarks of U.S. transportation Public-Private-Partnerships (PPP) projects: Preliminary results. Submitted for consideration for publication and presentation at the 94th Annual Meeting of TRB. Under review.
- [6] 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. *ASCE Journal of Construction Engineering and Management*. In preparation for submission.
- [7] Song, T., S. Kim, N. Rouphail, B. Aghdashi, A. Amaro and G. Goncalves. 2014. Exploring the association of crash propensity and micro-scale driver behavior. Submitted for consideration for publication and presentation at the 94th Annual Meeting of TRB. Under review.
- [8] Stich, B. 2014. Intermodal transportation disruption and reroute simulation framework: lesson for freight planning”, *Transportation Research Record*, 2014.
- [9] Stich, B., Griffith, K. 2014. Federalism and transportation finance. *Public Works, Management & Policy*. Forthcoming.
- [10] Stich, B., Platt, J. 2014. The Evolution of the Section of Transportation Policy & Administration. Forthcoming.

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] Asadabadi, A., Miller-Hooks, E. 2014. Objective decision-making tools for infrastructure investments to combat impacts of sea level rise. To be presented at INFORMS, San Francisco, November 2014.
- [2] Chris Frey. 2014. Evaluating and calibrating emission impacts of traffic management strategies through simplified emission estimation model and mesoscopic dynamic traffic simulators. Presented in a meeting hosted by the U.S. Environmental Protection Agency, Ann Arbor, MI on March 05, 2014.
- [3] Collins, A. J., Frydenlund, E., Robinson, R. M., Cetin, M. 2015. Exploring a toll auction mechanic enabled by vehicle-to-infrastructure technology. *The 94th Transportation Research Board Annual Meeting*, Washington, D.C., 15-2825. Under review.
- [4] 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.
- [5] Masoud Hamed, Ali Haghani, Yanru Zhang. 2014. Methodology for measuring performance of high occupancy vehicle lanes. *The 20th Conference of the International Federation of Operational Research Societies (IFORS 2014)*, Barcelona, Spain, July 2014.
- [6] Nichols, A.P., Cetin, M., Chou, C.S. 2014. Enhancing a vehicle reidentification methodology based on WIM data to minimize the need for ground truth data. *NATMEC: Improving Traffic Data Collection, Analysis, and Use*, Chicago, IL, June 29– July 2, 2014.
- [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. Under review.
- [8] 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.
- [9] 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.
- [10] Tanvir, S., Zhou, X., Roupail, N.M., Frey, H.C. 2014. Assessing emissions impacts of transportation management strategies for large scale regional networks. *The 94th Transportation Research Board Annual Meeting*, Washington, DC. Under review.
- [11] 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;
- [12] 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
- [4] was developed as a pre-survey for the *Behavioral Study for Managed Lane Pricing with Refund Option*.
- [5] 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

The *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator* aims to develop a preliminary driving simulator test bed by developing JavaScript coding that will enable a lead vehicle in a driving simulator generated scenario to communicate alert messages to the simulator when certain time-to-collision thresholds are reached. The successful development of the preliminary driving simulator test bed will enable benefits of the Connected Vehicles technology to be explored under controlled experimental conditions.

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

Software for the calibration of dynamic discrete choice models is developed as a product of the *Revenue Management and Operations Optimization for High Speed Rail*.

3.F. OUTREACH ACTIVITIES

On Thursday, August 28, 2014, the A. James Clark School of Engineering hosted its first-ever Advanced Transportation Technologies Day event, during which nearly 40 representatives from governments, industry, academe and media attended the event. A number of projects were introduced to public.


NTC and the Gulf Coast Center for Evacuation and Transportation Resiliency hosted the 2014 Engineering High Ability Multi-Cultural Students (REHAMS) Summer Camp on June 19, 2014. Recruiting into REHAMS gives multi-cultural students an opportunity to explore the various disciplines offered by the College of Engineering (CoE), including biological, chemical, petroleum, industrial, civil, electrical and computer engineering, computer science and construction management. "The most valuable part was seeing how hard works pays off," said George Tullock-Harris, an 11th grade student from Chicago, Ill. "No matter how big of a challenge the students and professors knew engineering was going to be, they all went the extra mile and succeeded. Everyone has a passion for what they're doing. Throughout the program, they sugar-coated nothing, and I liked that. They made sure I knew everything about engineering, even the things I thought I wouldn't need to know. Overall, it was fantastic."

