



## Program Progress Performance Report for University Transportation Centers

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Research and Innovative Technology Administration

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**Project Title:** NEXTRANS - Integrated and Sustainable Transportation Solutions:  
From Concepts to Deployment

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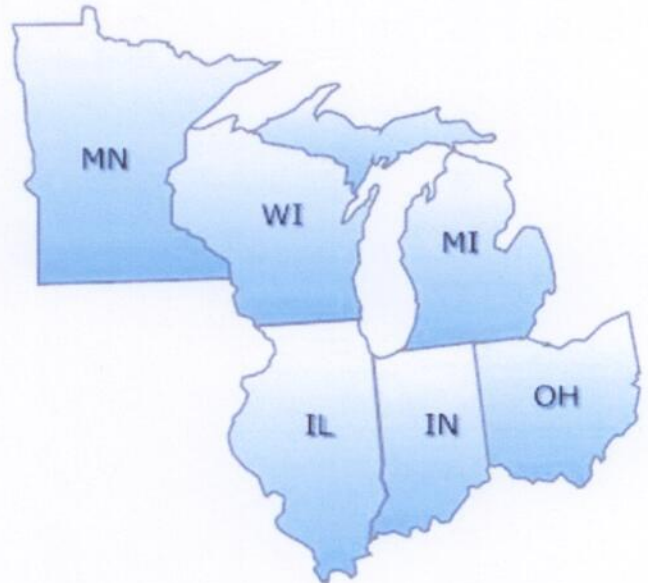
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**Grant Period:** January 2012 - January 31, 2016

**Reporting Period End Date:** December 30, 2015

**Report Frequency:** Semi-annual



Signed: \_\_\_\_\_

A handwritten signature in black ink that reads "Ned Howell".

Ned Howell, Managing Director

## **Part 1: ACCOMPLISHMENTS**

### **Major Goals**

There have been no changes to program goals.

### **Major Activities**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Developed a Bayesian statistical model to estimate the dynamic Origin-Destination demand matrices.
- The model has been validated in a small test network; the Bayesian method has been applied to the network of Chennai, India.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Revised and added the experiment scenarios based on the observations during the experiments;
- Recruited experiment participants focusing on the higher-aged group;
- Have had 245 participants completed the driving simulator experiments by December 31, 2015;
- Completed data archiving and analyses using the experiment data;
- Reviewed previous studies related to eye-tracking device and EEG sensor integration.

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Tested Background detection in Cartesian XYZ coordinates and identified limitations
- Improved tracking of objects in face of occlusion (Back Tracking)
- Refined technique for estimating dimension of vehicle

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Footprints*

- Collected highway traffic data of six Midwestern states
- Greenhouse Gas estimations from transportation for Ohio at county levels
- Development of Self Organizing Maps (SOMs) to group the counties in terms of emissions
- Incorporated “air pollution due to transpiration” and “Greenhouse gases” components into the course curriculum of “Air Quality Engineering”
- Trained students with MOVES, the Motor Vehicle Emission Simulator in collaboration with RAPCA.

*Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Design of framework for the agent-based dynamic information spreading and evacuation behavior model
- Literature review regarding the agent-based dynamic information spreading and evacuation behavior model
- Construct a nested logit form to describe information post/repost patterns through SNS
- Design surveys to collect data for understanding both information spreading and decision-making.
- Development of hybrid decision-making model

*Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Formulated a mixed integer dynamic capacitated intermodal facility location model
- Explored the impacts of several factors on commodity flow distribution.

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Analyze survey data
- Construct models for the data
- Design livability index

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Developed decision support tool to estimate the link driving cycles and machine learning model based on clustering algorithms.

*Research, Education and Outreach from Campus Transit Laboratory*

- Summarized directly observed CTL OD flows for stakeholders and research efforts
- Collaborated with a private company in conducting a Small Business Initiative Research (SBIR) Phase I project
- Prepared and submitted a paper based on CTL infrastructure and data
- Revised and resubmitted a paper for presentation using CTL infrastructure and data
- Collected CTL automatic passenger count (APC) and automatic vehicle location (AVL) data on a regular basis
- Collected directly observed CTL onboard bus route passenger origin-destination (OD) flows on a regular basis
- Developed a modification to manual CTL onboard bus route passenger origin-destination (OD) flows
- Processed CTL APC data for research and outreach efforts

- Estimated CTL OD flows from processed APC data
- Used CTL-derived knowledge and expertise for an externally funded “companion project.”
- Refined and used CTL-based education activities in one course
- Supervised efforts of a PhD student using CTL data in his research
- Provided CTL-based expertise in the context of a committee addressing formal planning for sustainable university resources

• Held discussions to apply CTL-based framework and concepts to anticipated university bike sharing program

*Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Continued to test and refine developed models for bus route-level transit passenger origin-destination (OD) flow estimation using automatic passenger count (APC) data capturing clusters of flow patterns across bus trips.
- Conducted additional numerical investigations and assessments of the refined models.
- Prepared a presentation for an international conference.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Continued developing a methodology to determine an appropriate number of clusters.
- Started assessing the refined models using empirical data on routes with familiar flow patterns and passenger trip purposes.

*Roadway Traffic Data Collection from Mobile Platforms*

- Investigated readiness of sensors and van platform to collect data on a regular basis
- Determined needed repairs to platform and required sensor replacement purchases for regular data collection

*Integration of ground access to airports in measures of inter-urban accessibility*

- MA Thesis written by Muzi Feng reviewed the project and produced maps.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Conducted a preliminary review of literature on chloride corrosion and carbonation of concrete structures
- Organized and held meetings with technical staff at the Ohio Department of Transportation

*Truck Activity and Wait Times at International Border Crossings*

- Received additional geo-fence based time and location data for trucks using border crossing facilities

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Rewrote computer codes to process geo-fence based time and location data more flexibly
- Debugged and ran new code with new geo-fence data and old geo-fence data for quality control
- Investigated reasons for results produced from debugged codes

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Research into various air quality sensors complete
- Selection and purchase of prototype sensors complete
- Selection and purchase of data acquisition platform complete
- Testing protocol for sensors established

*Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base*

- Gathered and chose appropriate quotations from focus groups and interviews to include in the final report.
- Expanded bibliography and included additional relevant citations in final report.
- Prepared graphics using InDesign to include in report.

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- A second round of data analysis was conducted based on feedback from the initial round of data analysis.
- The first draft of a manuscript presenting analysis results was revised to reflect the new analysis.

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Completion of database of New Mobility-allied industry sectors within Southeast Michigan.
- Finalized relational mappings for non-geospatialized data related to cluster formation
- Finalized New Mobility Cluster Catalyzing Projects mappings for several Southeast Michigan scenarios
- Completed revised Case Study Analysis for 3 existing New Mobility Clusters

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Develop new GIS-based data-driven analytic methods.
- Developed a framework and process for physical and spatial design.
- Prepare a framework and process to identify existing multi-source funding structures.
- Complete the execution of a series of spatial design prototypes.

### *Accessibility Analysis for Planning Decisions*

- Developed and tested a method for gauging the accessibility impact of proposed land-use changes.

