# Program Progress Performance Report for University Transportation Centers

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From Concepts to Deployment

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**Signed:** _____
Rick D. Evans, Managing Director

PURDUE UNIVERSITY
Discovery Park

## 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*
- Identified the network and types of field data for the case study. The network is located near the Indian Institute of Technology (IIT) Madras in Chennai, India.
- Developed a traffic simulation model in AIMSUN.
- Collected field data from multiple sources in the network.
- Developed the mathematical model for dynamic origin-destination demand estimation.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*
- Tested the driving simulator system comprehensively.
- Upgraded experiment software packages to improve experiment reliability.
- Analyzed the experiment data collected through pilot tests.
- Revised the analytical model based on the data collected through pilot tests.
- Revised experiment design, which includes the experiment network, computer program for triggering incidents and information provisions, and traffic demands for different scenarios.
- Hired undergraduate and high school interns

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*
- Completed case studies of impact of mobility-based evaluation in transportation and land-use planning
- Completed focus groups on barriers to accessibility-based evaluation and approaches to overcoming them
- Completed graphical representation of the distinction between accessibility-based and mobility-based evaluation at various geographic scales

*Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability*
- Develop application for IRB approval, questionnaire, literature review, and data for website

*Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base*
- Continued with conducting interviews with public officials at various levels of government, including local, regional, and federal, and document viewpoints on current data requirements and on the possibility of modifying current data to advance accessibility-based evaluation.
- Conducted focus group meetings with MPOs to understand current data reporting mechanisms, to propose and investigate how accessibility-related data might be provided, and to recommend the data and means of reporting that ought to occur.

*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 Case Study Analysis methodology to unpack agents and relations forming existing industry clusters (related to new mobility industry)
- Prototype Cartographic and Visualization standards for cluster description
- Develop industry database structure for evaluating agents within the new mobility economy.
- Coordinate NAICS industry classification structure with sector types included in expert evaluation of industries likely to be assembled within the new mobility economy.
- Completed 3 Case Studies related to New Mobility based on existing industry clusters within the Great Lakes Region: (Saguenay Aluminum Cluster, Michigan Battery Cluster, Ohio Polymer Cluster)

- Present work in Progress to industry representatives for methodology / legibility feedback.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Self-calibration of LiDAR motion
- LiDAR motion compensation using an inertial measurement unit
- Coordinates transformation
- Background detection and tracking

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- We have made the required modifications to the MARKAL model to incorporate CNG and LNG potential for trucks and buses and light duty vehicles. We presented a paper at the International Association of Energy Economics meeting in New York in June.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- Participation in the 12th International Conference on ITS Telecommunications (2012 IEEE ITST), November 5-8, 2012, Taipei, Taiwan.
- Research progress, including: 1. Reconfirm the research motivation and objectives; 2. Conduct a comprehensive literature review and comments; 3. Develop the theoretical models and mathematical programs; and 4. Design and conduct a preliminary case study.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Categorized the commonly used parameters from a periodic maintenance cycle in transportation infrastructure for each asset type and other relevant characteristics
- Assembled a database of parameters including all the categorized attributes
- Developed a variety of case studies of comparative efficiency analysis for different types of assets, performance measures, input/output parameters, and levels of maintenance coverage area
- Started the analysis phase, involving running the different case studies through data envelopment analysis (DEA) modeling as an implementation of comparative efficiency analysis method

*Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems*

- Integrated the dynamic traffic simulator with our existing agent-based model framework
- Integrated vehicle simulator (ADVISOR) developed by NREL to compute vehicle microscopic battery discharging pattern into our framework
- Integrated the residential electricity demand model, the electric vehicle energy consumption model, and detailed traffic network model into one multi-paradigm model
- Get rough results of electricity demand of EVs when traffic conditions are taken into account

*Truck Activity and Wait Times at International Border Crossings*

- Received and processed additional geo-fence based time and location data for trucks using the Ambassador Bridge and Blue Water Bridge border crossing facilities
- Produced time-of-day and day-of-week patterns in queuing times and compared to previously produced patterns
- Used disaggregate geo-fence based queuing time and inspection time data and aggregate Public Border Operators Association volume data to determine general associations between queuing times for individual truck trips and monthly average daily truck volumes and between queuing times for individual truck trips and individual inspection times at the Ambassador Bridge and Blue Water Bridge facilities
- Used geo-fence based data to estimate time-series models of queuing times and inspection times at the Ambassador Bridge and Blue Water Bridge facilities, controlling for month-of-year and day-of-week effects

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

- Coding of the 10,498 video clips in the project database was completed. The database was described in a previous progress report and consisted of 350 case clips (previously completed coding had

identified cell phone use by the driver) and 10,148 matched clips (clips of the same driver that did not show cell phone use and were matched on the same general time of day [daytime/nighttime], roadway, and traffic density as the case clip)
- The analysis dataset was finalized and included: secondary tasks engaged in (case clips only), hand position on steering wheel (left only, right only, both hands, no hands), eyeglance location, average speed, headway, minimum deceleration, maximum deceleration, number of lane deviations, braking, acceleration, lane boundary encroachment.