The *Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator* has also received local media support and has been 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-aba8-001a4bcf6878.html);

NTC researchers are working with SHA district office to deploy the research products on two high-speed intersections which are plagued by dilemma zone related accidents.

The *Impact of Freight Movement Trends on Highway Pavement Infrastructure* will be outreached to transportation professionals at Arizona Roads and Streets Conference. The results will be disseminated at the Annual Roads and Streets conference in Tucson, Arizona as part of a UTC themed session in the University Research Track of the conference.

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 will host the 1st Annual Port of New Orleans Maritime Workforce Summit October 8. 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>)



The *Enhancing the Impact of the Freight Academy via Academic Collaboration* promoted the freight expertise of NTC to participants from across the US.

3.G. COURSES AND WORKSHOPS

The course of *Revenue Management and Operations Optimization for High Speed Rail* was provided in the Doctoral school – Politecnico di Torino (Italy) May 2014.

Based on the study of the *Efficiency and Reliability in Freight Transportation Systems*, problems, analysis methods and results have been presented in existing undergraduate and graduate courses at UMD.

The results of *Quantifying and Benchmarking the Delivery Performance of U.S. PPP Transportation Projects* will be included in the graduate course (CON551) on Alternative Project Delivery Methods. The course was recently added as a required course for all online MS students in construction at UMD.

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

Nothing to report this period.

3.I. SEMINARS AND OTHER EVENTS

- **NTC Sponsored Seminar Series @ UMD**

- [1] Prof. Tom van Vuren. Importance of integrating land use policies with transportation modeling. University of Leeds, England, September 10, 2014.
- [2] Prof. Tatsuo Oyama. Investigating the damaging impacts of the 2011 Great East Japan Earthquake and evaluating the restoration and reconstruction performance. National Graduate Institute for Policy Studies, Japan, August 6, 2014.
- [3] Prof. Refael Hassin. Rational queueing. Department of Statistics and Operations Research, Telaviv University, June 4, 2014.
- [4] Prof. Yafeng Yin. Effectiveness of variable speed limits. Department of Civil and Coastal Engineering, University of Florida, May 8, 2014.
- [5] Prof. Eric J. Miller. Agent-based microsimulation of urban activity & travel. Department of Civil Engineering, University of Toronto, April 30, 2014.
- [6] Dr. Mohamadreza Banihashemi. Introduction to Highway Safety Fundamental, Implementation of HSM in the IHSDM software. Senior Transportation Research Engineer of the Geometric Design Lab, TFHRC, FHWA, McLean, VA. April 4, 2014.
- [7] Dr. Samer H. Hamdar. From roadway networks to social networks: safety-oriented driver behavioral modeling and evacuation traveler departure time choice. Department of Civil and Environmental Engineering, The George Washington University.

- **2014 Transportation Technology Legislative Fair:** NTC was an exhibitor in the 2014 Transportation Technology Legislative Fair, held on March 19, 2014 in Annapolis, MD. The purpose of this event was to inform the Maryland legislature about activities in technology as applied to transportation management and operations, and in particular how such technologies are being applied in Maryland.

3.J. OTHER PRODUCTS

High resolution driving behavior database (with over 7 million second-by-second records) of the the *Vehicle Trajectory Tool*.

An agent-based simulation is currently being developed in VISSIM to analyze the behavior under the dynamic and differentiated tolling scenarios.

A data warehouse for hosting HOV related traffic data such as travel time, volume, ridership and etc. A software system for processing, compiling and visualizing HOV performance measures



Databases on railway ticket purchase over time, and on cancel and exchange behavior; software on dynamic discrete choice models; discrete choice models for revenue management of high speed rail; summer school on advanced discrete choice models.

A dataset of extreme heat forecasts for the US West was created by the study of *Long-distance Transportation Infrastructure in a Climate-constrained Future*. A geospatial model of the US West is being created to identify power generation facilities that are vulnerable to climate change (either from extreme heat or stream flow change).

A model for analyzing transfer terminal operations and especially dispatching decisions has been developed and documented in a paper that is being prepared for submission to a journal.

A database of PPP transportation projects cost and schedule performance in the U.S. was produced. The database can be used for further research and education on the emerging PPP method.