### *Factor of Heavy Vehicles for Roundabout Design*

- Ongoing video data collection and processing; research literature review

### **Specific Objectives**

#### *Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Propose a method that can fully use multiple sources of data to estimate dynamic origin-destination demand matrices.
- Collect multiple sources of data on a real network.
- Calibrate/validate the method by the field collected data.
- Identify the optimal locations of node sensors and link sensors

#### *Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Provide a robust environment for driving simulator experiments.
- Explore the role of human factors in driver's perception and cognition of the provided information.
- Construct reliable models to better assess the comprehensive value of real-time travel information.
- Provide transportation policy makers and public/private transportation information providers better performance measures of the benefits of real-time travel information.
- Provide graduate and undergraduate students an opportunity to better understand the present state-of-the-art.

#### *Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Test the algorithm developed for background identification in XYZ Cartesian coordinates
- Account for false identification and occlusion problem

#### *Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Building an inventory of current GHG emissions from on-road vehicles
- Identifying or conceptualizing alternative transportation scenarios that could reduce the GHG emissions
- Incorporating transportation related educational components into Air Quality Engineering course
- Mentoring and training undergraduate students in transportation related air quality research

#### *Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Develop a multi-layer information propagation network
- Develop an agent-based evacuation decision-making model
- Develop a realistic model of vehicular/pedestrian flows and determine effective evacuation strategies

#### *Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Propose an intermodal facility location model that incorporates downside risk

#### *Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Proposes an interactive accessibility information intervention strategy
- Design an interactive online accessibility mapping application
- Conduct experiments and recruit participants to use the developed online accessibility mapping application

#### *A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Develop a similarity based clustering technique that finds the representative trajectories accounting for vehicular activities,
- Find optimal sets of Link Driving schedule (LDS) using representative trajectories on a link that can be input for MOVES to estimate emissions,
- Demonstrate the applicability of the technique.

#### *Research, Education and Outreach from Campus Transit Laboratory*

- Sustain, develop, and showcase the CTL as a living lab infrastructure supporting research, education, and outreach
- Archive and process data on passenger flows, vehicle locations, and community perceptions and travel patterns
- Develop seed research investigations, modules for coursework, training of students in data collection, and focused studies of immediate interest to service operators
- Develop collaborations with transit, transportation, and planning agencies and other investigators

#### *Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Improve transit passenger OD flow representation and estimation.

- Quantify the achieved improvements with respect to other state-of-the-practice and art methods.
- Demonstrate the feasibility of the new model and methods and their ability to produce interpretable results..

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Improve transit passenger OD flow representation and estimation.
- Quantify the achieved improvements with respect to other state-of-the-practice and art methods.
- Demonstrate the feasibility of the new model and methods and their ability to produce interpretable results.

*Integration of ground access to airports in measures of inter-urban accessibility*

- The project has been extended and the new objective of measuring airport access change has been added.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Gain a better understanding of underlying physical and chemical processes of corrosion initiation and progression.
- Identify databases (from ODOT and other state DOTs) for structural details and inspection records of bridges
- Revise and refine existing concrete bridge deterioration.
- Develop methods to update the parameters of these models on a regular basis as new data becomes available

*Roadway Traffic Data Collection from Mobile Platforms*

- Investigate and demonstrate ability to obtain meaningful traffic flow and speed estimates from a mobile platform.
- Determine reliable uncertainty quantifications for the traffic flow and speed estimates.
- Generate interest among potential stakeholders

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Obtain geo-fence-based truck time and location data for trucks crossing the Ambassador and Blue Water bridges
- Process data into information on times trucks incur at various activities at and near the Ambassador Bridge and Blue Water Bridge border crossing facilities
- Interpret processed information into results of general and targeted interest
- Deliver targeted information to stakeholders

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Identify key sensor components required for mobile air quality monitoring unit
- Develop and implement air quality monitoring unit on a mobile platform
- Collect ambient and transportation-related air quality data using mobile and stationary sensors.
- Investigate contribution of the data collected to that collected using stationary sensors

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- Finish the revised data analysis
- Publish the results in a peer-reviewed journal.

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Refine graphical depictions between regional assets, regional infrastructures, and new mobility opportunities.
- Refine description of specific industry agents within the new mobility economy
- Complete automation of the data to visualization process for industry sector cartographies

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Utilize a data-driven GIS-based platform to assemble and evaluate existing transportation system data, demographic data and the distribution of social service delivery.
- Identify existing and emerging private sector mobility solutions active within the study area.
- Produce a series of prototypical design solutions, at varying scales, locations and intensities of intervention for the Chicago metro.

*Accessibility Analysis for Planning Decisions*

- Develop a tool that would be accessible to planners in local practice to carry out an accessibility analysis of land development projects.

*Factor of Heavy Vehicles for Roundabout Design*

- Analysis flow behaviors during incremental time frames surrounding truck presence and non-presence

**Significant Results**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- The Bayesian method can fully use the correlation among multiple sources of data by using the variance-covariance matrix of all considered variables.
- The Bayesian method has good performance on non-congested network, while the performance is not so good on congested network.
- The Bayesian method does not converge using the field data collected in the network of Chennai, India. It is suspected that the field collected data still needs to be processed and improved.
- The sensor location model can determine the numbers of link and node sensors and their installation locations.
- The sensor location model can capture the impact of the time duration for which traffic data measurements are available on the optimal sensor deployment strategy

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Improved reliability of the experiments could be accomplished by precise demand calibration of microscopic traffic simulation and integration with the driving simulator software packages.
- Cognitive load is the most significant human factor that affects driver perception of real-time travel information.
- Drivers' individual attributes are important to determine the attitude toward the provided real-time travel information.
- To enhance the reliability, more comprehensive biosensors including electroencephalogram (EEG) are required and its calibration for each participant is critical to evaluate the driver's physiological burden precisely.
- Drivers' emotions derived from the travel context and real-time information in the experiments cannot reflect the realism because the simulated environment cannot simulate *urgency* associated with the travel context.

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Developed a method to account for false identification and a specific case of occlusion
- Developing a testing and evaluation methods based on tracking vehicles on video as a ground truth
- Developed polynomial fitting based testing of trajectories.
- Improved dimension estimation to better represent the object using entire history of point cloud
- In evaluating the algorithms with data, we discovered several limitations which we are endeavoring to overcome.
- Investigating a hybrid method of background removal that combines the strengths both special coordinate and Cartesian coordinate based background identification.

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Footprints*

- Determined that about 154000 metric tons of CO<sub>2</sub>, 1500 metric tons of NO<sub>2</sub> and 2500 metric tons of CH<sub>4</sub> are emitted daily in the state of Ohio in 2008.
- MATLAB based SOM was developed to classify the counties based on the greenhouse gas emission

*Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- The downside risk analysis reveals that investing in intermodal terminals is preferable to investing in ports.
- The expected system costs increases with lower allowed system level downside risk.
- The cost variance increases with lower allowed system level downside risk.