*Research, Education and Outreach from Campus Transit Laboratory*
- Produced empirical results and interpretations regarding quality of collected onboard-survey-based boarding-to-alighting data, APC data, automatic fare collection (AFC) data, and Wi-Fi data on Central Ohio Transit Authority (COTA) routes
- Delivered summaries of APC-based estimated OD flows and APC boarding and alighting data to stakeholders for campus-wide transportation planning (in response to request from Vanesse Hangen Brustlin, Inc., consulting firm, which is developing a long-term transportation and parking plan for OSU)

*Modeling CO2 Emissions as a Function of Transportation, Land-Use, and Regulation Variables*
- Continued to write and revised papers on the findings arrived at through the analysis of data on transportation supply and demand, urban form, policy, and CO2 emissions in US urban areas.
- Begun investigating previously organized data on non-US urban areas around the world from multiple sources.

**Specific Objectives**

*Field Data Based Data Fusion Methodologies to Estimate Dynamic Origin-Destination Demand Matrices from Multiple Sensing Technologies*
- Use field collected experiment data and the analytical models developed the state-of-the-art methodology in origin-destination demand matrix estimation.
- Develop a data fusion methodology to synthesize multiple sources of data.
- Develop a comprehensive methodology to estimate the origin-destination demand matrices that synthesizes multiple sources of data.
- Use field collected experiment data to calibrate and validate the developed model.

*Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs*
- Establish and sustain the Driving Simulator Lab as infrastructure to conduct interactive experiments using travelers so as to perform research on driver behavior and safety as well as policy and market aspects of Advanced Traveler Information Systems.
- Develop a comprehensive methodology to better assess the potential value of real-time information to travelers.
- Exploit synthetic driver choice behavior data to construct reliable quantitative models for evaluating Advanced Traveler Information Systems using performance measures beyond travel time benefits.
- Use archived interactive experiment data and the analytical models developed as educational materials to help graduate and undergraduate students better understand the present state-of-the-art in human performance modeling and related safety aspects.
- Use the Driving Simulator Lab platform to generate education modules to highlight various dimensions related to driver performance, behavior, and safety for middle and high school students.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*
- To research four questions: what has been the impact of mobility-based planning, what difference would a shift to an accessibility basis make, what are the obstacles to that shift, and what are approaches to overcoming those obstacles?

*Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability*
- test impact of information provision on combined residential-location decision and travel behavior for

newcomers to Ann Arbor, MI and Lafayette ,IN

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

- The final product will explain practices in data standardization that we discover through the historical analysis, document the current state of practice in data collection, and propose a means for achieving a standardized collection of data to support accessibility metrics at the national level.

*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*

- Utilize Case Study Analysis of existing industry clusters to predict factors affecting cluster formation
- Utilize Case Study Analysis to identify role of policy in shaping regional assets underlying cluster formation.
- Deepen understanding of relationship between underlying regional assets, extant regional infrastructures, and nascent new mobility opportunities (events) in producing emerging industry clusters.
- Produce description of specific industry agents within the new mobility economy via existing industry classification structures (NAICS & Others)
- Develop standardized visualization techniques for industry cluster description (geospatialized and relational mappings)

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Detection of static background planes
- Estimation of translation and rotation of static background planes to estimate LiDAR motion
- Estimation of LiDAR motion with inertial measurement unit
- Compensation for LiDAR motion induced by wind-structure interaction

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- The major objective of this research is to evaluate a series of natural gas for transportation policy options and to compare them with existing options for electric vehicles, biofuels, CAFE standards, etc. The policy incentives that will be considered are: 1) incentives to create natural gas fueling stations, 2) subsidies for natural gas vehicles comparable to the benefits provided to the country from their use, 3) incentives for retrofitting gasoline vehicles for conversion to CNG, and 4) incentives for fleet adoption of CNG.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- To estimate a set of time-dependent intersection turning proportions using information from partial link traffic counts and limited observed turning proportions provided by heterogeneous sensor technologies;
- To address the optimal heterogeneous sensor location deployment problem that maximizes observability in terms of the turning proportions at intersections; and to design and evaluate the developed adaptive traffic signal control (ATSC) logic based on traffic simulation experiments.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Setting up parameters for analysis and testing the interaction between parameters
- Preparing case studies and perform DEA modeling of decision making units in a maintenance cycle

*Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems*

- Develop a flexible framework to study various car designs and technology advances using realistic drive cycles
- Evaluate energy demand curves for 5 Indianapolis zones
- Analyze the electricity demand of transportation system in detailed traffic conditions
- Integrate the effect of the operation of transportation system on electricity demand of EVs

*Truck Activity and Wait Times at International Border Crossings*

- Obtain geo-fence-based truck time and location data for trucks crossing the Ambassador and Blue Water bridges
- Process data into information on times truck 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

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

- There were three specific objectives during the current period: Finish coding the video clips. Prepare and finalize the dataset for analysis. Begin data analysis

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

- The findings reported above have helped the investigators begin identifying variables that potentially predict distracted driving and the analyses completed to date have provided important input toward the creation of the algorithm to identify distracted driving and estimate the level of distraction using kinematic/driver performance indicators.