An agent-based calculation module has been incorporated and tested in the open-source package Agent+ available at <https://code.google.com/p/agent-plus/>

An emission calculation module has been incorporated and tested in the open-source package DTALite/NEXTA available at <https://code.google.com/p/nexta/>

A person-based national travel demand model was developed.

4. PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

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

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

- 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
- Maryland State Highway Administration, MDSHA
- Maryland Department of Transportation, MDOT
- North Carolina Department of Transportation, NCDOT
- Port of New Orleans
- Virginia Department of Transportation, VDOT
- San Francisco County Transportation Authority
- Transportation Engineering Program, UMD
- University of New Orleans Transportation Institute
- Valley Metro in Phoenix

Collaborative efforts with NTC consortium:

- UMD, NCSU, MSU have collaborated in the research of *Efficiency and Reliability in Freight Transportation Systems*. Discussions are continuing on how the work can be coordinated and integrated with related activities at those universities.



- This project of *Open Toll Lanes in a Connected Vehicle Environment* is currently conducted at ODU as a collaborative effort between faculty from Civil Engineering and Modeling, Simulation, and Visualization Engineering (MSVE) Department.
- This *Behavioral Study for Managed Lane Pricing with Refund Option* is conducted by ASU School of Sustainable Engineering and The Built Environment and ASU Parking and Transit Service.
- The *Evaluating and Calibrating Emission Impacts of Traffic Management Strategies* is a collaborative effort of ASU, ITRE at NCSU.

4.B. HAVE OTHER COLLABORATORS OR CONTACTS BEE INVOLVED?

UMD collaborated with Ms. MaryGrace Parker of the I-95 Corridor Coalition and other freight industry experts that assisted in the capstone mentoring and review process.

Significant collaborators and contacts outside the UTC have provided valuable data that made the research of Quantifying and Benchmarking the Delivery Performance of U.S. PPP possible. These knowledgeable and supportive collaborators include Gordon Burton (Alaska DOT), Alicia Torrez and Sara Ulbrich (Texas DOT), Lisa Loftus-Otway (Texas, UT Austin), Neal Belitsky (American Roads LLC), Jessica Keane and Maribel Lena (Florida DOT), Ron Marsico (Port Authority of NY/NJ), Kathy M. (Lake of the Ozark Community Bridge), Peter Femia (Connector 2000 Association), Jessica Cowardin and Larry Cloyed (Virginia DOT), Nancy Herera (Texas DOT), Barbara Kelleher (Florida DOT), John McCuskey (E-470 Public Highway Authority), John Flansberg (City of Reno), Crystal Gorman and John McShaffrey (Florida DOT), Kirk Avila (Orange County Transit Authority), Maria Melendres (Alameda Corridor Transportation Authority), Sam Johnson (Caltrans, SANDAG), Neal Fitzsimmons (NJ Transit Authority), Kimberlee Akimoto (Tri Met), Benjamin Asher (Texas DOT), Ian Satter (Florida DOT), Mary Koester (Minnesota DOT), Todd Walker (Las Vegas Monorail LLC), Mark Shotkoski (NWP Public Highway Authority).

A group of scientists at the University of Montreal (Canada), Department of Operational Research, have been involved in the *Revenue Management and Operations Optimization for High Speed Rail*.

Louis Rossi, former director of the Rail Division at NYSDOT, and a recognized pioneer for spearheading the introduction of high speed rail service between Albany and New York City, has been a source of insights about the topics that are important in the *High Speed Rail Short Course*.

Ms. Lu Yu, a lecturer from Harbin Institute of Technology in China, has been working on the quantitative analyses and preparing the working papers and TRB paper submission.

5. IMPACT

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

Projects selected in the first round have impact on several aspects of transportation policy making and decision making that contribute to the overall theme of economic competitiveness as follows.

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

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

The developed methods and algorithms of *Combining Different Data Sources to Predict Origin-Destinations and Flow Patterns for Trucks in Large Networks* will contribute to the state-of-the-art on vehicle re-identification techniques.



The products UMD should eventually be useful in improving the *Efficiency and Reliability in Freight Transportation Systems* relying on transfers at hub terminals. The materials developed at NCSU will (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; (3) improve the ability of governmental agencies to understand the impacts on freight reliability and efficiency afforded by capital investments and operational changes.