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Participants in the experimental group are statistically significantly different from participants in the control group.
- Simultaneous-equation models are applied to study the impact of the proposed strategy and other contributing factors.
- The proposed strategy, an individual's travel behavior before relocation, marital status, and frequency of accessing transportation related information have a strong correlation with the participants' neighborhood accessibility, and a participant's neighborhood accessibility has a significant impact on automobile usage.
- The developed interactive online accessibility mapping application is built on generally available data and provides personalized accessibility information to users,.

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Data collection from EPA inventory; post processing module of trajectory data for traffic simulator; cluster based algorithm for estimating disaggregate emissions;

*Research, Education and Outreach from Campus Transit Laboratory*

- CTL physical and institutional infrastructure were used for empirical validation studies in an FTA-supported, externally funded SBIR project in collaboration with a private company
- Value of using aggregated Wi-Fi data was investigated in a companion project

- OD flow data were manually collected and provided to researchers evaluating the performance of OD estimation models and data collection technologies
- CTL data and analytical techniques served as benchmarks for externally funded research conducted using Central Ohio Transit Authority data
- Discussions were held with a private company to develop a proposal for an external project using the CTL
- An environmental sensing project using CTL physical and institutional infrastructure was approved
- CTL infrastructure, data, and context were successfully used in an OSU transportation course taken by undergraduate civil engineering students

*Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- The variational Bayes aspect of the developed estimation method determines overall flow patterns that are superior in accuracy to those determined by state-of-the-practice and -art methods even when only one cluster is present.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- The method being developed to determine the appropriate number of clusters is generally equal to the true number of clusters assumed in the numerical simulation study.

*Integration of ground access to airports in measures of inter-urban accessibility*

- A paper describing our new airport access change has been submitted for peer review.

*Truck Activity and Wait Times at International Border Crossings*

- Obtained new data with refined geo-fences to be used in future project

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Produced, debugged, and checked new data processing codes that now seem to be working
- Determined that some new geo-fences need adjustments

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Several cost effective sensor options were identified for the detection of pollutants of interest.
- A blueprint for sensor unit design was completed

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Developed recommendations for the support of New Mobility industry sectors.
- Developed workshop method for project presentation to industry partners (forthcoming 2016).

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Identified a large number of existing and uncoordinated entities aiming to deliver access to Health, Learning, Food and alternate mobility options that are physically difficult to access given current physical locations, and transit connectivity.
- Leveraging publically-owned and operated spaces of transit infrastructure as a spatial product for access-delivery may produce significant cost savings and ease of access for transit users.
- IT-enabled access provision will form a significant and emerging domain in access provision in the coming years, and guidance is required to assist public officials in understanding the scope of transformation through rethinking existing single-use transit spaces as “platforms for access”.

*Factor of Heavy Vehicles for Roundabout Design*

- Preliminary results indicate a passenger car equivalent greater than the current HCM value of 2.0 PCE

**Key Outcomes and Other Achievements**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Field data on the link count and travel time information was collected from multiple sources in the network.
- Field data is analyzed and a Bayesian statistical method is proposed.
- The Bayesian statistical method is in the process of estimating dynamic O-D demand by field collected data in the network of Chennai, India.
- A sensor location model is proposed and applied in the network of Chennai, India.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- The driving simulator experiment scenarios were updated and finalized.
- The driving simulator experiments are being carried out and experimental data have been carefully archived and analyzed.

- Research findings and experiences have been summarized and presented in relevant international conferences.

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Determined a possible method for removing background from LiDAR data
- Implemented back tracking algorithm to better key variables.
- Tackled a specific case of occlusion using backtracking.
- Identified fundamental limitation of LiDAR for dimension estimation of objects. If over a period of time only the side of a vehicle is exposed, then it is hard to estimate the width of the vehicle accurately.

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Conference on Renewable Natural gas for transportation titled “Waste to Wheels II” at Central State University on December 2, 2015.
- Trained environmental engineering students in transportation related air pollution and greenhouse gases.

*Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Model can assist decision-makers in strategic intermodal facility investment planning.
- The results illustrate the importance of system-level and coordinated planning in strategic intermodal investment decision-making process.

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- An interactive online accessibility mapping application

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Decision support tool to assess disaggregate emissions at the local and city level.

*Research, Education and Outreach from Campus Transit Laboratory*

- CTL infrastructure and concepts were used in an externally funded project
- A presentation based on CTL data and concepts was accepted for a national conference
- Ten additional undergraduate students were recruited for data collection efforts

*Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Continued to produce additional numerical results that provide clear validation of the estimates.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- A presentation at a national conference was accepted.
- Additional results indicated that the method being developed to determine the number of clusters is promising.
- Supported promising numerical results using empirical data.

*Integration of ground access to airports in measures of inter-urban accessibility*

- A main finding is great stability in the access of nodes that are major hubs or gateways, but also a complex set of lower order places some of which need subsidy to overcome their intrinsic inaccessibility.

*Truck Activity and Wait Times at International Border Crossings*

- Additional data were obtained
- Transition to a new graduate research associate was completed

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Confirmed that codes were working properly
- Determined new truck activity time statistics

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- Identifying variables and the analyses completed to date have provided important inputs toward the creation of the algorithm to identify distracted driving and estimate the level of distraction.

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Preparation of key findings into a 10 minute film for distribution to project partners.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Developed and prototyped a methodology of evaluating potential for access-enabling architectures.
- Work has been assembled and disseminated to disciplinary venues, and a preliminary assembly of materials has been developed for dissemination in video format.

*Accessibility Analysis for Planning Decisions*

- We are also developing a web-based tool to support the more widespread use of this kind of analysis.



## **Efforts to Disseminate Results**

### *Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- One paper was submitted for presentation and publication in the 95th annual meeting of TRB.
- Another paper was in preparation for a journal submission.

### *Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Presentations in public forums
  - Climate impacts on the environment – Dr. Ramanitharan Kandiah, Presentation to the US President's Initiative; Central State University, Wilberforce, OH; 30<sup>th</sup> October, 2014
  - Waste to Wheel Conference – Dr. Sritharan, Dean of College of Science and Engineering discussed the environmental engineering program's efforts on estimating greenhouse gas emissions from the transportation sector in Ohio and six Midwestern states.
- Incorporated into course curriculum, "Air Quality Engineering" for undergraduate students

### *Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Presentations at international conferences
  - D. Song, Y. Hsu and S. Peeta, "Psychological effects of real-time travel information on route choice decision-making processes in multi-tasking travel environments", 14th International Conference on Travel Behaviour Research (IATBR 2015), July 2015.
- Abstracts accepted at international conferences (planned)
  - D. Song and S. Peeta, "Psychological Effects of Real-Time Travel Information for Heterogeneous Driver Classes", 7th International Conference on Applied Human Factors and Ergonomics (AHFE 2016).

### *Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Paper submitted for peer review (October 2015): - Scenario-Based Dynamic Model of System Level Strategic Intermodal Facility Investment Planning under Freight Transportation Demand Uncertainty
- Conferences:
  - INFORMS 2015. Philadelphia. "Downside Risk Analysis for Planning Intermodal Facility Investments"
  - TRB 2016. Washington. "Scenario-Based Dynamic Model of System Level Strategic Intermodal Facility Investment Planning under Freight Transportation Demand Uncertainty".