*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 related to a technology-enhanced transit service
- Exploit CTL to 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 based on CTL-related activities

*Modeling CO2 Emissions as a Function of Transportation, Land-Use, and Regulation Variables*

- Document findings based on US data in the form of papers.
- Examine relationships among transportation supply and demand, urban form, policy, and CO2 emissions variables in non-US urban areas.
- Compare US and non-US results and consider possible combined analyses if the nature of the data-sets allows.

**Significant Results**

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

- The simulation model was integrated and tested through comprehensive tests. The simulation model in AIMSUN was calibrated and validated; the link count data matches the traffic volume in the simulation model.
- Cameras were setup at 16 intersections. In total there are 32 cameras. Those video cameras can provide link count data.
- Bluetooth is setup in 5-6 locations. The market penetration of Bluetooth is about 7%-8%. Bluetooth data can provide route travel time information.
- GPS data is setup. The market penetration of GPS data is about 15%-20%. GPS data can provide route travel time information.
- The field data indicates that in the selected network traffic is not in the user equilibrium.

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

- The driving simulation system was further tested through comprehensive pilot tests.
- The traffic module of the driving simulation system was not able to handle some experiment

scenarios with heavy traffic demands. The simulation software crashed due to the large-scale transportation network and heavy traffic.

- The traffic module of the driving simulation system was not able to recover from a pause status, which is needed during the driving simulator experiment to allow participants to fill out the survey related to their en route decisions and their perception of real-time information.
- Traffic cannot be assigned into the experiment network under some circumstances.
- These issues have been reported to the vendor for solutions. The driving simulation software was updated; however, some issues remain unsolved.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- Case study analyses illustrate impact of mobility-based evaluation on both transportation and land-use planning.
- Focus groups and interviews explore obstacles and approaches to overcoming them

*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*

- Identified significant relationships between underlying regional assets, extant regional infrastructures, and nascent new mobility opportunities (events) in producing industry clusters, not currently captured within dominant tropes of cluster mapping practices.
- Development of standardized visualization formats capable of describing geospatial and relational networks of new mobility cluster agents. Geospatial format and Relational Formats developed and tested.
- Application of techniques developed in first phase of project to be applied to Region V / SE Michigan (underway)

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Developed algorithms for plane detection and tracking with precise statistical properties that depend only on the resolution and precision of the LiDAR sensor used.
- Quantified the statistical properties and evaluated with data.
- Determined the sensitivity of both detection and estimation algorithms.
- Developed a procedure to adjust the measurements for the motion of the LiDAR using an Inertial Measurement Unit (IMU) and the Extended Kalman Filter (EKF).
- Developed computer codes for all the algorithms as open-source routines. In evaluating the algorithms with data, we discovered several limitations which we are endeavoring to overcome.
- The sensitivity of the plane detection and tracking increases (estimation error increases) with the distance and the reduced measurement density.
- LiDAR reference coordinate system cannot be adjusted successfully with the background planes because of the above sensitivity.

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- When a subsidy equivalent to that provided to electric vehicles is provided to natural gas vehicles, there is significant penetration of CNG, especially in the truck and bus fleets.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- A nonlinear least square (NLS)-based intersection turning proportion estimation model using heterogeneous traffic information is developed and evaluated.
- Using link flow information to estimate turning proportions of a unidirectional network is acceptable, but satisfactory results cannot be obtained due to the highly underdetermined problem.
- Incorporating heterogeneous traffic information into the estimation model can improve the estimation accuracy by deploying different sensors in a strategic manner.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Database of parameters in a maintenance cycle for each asset type
- Results from parameters interaction test confirming usage of parameters in case studies

- Results from case studies showing significant parameters that affect efficiency of maintenance resource allocation strategy

*Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems*

- When considering traffic conditions, the electricity demand of EV decreases about 5% compared with no traffic case

*Truck Activity and Wait Times at International Border Crossings*

- Preliminary results using disaggregate (truck trip level) geo-fence data with aggregate (average) truck volume data are showing strong statistical relations, indicating the potential of using the data collected in this project for modeling
- Strong month-of-year and day-of-week components were found in time-series analyses
- Differences in magnitudes and temporal patterns of recently processed and previously processed queuing times were observed

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

- Preliminary Markov analyses within driver have shown that lateral measures of driving performance (e.g. steering, lateral speed) have different predictive tendencies than longitudinal measures of driving performance (e.g. average vehicle speed, acceleration).
- Preliminary analyses completed during this period using the population spline fitting approach focused on the speed variables and showed more speed variability by drivers during case clips than during control clips.