The findings from the *Impact of Freight Movement Trends on Highway Pavement Infrastructure* research will result in a visual representation of the major transportation corridors and critical locations. They impact the field of transportation engineering by quantifying the effect of projected freight trends on pavement infrastructure.

NTC found there were needs of the efficient freight flow system in the Baltimore area. The expected findings of the *Multi-layered Integrated Urban Freight Delivery Network* will provide guide to policy makers what plan should be implemented first.

Congestion Mitigation with Multi-Modal Strategies

The *Behavioral Study for Managed Lane Pricing with Refund Option* is expected to shed more light on the implication of risks and uncertainties on managed lane users' travel behaviors. Results will provide a more realistic behavioral basis for future modeling and analysis of priced MLs.

The product of *Evaluating and Calibrating Emission Impacts of Traffic Management Strategies through Simplified Emission Estimation Model and Mesoscopic Dynamic Traffic Simulators* will allow state DOT and metropolitan planning agencies to quickly test the emission impact of a full suite of innovative traffic management strategies at both the corridor and network levels. The AMS data hub and open-source simulation work NTC researchers have been doing for FHWA in advancing the modeling practice, which will allow FHWA and state DOTs to build upon the significant progress already made with emission modeling environments.

The *HOV Lane Performance Monitoring System* has introduced a unique an innovative approach for separating travel time data on HOV and general purpose lanes using a pattern recognition and clustering algorithm.

Establishing an optimization framework for the selection of actions to combat the impacts of sea level rise can change perspective on the problem and open the door for more mathematical approaches to the problem among civil engineer researchers.

By investigating a new tolling mechanism involving V2I technology, the *Open Toll Lanes in a Connected Vehicle Environment* will provide decision-makers with information, not available through empirical means, to generate and implement innovative tolling policies.

The results of *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* will lead to innovative ways to manage evacuation corridors. If found to be promising, the results are planned to be presented to emergency management officials in Louisiana's Governor's Office of Homeland Security and Emergency Preparedness. It is also anticipated the finding of this research will provide new insight in directing emergency traffic. Potentially leading to new policies and procedures for police.

This *Vehicle Trajectory Tool* is critical as we move into the Connected Vehicle Environment, as the i2d system will produce high resolution data that can be transmitted from one equipped vehicle to another, depending on the event to be transmitted.

Smart and Strategic Investments in High Speed Rail

The *Long-distance Transportation Infrastructure in a Climate-constrained Future* will help 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* make an important impact on the base of knowledge concerning the delivery of transportation projects. The performance of PPP projects has not been quantified in a scientific manner and this effort will help public agencies assess whether leveraging private funds and delivering transportation projects non-traditionally is resulting in a better allocation of time and money resources.

The *Revenue Management and Operations Optimization for High Speed Rail* develops a dynamic framework for discrete choice modeling on finite horizon, which extends existing static framework that are 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* represents the first attempt to develop a microsimulation-based national long-distance travel demand for high speed rail and national travel analysis. All major behavioral dimensions of long-distance travel is considered, except for route choice and network loading that require significant new network data collection/coding efforts and cannot be achieved with the limited budgeted of this project. The developed model system can help researchers and decision makers in development and quantitative evaluation of national transportation policies from infrastructure investment to infrastructure operation and management.

5.A.ii. Education and Technology Transfer

The *High Speed Rail Short Course*, once developed, will have an impact on the level of understanding about high speed rail that exists within the transportation discipline.

Webinars series of *Moving Transportation Research to Practice* will broadly disseminate research findings to the research community and beyond. Results will enhance academic pursuits by expanding knowledge in the specified research areas.

The collaboration of NTC with the Freight Academy provided the opportunity for two students from underrepresented regions to participate in the Academy. As result, they can take their improved knowledge back to their agencies while promoting the expertise and impact of NTC.

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

NTC projects will have impact on other fields of transportation such as traffic engineering and reliability analysis.

The research of *Multi-layered Integrated Urban Freight Delivery Network* conjoint analysis that has been widely used in marketing research.

The research of *Efficiency and Reliability in Freight Transportation Systems* is also applicable to public transportation systems and airline networks. The tools and techniques will have an impact on logistics practice as well as enterprise management.