### *Research, Education and Outreach from Campus Transit Laboratory*

- Input to a final report based on CTL infrastructure and expertise was developed and submitted to prime, and final report was submitted to federal sponsor
- A paper for presentation at a national conference was written, submitted, and revised
- An executive summary for an externally supported project that used CTL expertise and was motivated by CTL results was developed and submitted to sponsor

### *Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Prepared and presented some aspects of the study at an international conference.

### *Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Submitted a paper for presentation at a national conference. (TRB)
- Prepared and submitted a paper for presentation at an international conference. (WCTR)

### *A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Paper to 14th World Conference on Transport Research to be held in Shanghai, China in July 2016. -- accepted.

### *Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Four undergraduate researchers will be presenting their work in upcoming undergraduate research forums on campus.
- Discussed concepts with local public health officials as well as faculty in the OSU College of Public Health.

### *Integration of ground access to airports in measures of inter-urban accessibility*

- We have submitted our work for peer review.

### *Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- The manuscript in preparation will be disseminated via publication in a peer-reviewed publication

### *Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven*

### *Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- SMART has a database of over 16000 transportation professionals and leaders worldwide. We have announced the work through our website (see <http://um-smart.org/blog>), through our targeted news, and we have held a range of multi-sector meetings where we have referred to the work.
- Project Team has engaged MTC at U Michigan <http://www.mtc.umich.edu/>. Zielinski named as part of Faculty Council, Thün invited to join MTC executive board. Project team will seek support to apply findings from this project to new work engaging autonomous vehicle sector / potential cluster in SE Michigan.
- Project team has made several presentations referring to the work in US and international meetings.
- Completing papers for submission to Journals.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Conference paper to national ACSA conference submitted and accepted.
- Journal Paper prepared, submitted to OASE, submitted and accepted.
- Work in progress presented at a range of SMART partner meetings throughout fall of 2015.

*Accessibility Analysis for Planning Decisions*

- We are currently revising an article for journal submission.

**Plans for Next Reporting Period (January - June, 2016)**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Use field collected data to calibrate and validate the developed model.
- Write a technical paper for publication in a journal and present the results in outreach conferences.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Design additional scenarios (travel context and information) to factorize biosensor data in the experiments.
- Recruit more participants to complete driving simulator experiments with biosensors.
- Collect data of participant's gaze points and focusing patterns using eye-trackers.
- Collect data from EEG devices to analyze driver's physiological burden.
- Analyze the experiment data to identify factors in traveler decision-making process and the psychological effects.
- Summarize research findings into journal papers and research reports and present our research findings.

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Develop a hybrid method of background identification
- Test backtracking for its effectiveness on multiple datasets with diverse traffic and climatic conditions.
- Improve trajectory estimation of bounding box of the object (vehicle/pedestrian).
- Classifying the tracked objects
- Developing an implementation version of the codes for real-time processing
- Integrate the user interface with the data collection
- Continue with testing and evaluation
- Evaluate SSAM interface with TScan

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Estimation of GHG emissions from transportation and identification of the GHG hotspots for Three more Midwestern states (MI, IN and IL)
- Using MOVES and GREET to estimate the GHGs with alternative energy sources as fuels for these states
- Presenting the findings in a peer reviewed national or international conference
- Training two more students in Spring-summer 2016 in MOVES and GREET software
- Sending one student for Summer research training with one of the NEXTRANS partners
- Purchasing ADR1500-Dust Monitor equipment for measuring particulates (PM<sub>2.5</sub> and PM<sub>10</sub>) from on-road vehicles.

*Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Survey regarding evacuation behavior and SNS use to collect data for understanding information spread through SNS
- Establish a nested logit model to address each respondent's SNS use in terms of trust in information and information dissemination
- Build an agent-based model to explore the interaction between the individuals including herding behavior under emergency situations
- Explore the effects of heterogeneous information through multiple dissemination sources on evacuation travel decision-making

- Analyze the traffic network-level interactions based on the evacuation-related decisions of drivers and pedestrians
- Develop a multi-layer network to capture the dynamic evolution and propagation of evacuation information from the multiple source of information
- Collect sample SNS data to calibrate the difference between stated preference (surveys) and revealed preference data under evacuation situations

*Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Developing framework to measure connectivity of intermodal facility terminals and ports.
- Paper planned for submission for peer review (early 2016): Risk Management in a Systems View of Intermodal Facility Investment under Uncertainty in Freight Commodity Flow

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Construct livability index

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Validate the model, fine tune decision support tool and finalize the project report.

*Research, Education and Outreach from Campus Transit Laboratory*

- Continue developing ways to use CTL physical and institutional infrastructure for new projects
- Discuss results and future efforts with transit, transportation, planning, and other agencies, and prepare and submit/deliver articles and presentations
- Collect automatic vehicle location (AVL), automatic passenger counter (APC), Wi-Fi derived OD flow, and directly observed OD flow data
- Exploit manual, web-based, and automatic data-driven investigations to generate and investigate research hypotheses
- Use CTL-based modules in OSU courses
- Develop analytical and methodological skills of graduate students; offer data collection opportunities for graduate and undergraduate students

*Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Refine additional numerical investigations.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Continue conducting empirical investigations to further validate the quality and interpretability of the flow estimates determined by developed model and estimation methods.
- Continue writing papers for submission for possible publication in peer-reviewed journals.
- Present at a national and international conferences.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Identify appropriate probabilistic models for prediction of initiation of corrosion deterioration and its progression over time in concrete bridge structures
- Examine the sensitivity of the selected models to their input parameters
- Identify bridges with concrete decks in the inventory of ODOT.
- Write the paper on the proposed framework for The World Conference on Transport Research (WCTR).

*Roadway Traffic Data Collection from Mobile Platforms*

- Calibrate replacement sensors and integrate with van platform; begin collecting empirical data; develop validation protocols

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Calibrate and test sensors under controlled laboratory conditions; Test sensors in outdoor mobile conditions
- Design and construct sensing housing unit for vehicle mount
- Upon finalization of prototype design, the fabrication of 10 more units will be undertaken.
- These units will be deployed on vehicles during the summer term, to obtain preliminary data for analysis.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Adjust erroneous geo-fences; Produce summary statistics and visualizations for stakeholder comparison

*Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base*

- Continue drafting of final report.

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- Finish second round of data analysis ; Finish manuscript revision/preparation and submit to a peer-reviewed publication; present results to peers at meetings/conferences

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Paper finalization for submission to journals.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Work from this grant has been presented to thought-leaders at Ford Motor Company, and a 2016-2018 Ford Alliance Grant of \$220K has been awarded to support further development of the project methodologies and applications in Southeast Michigan, and to produce a general toolkit to enable applications across US metros.

*Factor of Heavy Vehicles for Roundabout Design*

- Continue video data collection at roundabouts and further analyze data

## **PART 2: PRODUCTS**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Senlai Zhu, Hong Zheng, Srinivas Peeta, Yuntao Guo, Lin Cheng and Wei Sun. Optimal Heterogeneous Sensor Deployment Strategy for Dynamic Origin-Destination Demand Estimation. *In: Proceeding of the 95th Annual Meeting in Transportation Research Board, TRB 2016.*
- Senlai Zhu, Hong Zheng, Srinivas Peeta and Lin Cheng. A Bayesian method for dynamic origin-destination demand estimation synthesizing multiple sources of data. To be submitted to *Networks and Spatial Economics*.
- Technologies or techniques: The project use video camera, GPS and bluetooth to collect traffic data.
- Model: The project developed a traffic simulation model in AIMSUN.
- Model: The project developed a Bayesian statistical methodology to estimate origin-destination matrices that synthesize multiple data sources.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- D. Song, Y. Hsu and S. Peeta, "Psychological effects of real-time travel information on route choice decision-making processes in multi-tasking travel environments", 14th International Conference on Travel Behaviour Research (IATBR 2015), July 2015.
- S. Peeta, D. Song, S. He, S. Agrawal, Y. Guo and Y. Kim, "Design of interactive driving simulator experiments for real-time route guidance that capture human factors considerations", 6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015), July 2015.
- D. Song and S. Peeta, "Effects of cognitive load on traveler response under real-time travel information provision", 6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015), July 2015.
- W. Sun, S. Peeta, S. He, "Dynamic fatigue driving recognition based on double-level fusion", 6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015), July 2015.

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Publications, conference papers, and presentations
  - Climate impacts on the environment – Dr. Ramanitharan Kandiah, Presentation to the US President's Initiative; Central State University, Wilberforce, OH; 30th October, 2014
  - Waste to Wheel Conference – Dr. Sritharan, Dean of College of Science and Engineering discussed the environmental engineering program's efforts on estimating greenhouse gas emissions from the transportation sector in Ohio and six Midwestern states.
- Databases: Annual Average Daily Traffic (AADT) data; estimated annual Greenhouse Gases for Ohio
- Educational aides or curricula
  - One week 3Hr lecture presentation on Transportation related air pollution and MOVES for "Air Quality Engineering" course
  - Two hour transportation, environment and greenhouse gases related lecture for middle school and high school kids

*Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Presentations at international conferences: D. Song, Y. Hsu and S. Peeta, "Psychological effects of real-time travel information on route choice decision-making processes in multi-tasking travel environments", 14th International Conference on Travel Behaviour Research (IATBR 2015), July 2015.

*Intermodal infrastructure investment decisions and linkage to economic competitiveness*

- Paper submitted for peer review (October 2015), Transportation Research Records: Scenario-Based Dynamic Model of System Level Strategic Intermodal Facility Investment Planning under Freight Transportation Demand Uncertainty
- Conferences:
  - INFORMS 2015. Philadelphia. "Downside Risk Analysis for Planning Intermodal Facility Investments"
  - TRB 2016. Washington. "Scenario-Based Dynamic Model of System Level Strategic Intermodal Facility Investment Planning under Freight Transportation Demand Uncertainty"

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Conference paper: The impacts of interactive accessibility information on residential location choice and travel behavior: an experimental study, 4<sup>th</sup> symposium of the European Association for Research in Transportation
- Publication: The Impacts of interactive accessibility information intervention strategy on residential location choice and travel behavior, planned to submit to Transportation Research Part A

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Publication: Aziz, H.M. and Ukkusuri, S.V. Finding the link driving schedules LDS for integrated traffic emissions EPA-MOVES simulator by clustering with dynamic time warping measures. In review Transportation Research Part D (2015).

*Research, Education and Outreach from Campus Transit Laboratory*

- Publications, conference papers, presentations
  - Mishalani, R.G., M.R. McCord, and H. Reinhold M. Etefagh, 2015. Transit Route-level OD Flow Determination from Passengers' Mobile Devices' Wi-Fi Signals: Methodology and Empirical Evaluation. Under review for publication in Transportation Research Record (acknowledgement of federal support: yes)
  - Mishalani, R.G., M.R. McCord, and H. Reinhold, 2015. Transit Route-level OD Flow Determination from Passengers' Mobile Devices' Wi-Fi Signals: Methodology and Empirical Evaluation. Accepted for presentation at 95th Annual Meeting of the Transportation Research Board, Washington, DC (acknowledgement of federal support: yes)
- Websites: A website includes among other things, activities and results from this project: <http://transitlab.osu.edu/campus-transit-lab>
- Technologies, techniques:
  - Commercial-grade state-of-the practice automatic vehicle location technologies, passenger information systems, and automatic passenger counter technologies implemented on an operational bus service provide data that are regularly downloaded and stored
  - Systematic data collection using mobile-based Wi-Fi sensing technologies is regularly conducted, and techniques are developed to produce OD flow estimates from the data
- Databases: Databases that include bus location, position, and speed data, bus passenger boarding and alighting data, estimated and observed bus passenger origin-destination flows are developed and updated
- Physical collections: bus passenger origin-destination flows are manually collected; manually assisted, Wi-Fi based flow data are collected
- Software or NetWare: various codes for archiving, processing, and analyzing the rich and large datasets collected through the Campus Transit Lab are used
- Educational aids or curricula
  - Data obtained from the CTL, as well as the physical infrastructure, are used in classes
  - Data are provided to students conducting independent research or project activities not associated with the project
  - Hands-on experience in transit data collection is provided to graduate and undergraduate students associated with the project
  - Experience with practical transit planning and operations issues is provided to graduate students through outreach activities
- Instruments or equipment: collaboration with bus service operators is undertaken to maintain the sensing equipment on the bus fleet, the storage of data on the buses, the communication of the data to the server, the accompanying software to manage these processes, and the real-time passenger information system
- Data and Research Material: data that include bus location, position, and speed data, bus passenger boarding and alighting data, and estimated and observed bus passenger origin-destination flows are collected and stored
- Models: models needed to investigate preliminary hypothesis are developed, and validation studies are conducted for models developed under other projects

*Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- Publications, conference papers, presentations: Landgraf, A., Mishalani, R.G., Goel, P.K., McCord, M.R. Estimating Transit OD Flows using Boarding and Alighting Data: A Clustering-based Variational Bayes Method that Recognizes and Identifies Several Underlying Latent OD Matrices. Proceedings of the 13th International Conference on Advanced Systems for Public Transport to be held in Rotterdam, The Netherlands, 19-23 July 2015.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Publications, conference papers, presentations:
  - Landgraf, A., Mishalani, R.G., McCord, M.R. Goel, P.K. Estimating Transit OD Flows using Boarding and Alighting Data: An Efficient Variational Bayes Method and Clustering-based Extension that Recognizes Multiple Latent OD Flow Matrices. Submitted for possible presentation at the Transportation Research Board 95th Annual Meeting, Washington D.C.
  - Landgraf, A., Mishalani, R.G., McCord, M.R. Goel, P.K. Variational Bayes Method for Estimating Transit Route OD Flows using Boarding and Alighting Data in the Presence of Multiple Latent Flow Patterns: Methodology, Evaluation, and Validation. Submitted for possible proceedings publication and presentation at the 14th World Conference on Transport Research, Shanghai, China.
- Technologies, techniques: new techniques are developed that improve upon the estimation of transit passenger OD flows using APC data.
- Software or NetWare : various codes for applying the new estimation methods and for conducting the numerical and empirical investigations.
- Models: model for better representing transit passenger OD flows considering clusters of flow patterns across bus trips.