The *Impact of Freight Movement Trends on Highway Pavement Infrastructure* will impact disciplines focusing on national, regional, mega-regional, and local planning.

The findings of the *Behavioral Study for Managed Lane Pricing with Refund Option* regarding managed lane users' risk-taking behaviors may have an impact on behavioral sciences.

The *HOV Lane Performance Monitoring System* improves the implementation of computer science techniques to solve transportation problems.

The *Quantifying the Effects of Manual Traffic Control on Evacuation Corridors* has a significant impact in the disciplines of Disaster Management.



The *Vehicle Trajectory Tool* has impact on both computing (given the scale of the collected data—millions of data points per month); GIS representation and of course communications capacity.

The methodology of *Revenue Management and Operations Optimization for High Speed Rail* and the results obtained have been presented during two invited seminars at the Erasmus Business School in Rotterdam and at the Department of Economics, Vrije Universiteit, Amsterdam, Netherlands. Both groups have found our methodology highly innovative and have expressed interest in our methods and our results. NTC researchers are also working with the department of mathematics at the University of Maryland under and Advance program; the objective is to establish close collaboration between the Clark School of Engineering and the Applied Math Program (AMSC).

The results of the *Long-distance Transportation Infrastructure in a Climate-constrained Future* will be relevant to many disciplines such as planning, operations research, and even public health.

Quantifying and Benchmarking the Delivery Performance of U.S. PPP have impacts on the design and construction of non-transportation infrastructure, such as water infrastructure.

In addition to enabling national-level infrastructure investment and operational analysis, a long-distance passenger travel demand model can also support large-scale evacuation planning and operations due to natural disasters or targeted attacks, and enable micro-level analysis of the spread of pandemic diseases resulting from long-distance travel.

The *High Speed Rail Short Course* will have an impact on mechanical engineering and electrical engineering, both of which are involved in developing the trains and control systems.

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

NTC researchers (1) integrated the research produced algorithms into the graduate courses in transportation (e.g., the collected per-vehicle data were used in class projects to analyze traffic flow behavior); (2) helped educate undergraduate and graduate students in transportation engineering, including women and underrepresented minorities, and thus prepare them for careers in transportation fields; (3) taught graduate courses wherein students have obtained the skills necessary to engage in the transportation community and workforce, especially in the area of Modeling and Simulation; (4) updated training manual and workshops for training police officer on how to direct traffic more safely and efficiently; (5) intended to acquire units for use in classroom instruction, as the trajectory-based data are the most detailed mobility data and will be essential to be understood and analyzed by the next generation of transportation engineers and planners; (6) implemented findings from the research as a module in several graduate courses to help train the next generation workforce that how transportation infrastructure are susceptible to climate change and strategies for reducing the vulnerabilities; (7) developed and disseminated new findings and providing exposure to transportation delivery for practitioners and students in the engineering and construction disciplines.

The open-source online learning package which is currently developed and enhanced by NTC, will provide a clean open-source code base to enable transportation researchers and software developers to continue to build upon and expand its range of capabilities to other simulation/optimization packages. This package also provides a free education tool for students to understand the complex decision-making process in transportation planning and optimization processes involving both mobility and emission measures.

The methods, data and results of the *Revenue Management and Operations Optimization for High Speed Rail* will be part of the classes at UMD (ENCE 688G Survey Methods in Transportation and ENCE 688L Advances in Transportation Demand Analysis). Moreover a new class (ENCE 688L Computational Methods for Transportation Demand Analysis) is under development at UMD, which is mainly based on the new techniques developed. Students at UMD have got the opportunities to spend short periods abroad (i.e. Canada) to participate to exchange activities and to advance their research on dynamic discrete choice



models. One NTC researcher, Dr. Cinzia Cirillo, has been also invited to present dynamic discrete choice models at the University of Taiwan and at the KTH in Stockholm for a class of 60 PhD students from different European universities. The material developed (both the theory and the results) have been part of a workshop to graduate students at the Politecnico di Torino (Italy).

The developed national travel demand model provided a capable long-distance passenger travel analysis tool in the U.S. for researchers to conduct the national-level infrastructure investment and operational analysis. Besides, it helped analyze the impact of socio-demographic, economic, and transportation infrastructure changes on long-distance travel demand, the influence of energy (e.g. fuel price) and environmental factors (e.g. climate change and related regulations) on long-distance passenger travel, and improved the long-distance passenger travel module in statewide and even some metropolitan-level travel demand model.