*Integration of ground access to airports in measures of inter-urban accessibility*

- Publication: Computation and interpretation of accessibility changes from spatial interaction data in the contiguous US air transport system; Yongha Park and M.E. O’Kelly. Paper submitted for peer review.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Publications, conference papers, and presentations: Shafieezadeh, A., Mishalani, R., “A Bayesian updating procedure based on visual inspection data for enhanced prediction of surface cracking in prestressed concrete bridge decks,” 14th World Conference on Transport Research, 10-15 July 2016, Shanghai, China, Abstract Accepted
- Software or NetWare: preliminary MATLAB code for probabilistic corrosion modeling of prestressed concrete bridge structures has been developed

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Technologies or techniques: vehicle location and timing technologies in use on operating trucks and virtual geofences are combined to produce unique datasets.
- Databases: aggregated longitudinal and disaggregated, truck trip-level databases are developed for truck times incurred in multiple activities. (Data are received from private trucking company, and truck trip-level data are not presently available for public dissemination.)
- Software or NetWare: various codes are developed to process raw data into times truck incur at various locations and to process truck trip-level times into summary measures
- Data and Research Material: unique aggregated longitudinal and disaggregated, truck trip-level data are amassed

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- A draft manuscript has been prepared and is currently being revised to reflect new data analysis

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Audio or Video products: Project video completed Dec 2015, currently being formatted for distribution via SMART project partner network (Spring 2016)

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Peer –reviewed conference paper: K. Velikov and G. Thün "Assembling Urban Platforms for Appropriation: Protean Prototypes," at ACSA 104th National Conference, Shaping New Knowledges, Seattle, WA, Mar. 17-19, 2016. (*presentation forthcoming*) - acknowledgement of federal support
- Peer-reviewed journal articles: K. Velikov, G. Thün, “Urban Platforms for Appropriation: Protean Prototypes” in *OASE Journal for Architecture: OASE #96: SOCIAL POETICS \_ The Architecture of Use and Appropriation*, E. Vervloesem, M. Goethals, H. Yegenoglu, M. Dehaene, Vol 96 2016 (*accepted: in final editorial review*) -- - *acknowledgement of federal support:*

- Databases: "Access-Enabling Agents in Chicagoland": excel-based geo-encoded database assembling public, NGO and private organizations delivering access to "Health, Learning, Food and alternate mobility options for the Chicagoland metro.
- Audio or Video products:
  - "Protean Prototypes: Access Enabling Architectures for Chicagoland Part I" (video) 19:31, <https://vimeo.com/108468499> -- This video assembles a range of city-wide maps prepared for the project illustrating the concepts of 'geographies of exclusion', and systems of delivery of access across themes of Health, Learning, Food and alternate mobility options for the Chicagoland metro. Video is currently published through Vimeo and linked to the RVTR Research Group website. (Total Views: Jan 15 2016: 124)
  - "Protean Prototypes: Access Enabling Architectures for Chicagoland Part II" (video) 7:59; <https://vimeo.com/108468500> -- This video illustrates the application of access- enabling architectures across three scales of transit intervention situated in the Chicagoland metro. Video is currently published through Vimeo and linked to the RVTR Research Group website. (Total Views: Jan 15 2016: 97)

#### *Accessibility Analysis for Planning Decisions*

- Conference presentation: "Project-Level Accessibility Analysis for Planning Practice." Presented at the conference of the Network on European Communications and Transport Activities Research, Ann Arbor, and the conference of the Association of Collegiate Schools of Planning, Houston.
- Website under development: technique for evaluating accessibility impacts under development and will be facilitated by a publicly available web tool.

### **PART 3: PARTICIPANTS & COLLABORATING ORGANIZATIONS**

#### **Partnership Organization Information**

##### *Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Collaborate with Gitakrishnan Ramadurai (Co-PI), Department of Civil Engineering, Indian Institute of Technology, Madras, India

##### *Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Indiana Department of Transportation via Joint Transportation Research Program, West Lafayette and Indianapolis, Indiana – supplementary financial support; advisory committee representing the end user

##### *Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Regional Air Pollution Control Agency (RAPCA)- Dayton, OH: Demonstration of Air quality measurements, guest lecture for Summer Transportation institute on Greenhouse gases, MOVES demonstration
- NETInCubator: Collaborated with Environmental Engineering Program to coordinate efforts at Central State University in organizing the Waste to Wheels Conference

##### *Research, Education and Outreach from Campus Transit Laboratory*

- The Ohio State University Department of Transportation and Traffic Management, Columbus, Ohio – financial support, in-kind support, facilities
- Clever Devices, Woodbury, New York -- in-kind support
- Ohio Department of Transportation, Columbus, Ohio -- in-kind support
- Mid-Ohio Regional Planning Commission, Columbus, Ohio -- in-kind support
- Central Ohio Transit Authority. Columbus, Ohio -- in-kind support
- Intelligent Automation, Inc., Rockville, Maryland -- in-kind support

##### *Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data*

- The Ohio State University Department of Transportation and Traffic Management, Columbus, Ohio – financial support, in-kind support, facilities

##### *Integrating multiple sources of data for the estimation of transit origin-destination flows*

- The Ohio State University Department of Transportation and Traffic Management, Columbus, Ohio – financial support, in-kind support, facilities

##### *Integration of ground access to airports in measures of inter-urban accessibility*

- The Ohio State University, Columbus, Ohio – Department of Geography and Center for Urban and Regional Analysis provided the platform for this work.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Ohio Department of Transportation, Columbus, Ohio – in-kind support

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Michigan Tech Research Institute, Ann Arbor, Michigan – in-kind support, facilities, collaborative research
- CEVA Logistics, worldwide offices – in-kind support

*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*

- University of Michigan Risk Science Center, University of Michigan School of Public Health Ann Arbor, Michigan – financial collaboration

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- NEXT Energy, Detroit, Michigan – data sharing, in-kind staff support
- Ford Motor Company, Detroit, Michigan – through University Research Project

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Ford Motor Company, Alliance project – financial support

*Accessibility Analysis for Planning Decisions*

- Alamo Area Metropolitan Planning Association, Alamo, Texas -- sharing its TELUM data.

### **Other Collaborators and Contacts**

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Faculty and research assistants from the Lyles School of Civil Engineering and the School of Mechanical Engineering
- PI is a member of the Advisory Board for European Union large program: InDev involving several European universities.

*Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Jin-Hyuk Chung, Professor (Co-PI) -- Department of Urban Planning and Engineering, Yonsei University, Seoul, Korea, Collaborative research – Pedestrian behavior and flow modeling in emergency situations
- Yu-ting Hsu, Professor, National Taiwan University -- Professor Yu-ting has a background of traveler behavior modeling under evacuation situations.

*Research, Education and Outreach from Campus Transit Laboratory*

- Civil Engineering, City and Regional Planning, and Statistics researchers and students.
- A faculty member at Tongji University uses CTL data for education and research purposes at his institution. NEXTRANS researchers are collaborating with same individual on activities of value to the project.
- CTL researchers collaborated with a company to conduct a validation study using CTL infrastructure.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Civil Engineering and Statistics researchers and students collaborate on various project activities.

*Roadway Traffic Data Collection from Mobile Platforms*

- Civil Engineering and Electrical Engineering researchers collaborate on various project activities

*Truck Activity and Wait Times at International Border Crossings*

- Michigan Tech Research Institute is a subcontractor and provide valuable services
- Data are obtained from international carriers, with focus on Canada-U.S. cross border trips.

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Undergraduate students in civil engineering, environmental engineering, and computer science working closely with a graduate student (advised by one of the Co-I's) to fabricate and test the first prototype.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Civil Engineering and Geography researchers collaborate on project activities
- Michigan Tech Research Institute is a subcontractor and provide valuable services because of their close proximity to the border crossing facilities
- Data are obtained from international carriers, with focus on Canada-U.S. cross border trips.

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- SMART is supported by over 40 advisors who are deans, department heads, directors and professors representing the full range of departments, institutes, and initiatives related to sustainable transportation at the University of



Michigan. This NEXTRANS Project has been presented to the SMART steering committee at its quarterly meeting, for feedback on refining methodologies and identifying partner organizations for whom the work would constitute value and impact.

- The NEXTRANS project is also synergistic with a wider SMART project on mobi platform, industry analysis and consumer uptake, sponsored by Ford Motor Company.

#### **PART 4: IMPACT**

##### **Impact on the Development of the Principal Discipline(s) of the Program**

###### *Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Introduce a new methodology to estimate dynamic OD matrices. The model is calibrated/validated using the field collected data.
- Introduce a new methodology to identify the numbers and locations of node sensors and link sensors for dynamic OD matrices estimation.

###### *Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Quantitative safety estimates and predictions will become possible because the availability of real data.

###### *Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- An environmental engineering program without any specific courses on transportation engineering, this grant helped to incorporate and train the students on the on-road transportation related pollution control.

###### *Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Multi-layer structure representing (i) information spread and (ii) evacuation decision (and behavior) can leverage the understanding of the relationship between characteristics of information propagation through different sources and the evacuation behavior.
- Agent-based approach in the context of evacuation decision and behavior can provide a descriptive explanation for key behavioral attributes.

###### *A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Estimating emissions will be important to take mitigation actions in urban areas

###### *Research, Education and Outreach from Campus Transit Laboratory*

- Add to the body of knowledge on transit travel behavior and transit operations and also motivate additional studies by the project research team and others. In addition, the results can inspire improvements in decisions taken by transit planners and operators that allow better transit service to be provided at lower cost.
- Successful implementation of course modules based on CTL activities, context, and data help promote the pedagogical use of “living laboratories” in Civil Engineering instruction.

###### *Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Improve the richness and quality of transit passenger OD flows representation and estimation using APC data, which in turn has the potential to improve the planning for and design of transit services in urban areas carried out by metropolitan planning and transit agencies.

###### *A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Improve the richness and quality of concrete bridge deterioration representation, estimation, and forecasting using regularly collected bridge inspection data, which in turn has the potential to improve the maintenance decision-making at state DOTs.

###### *Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Novel ways to monitor air quality and new contributions of existing transit bus platforms.

###### *Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Unique information on times trucks incur when crossing two of the busiest and highest valued freight border crossings in North America

###### *Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Novel methods not previously deployed in transportation economic planning as related to region system representation. This work will help to produce a context where the study of emerging industry sectors and related clean-tech clusters will be given greater attention in planning regional development, and specific policy development related to the promotion of regional industry clusters.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Illustrated and documented the value of access-based models to mobility infrastructure. Create new interest in this area of design activity.

*Accessibility Analysis for Planning Decisions*

- Tool to replace mobility-based analyses of land-use and transportation projects with feasible accessibility counterparts.

*Factor of Heavy Vehicles for Roundabout Design*

- Better decision making regarding the use of Highway Capacity Manual procedures regarding roundabout traffic flows and capacity.

**Impact on other Disciplines**

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- The heuristic integration of data performed by computer scientists, such as in Google autonomous cars will be replaced by rigorous sensor integration with guarantees, likely using few and less expensive sensors.

*A Novel Decision-Support Tool to Develop Link-Driving Schedules for MOVES*

- Potentially applicable in estimating health impacts.

*Truck Activity and Wait Times at International Border Crossings*

- Collaboration among Civil Engineering and Geography researchers help the different disciplines better understand the use of geo-spatial and sensing technologies in addressing practical transportation issues

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Faculty in the OSU College of Public Health and professionals from the Columbus Public Health Department are interested in the sensor technology for applications related to pollutant exposure and the education of vulnerable populations (e.g., asthmatics).

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Collaboration among Civil Engineering and Statistics researchers help Civil Engineering researchers better understand data analysis techniques and Statistics researchers gain experience by working in an applied setting.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Anticipated developments may inspire and motivate researchers in statistics to develop new methods that address the complexities of the project's application in terms of the nature of the inspection data and the accuracy needs of the deterioration forecasting models.

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- This type of visualization products produced through this effort have not been done before. Industry partners with whom the work has been shared have expressed interest and demand for application to other regional areas of study. We expect that this interest and demand will escalate relative to rates of urbanization and tipping points in the delivery of sustainable transportation.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- Transportation planners and decision makers at the civic and municipal level will be provided with tools, realizable examples and a framework to assist in the uptake of access-based paradigms in planning transformations to their respective systems.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities

**Impact on Transportation Workforce Development**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Graduate students worked in the domain of mathematical modeling and traffic simulation, data fusion, and route choice behavior.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Driving Simulator Lab can provide graduate students the opportunity to understand multiple dimensions of human factor studies in transportation.

- Undergraduate/graduate students in transportation can learn the practical use of microscopic traffic simulation.
  - Undergraduate students were provided the opportunities to improve professional skills in transportation.
- Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Minority students in the environmental engineering program are trained in software (MOVES and GREET) that transportation industry and regulating agencies use.

*Research, Education and Outreach from Campus Transit Laboratory*

- Undergraduate and graduate students regularly collect passenger flow information on CTL buses using manual methods and a Wi-Fi based sensing technology.
- Graduate students regularly process and analyze automatically collected CTL data.
- Students in multiple classes use CTL data and CTL infrastructure for course assignments and projects.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- One Ph.D. student works directly with APC data and applies data to solve a pertinent transportation flow estimation problem.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- A civil engineering student with a structures background will work with actual bridge inspection data and deterioration models and, as result, will become prepared to address the complexities associated with the infrastructure degradation and the decisions that support the necessary improvements over the long run.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities •*

- One graduate student applies analytical geospatial skills to a new application area

**Impact on physical, institutional, and information resources at the university or partner institutions**

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- The advanced driving simulator has unique capability of replicating/mapping a large city network and creating ambient traffic via integration to microscopic traffic simulation software (AIMSUN). It also has key implications for safety and effectiveness of information in the real world. With its advanced features, the driving simulator provides a robust and realistic driving experience for drivers.