NTC provided (1) the short course that will positively affect the level of expertise that exists within the transportation workforce; (2) professional development opportunities via Webinar Series for transportation practitioners and aspiring practitioners through exposure to research expertise; (3) assistant in training some 40 freight professionals on the basic principles of freight management and analysis.

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 helped ODU receive valuable datasets (e.g., per-vehicle data from traffic sensors) from VDOT. The freight tools and techniques developed by NTC researchers could be used by NC State and partner institutions to improve the quality of the material presented insofar as freight is concerned. The freight data collected by in-depth interviews and conjoint survey will become precious resources to researchers and practitioners.

The *Vehicle Trajectory Tool* provided 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. This database will be used to understand fundamental traffic flow phenomenon at a resolution and scale that was unprecedented. It will also deliver key driver behavioral data.

NTC researchers are preparing the documentation on the code developed to estimate dynamic discrete choice models. The code, together with the data will be made available to the public. A company and a very well-known group of research have manifested interested in using our technology.

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* will 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* will be disseminated to professionals through the technical literature. Efforts will be made to identify freight transportation operators who will agree to implement and test the methods developed in this project. The tools and techniques can be showcased in technology transfer activities.

Understanding the freight movement effect on pavement infrastructure can lead to development of case studies for life cycle cost and life cycle assessment of freight strategies. These case studies can be disseminated to transportation professionals.

The travel time separation algorithm developed by NTC researchers may make 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* may lead to planning agencies adopting some portion of this research in the development/updating of their emergency traffic management plans.

Through several climate change impacts on infrastructure projects, NTC researchers have engaged with a variety of local infrastructure managers and are meeting with them roughly twice per year to disseminate the knowledge from our research.

There is a high potential for the transfer of the performance results to entities both in government and in industry, leading to the increased adoption of the new PPP delivery practice.

The results and the methods of the *U.S. National and Inter-Regional Travel Demand Analysis* will be disseminated to the decision makers and politicians in federal or state government through the technical literature. And it can help them better understand the person's long distance travel behavior, assist them systematically design and quantitatively evaluate the inter-regional infrastructure investment and operation and management policies.

The *High Speed Rail Short Course* will help individuals inside and outside of transportation to understand the important features of high speed rail. NTC's webinar series will more broadly disseminate information to the research community as well as transportation practitioners. This effort will also create a much larger awareness of the work being done at NTC. Hundreds of participants can be better informed about the impact of the center's research. Public agency freight professionals from across the US gained valuable freight training and general problem solving skills from their participation at the Freight Academy.

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 will have an impact on the cost of providing freight services. They will also reduce manufacturing and product delivery costs.

The *Impact of Freight Movement Trends on Highway Pavement Infrastructure* may be used in coordination with the Summer Transportation Institute (a program that engages high school students from low income rural areas in Arizona in Transportation careers).

Identifying business needs and implementing alternative freight delivery strategies could (1) decrease the number of truck trips that will have contribute to reducing tailpipe emissions; (2) mitigate traffic congestion and other conflicts between trucks and other modes of transportation, including bicyclists and pedestrians; (3) help businesses since travel time would decrease and they need to operate fewer fleets.

The pre-survey in the *Behavioral Study for Managed Lane Pricing with Refund Option* raised awareness (exposed faculty, staff, and students) of the connection between individual behaviors and the congestion problems, and may affect their future decision-making behaviors when it came to traveling.

The predicted travel time information by NTC researchers could result in better traveler route choice and departure time decisions.

NTC research efforts will aid governments and infrastructure owners and operators in effectively addressing the threats from potential sea level rise and significant, sustained flooding events that will arise more frequently with increased occurrence of extreme weather circumstances.



NTC research could lead to decreased emergency evacuation times resulting in fewer fatalities associated with major disasters such as wild fires, flash floods, hurricanes, etc.

NTC research results of the *Long-distance Transportation Infrastructure in a Climate-constrained Future* will show infrastructure managers how extreme heat and water can make their systems vulnerable and it is anticipated that over the coming decades this information will help guide responses to the creation of new science or the improvement of technology to maintain reliability.

NTC research results were likely to make an impact on improving public knowledge regarding the performance of PPP projects in the U.S., which could ultimately help change perceptions, policies, and transportation delivery practices nationwide.

A capable long distance travel analysis tool will enable 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* will help 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. In the long run, the funded research could (1) have impacts on increased reliability of freight movement; (2) help improve intermodal operation at and near the Port of Baltimore; (3) reduce in carbon foot print from freight delivery; and (4) provide jobs to the depressed neighborhood in or near former industrial zones near the Port of Baltimore.

6. CHANGES/PROBLEMS

6.A. CHANGES IN APPROACH AND REASONS FOR CHANGE

PI of the project "Congestion Mitigation Potential of Autonomous (Driverless) Vehicles: A Scenario-Based Approach" at ASU has changed from Dr. Ram M. Pendyala to Dr. Xuesong Zhou, as Dr. Pendyala has moved to Georgia Institute of Technology on August 1st , 2014.

6.B. OTHER CHANGES

Nothing to report this period.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report this period.

APPENDIX: NTC Funded Projects, 2013-2014

University	Principle Investigator	Category	Funded Project Titles
UMD	Paul Schonfeld	Applied Research	Efficiency and reliability in freight transportation systems
	Ali Haghani	Applied Research	HOV lane performance monitoring system
	Gang-Len Chang	Applied Research	Design and implementation of a detection, control, and warning system (DCWS) for dilemma zone applications
	Elise Miller-Hooks	Advanced/Applied Research	Objective Decision-Making Tools for Transportation Infrastructure Investment to Combat the Impacts of Sea Level Rise and Climate Change
	Cinzia Cirillo	Applied Research	Revenue management and operations optimization for high speed rail
	Mark Franz	Technology Transfer	Enhancing the impact of the freight academy via academic collaboration
	Tom Jacobs	Technology Transfer	Operations academy and regional traffic operations workshop series
	Ali Haghani	Education	Online master's degree program in transportation engineering and planning: Phase one
	Lei Zhang	Advanced Research	U.S. national and inter-regional travel demand analysis: person-level microsimulation model and application to high-speed rail demand forecasting
	Qingbin Cui	Applied/Advanced Research	Ex-post value for money analysis of public private partnerships in freight transportation infrastructure
	Ahmet Aydilek	Applied Research	Quantification of system-wide life cycle benefits of recycled materials in highways
ASU	Yingyan Lou	Basic Research	Behavioral study for managed lane pricing with refund option
	Mikhail V. Chester	Basic Research	Long-distance transportation infrastructure in a climate-constrained future: reliable HSR service for economic growth
	Xuesong Zhou	Research	Congestion mitigation potential of autonomous (driverless) vehicles: A Scenario-Based Approach
	Mounir El Asmar	Research	Quantifying and benchmarking the delivery performance of U.S. Public-Private-Partnership (PPP) transportation projects
	Xuesong Zhou	Research	Evaluating and calibrating emission impacts of traffic management strategies through simplified emission estimation model and mesoscopic dynamic traffic simulators
	Shane Underwood	Advanced Research	Impact of freight movement trends on highway pavement infrastructure
LSU	Brian Wolshon	Basic Research	Quantifying the effects of manual traffic control on evacuation corridors
	Sherif Ishak	Basic Research	Development of a simulation test bed for connected vehicles using the LSU driving simulator
MSU	Hyeonshic Shin	Applied Research	Multi-layered integrated urban freight delivery network – Phase I: identification of policy preferences based on qualitative and conjoint analyses
NCSU	James Martin	Technology Transfer	Moving transportation research to practice: TPID webinar series
	George List	Applied Research	Efficiency and reliability in freight transportation
	George List	Education	High Speed Rail Short Course
	Billy M. Williams	Applied Research	Validation of travel time reliability prediction from probe data
	Nagui M. Rouphail	Advanced/Applied Research	Vehicle trajectory tool (VTT): Application pilot for AMS test bed
ODU	Mecit Cetin	Advanced Research	Combining different data sources to predict origin-destinations and flow patterns for trucks in large networks
	Mecit Cetin	Basic Research	Open toll lanes in a connected vehicle environment: development of new pricing strategies for a highly dynamic and distributed system
UNO	Bethany Stich	Applied Research	Port city challenges