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

- Support the development of an accessibility-based livability index structured to capture the six principles of livability established by the U.S. Department of Transportation.

*Research, Education and Outreach from Campus Transit Laboratory*

- Campus Transit Lab is a unique living laboratory that is used for research, education, and outreach. This project makes a major contribution toward providing the physical and human resource infrastructure required to develop, sustain, and take advantage of the laboratory.
- CTL results in the amassing of large datasets relating to transit passenger flows, transit vehicle operations, passenger information systems, and transit user and non-user perceptions and attitudes towards transit services.

*Integrating multiple sources of data for the estimation of transit origin-destination flows*

- Improved planning for and designing of transit services on campus.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- The experience with using state DOT data and the corresponding interactions with state DOT technical staff may motivate improvements to inspection protocols that support the organizations' data resources and facilitate the adoption of the developed deterioration models and parameter updating methods in practice.
- The estimation results arrived at could contribute to improved maintenance decision making at Ohio DOT.

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- The project anticipates using existing transit bus platforms at the university as platforms for air quality monitoring

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Sharing of database information between planning, engineering and business units at the University of Michigan. New database structures related to clean-tech industry clusters will be produced, and that gaps in data acquisition (specifically for non-traded private agents in these sectors) will be identified.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities •*

- Large and unique dataset on truck times when conducting multiple activities at two major border crossings

### **Impact on Technology Transfer**

#### *Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*

- Provide public sector transportation agencies a robust methodology that can synthesize multiple sources of data and thus provide more convincing results of dynamic origin-destination estimation.
- Provide an alternative to transportation planning agencies to obtain the dynamic OD information with relatively low cost.
- The technical method can contribute to a wide range of applications in transportation planning practice.
- Provide an alternative to transportation planning agencies to determine the numbers and locations of sensors with relatively low cost under budget constraints.

#### *Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Provide government and public sector transportation agencies an assurance that they are targeting their limited funds toward technologies that are most likely to improve the nation's highway system and deliver maximum benefit to travelers.
- Help traffic information service providers and investment decision-makers in understanding the value of real-time information and traveler behavioral response to it. Also, it will help in deciding the content and amount of information necessary for travelers to make informed and effective routing decisions.
- Ability to explicitly quantify the human behavior dimension provides a broader set of performance measures to public/private sector stakeholders relative to the evolution of the traveler information services market.

#### *Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Footprints*

- Provide a methodology in estimating transportation related GHGs and comparing the uses of different fuels.
- #### *Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*
- Interactive online accessibility mapping application used in the proposed intervention strategy is built on generally available and standard geographic and transportation data, and can be easily accessed through an online platform to provide personalized accessibility information based on people's work location and travel needs using different transportation modes (walk, bicycle, public transit, and automobile). It is readily replicable throughout a range of metropolitan context, and is proved to be beneficial to relocators, planners, and policy-makers

#### *Research, Education and Outreach from Campus Transit Laboratory*

- Amassed data are leading to results of research and practical value that are communicated via presentations and publications and external projects.

#### *Integrating multiple sources of data for the estimation of transit origin-destination flows*

- The estimation results arrived at are also expected to contribute to improved planning for and designing of transit services more broadly in Columbus and other cities if the model and methods are adopted.

#### *A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- The models and methods arrived at may also contribute to improved maintenance decision-making more broadly at state DOTs across the country.

### **Impact on Society beyond Science and Technology**

#### *Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*

- Help in developing a comprehensive understanding of the mechanism in which more benefits can be derived from real-time traffic information systems.
- Lead to direct benefits to the individual travelers, as it facilitates the design of personalized traffic information that can help commuters choose their routes based on their psychological benefits (which link to the quality of travel experience) in addition to travel time savings.
- Contribute to the development of better methods to provide information to travelers and enhance the quality and safety of the travel experience.
- Improve public access to and awareness of the positive and negative impacts of real-time travel information.

- Platform to educate middle and high school students in various dimensions related to driver performance, behavior, and safety.

*Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections*

- Make traffic modeling, estimation, prediction, and the meeting of safety specifications a matter of systematic scalable engineering rather than heuristics with large scale human intervention as it is today.

*Integrated Approach to Achieving Environmental Sustainability in Transportation: Coupling Energy Efficiency Solutions with Reductions in Environmental and Climate Foot prints*

- Helps the minority environmental engineering students and graduates who are underrepresented in the programs and the industry get opportunities to gain in knowledge, research experiences so that they will be competitive in the workforce.

*Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior*

- Improve the understanding of the impact of emerging information dissemination media for disaster response authorities and homeland security agencies
- Help transportation planners to develop coordinated and effective response system-level strategies under evacuation situation

*Information and Transportation Choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II*

The proposed intervention can also assist relocators to select residential location that is suitable to their travel needs, and thus reduce the mismatch between residential location after relocation and transportation needs of individuals or family

*Research, Education and Outreach from Campus Transit Laboratory*

- Improving transit services, increasing transit utilization, and enhancing transit efficiency, all of which lead to more socially, economically, and environmentally sustainable transportation systems.

*A Bayesian updating procedure for prediction of corrosion-induced cracking in pre-stressed concrete bridges using visual inspection data*

- Improving the forecasting of concrete bridge deterioration to support proactive maintenance decision-making by agencies responsible for managing critical infrastructure assets leading to improved safety and reduced user costs for road transportation of passengers and goods, and a more cost-effective use of resources in achieving such results.

*Truck Activity and Wait Times at International Border Crossings*

- Improving freight flow across international borders, which is essential to international competitiveness.

*Mobile air quality monitoring for local high-resolution characterization of vehicle-sourced criteria pollutants*

- Improved air quality monitoring could lead to improved quality of life; for example, information on air pollutant concentrations with higher spatial resolution than currently available may prevent negative health effects in vulnerable populations (e.g., asthmatics, the elderly).

*Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions*

- Produce data-based graphical analysis that enables cross disciplinary / cross jurisdictional discourse on an the economic conversion to address current transportation challenges.

*Access-Enabling Architectures: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability*

- For participants engaged through the pilot process efforts in Chicago -- direct opportunities across the various entities will be activated. Through dissemination of the final work to reach multiple end users within the Region V area cascading impacts resulting from the translational capacity of the proposed process and examples for future implementation and policy transformation opportunities.
- Fill significant gaps, including uptake of accessibility-based perspectives in the planning of transportation systems and the related system-based solution sets.

*Documenting and determining distributions, trends, and relations in truck times at international border crossing facilities*

- The overall project is focused on improving freight flow across international borders, which is essential to international competitiveness.

**PART 5: CHANGES/PROBLEMS**

No activity to report.