*Research, Education and Outreach from Campus Transit Laboratory*

- Observed OD flow data were collected and summarized. Results were also provided to researchers evaluating the performance of OD estimation models and to other students not connected with the CTL project
- Value of using aggregated Wi-Fi data, either as direct estimates or in combination with APC data, was observed

*Modeling CO2 Emissions as a Function of Transportation, Land-Use, and Regulation Variables*

- Indications suggest that pertinent relationships among transportation supply and demand, population density, and CO2 emissions variables seem to be reflected in non-US urban areas.

**Key Outcomes and Other Achievements**

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

- The field network was selected in Indian Institute of Technology Madras, Chennai, India.
- A traffic simulation model was developed, calibrated and validated.
- Field data on the link count and travel time information was collected from multiple sources in the network.
- An analytical framework for dynamic origin-destination matrices estimation was developed.

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

- Comprehensive pilot tests were carried out.
- The driving simulation system was updated.
- The analytical formulation for evaluating the value of travel information was tested and revised using the data collected through the comprehensive pilot tests.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- In addition to results above, graphical analysis presented in primer form for practitioners

*Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability*

- Website under development and testing (led by Purdue partners)

*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*

- Dissemination of cartographic methods in development to advisory groups for feedback.
- Stakeholder meetings with key representatives of industry sector to discuss methods and comment on visualization legibility of representations and database-related methods.
- Retention of major industry player to support expansion of project (Ford Motor Co.)
- Invitation to present methods and techniques form the Province of Gelderland in the Netherlands

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- We have determined the best possible primitive for detection and tracking—planes.
- We have determined that integration of an inertial unit is essential to calibrate out LiDAR motion. Our inertial integration can estimate even 1 mm motion in the sensor position.

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- The CNG subsidy has a considerable impact on the makeup of the transportation fleet. It is clear that natural gas market penetration is much higher when natural gas vehicles have an equivalent subsidy to the PHEV subsidy.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- This research will help transportation/highway management agencies to determine a desirable sensor deployment plan in terms of how to prioritize the critical links for different sensor characteristics under an annual budget constraint.
- The results and findings of this research will be submitted to a peer-reviewed journal and the 2015 TRB annual meeting.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Preliminary analysis results showing how significant parameters are affecting efficiency of maintenance cycle
- Positive associations were seen between publicly available volume data and disaggregate queuing time data obtained with the geo-fence approach and between disaggregate queuing time and disaggregate inspection time data obtained with the geo-fence approach
- Time series models were estimated to allow analysis of queuing and inspection times through time

*Truck Activity and Wait Times at International Border Crossings*

- Positive associations were seen between publicly available volume data and disaggregate queuing time data obtained with the geo-fence approach and between disaggregate queuing time and disaggregate inspection time data obtained with the geo-fence approach
- Time series models were estimated to allow analysis of queuing and inspection times through time

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

- The findings reported above have helped the investigators begin identifying variables that potentially predict distracted driving and the analyses completed to date have provided important input toward the creation of the algorithm to identify distracted driving and estimate the level of distraction using kinematic/driver performance indicators.

*Research, Education and Outreach from Campus Transit Laboratory*

- Value of using aggregated Wi-Fi data collections, either as direct estimates or in combination with APC data, was observed

*Modeling CO2 Emissions as a Function of Transportation, Land-Use, and Regulation Variables*

- Documented the results based on US data.
- Identified indications of pertinent relationships among variables in non-US data.

**Efforts to Disseminate Results**

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

- In preparation of technical paper, writing for publication in a journal.

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

- Prepared a research paper for the coming INFOMRS 2014 Annual Meeting.

*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 16,000 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. We plan to have a meeting in March with New Mobility thought leaders and University of Michigan faculty to present interim results and get feedback
- Invited to present work in Progress at Wageningen Research University in the Netherlands
- Invited to present work in Progress at University of Trento IT
- Paper abstract accepted to 2015 Spaces and Flows in Chicago, IL

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Presentation at the 2014 NATMEC Improving Traffic Data Collection, Analysis, and Use conference in Chicago, June 2014
- Two publications in preparation to present the research results obtained so far: LiDAR self-calibration using plane detection LiDAR motion calibration using an Inertial Measurement Unit

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- We will submit a journal article shortly from this research. There was considerable interest in the research at the IAEE/USAEE meetings in New York in June.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- A research paper compiling the results of the project is being prepared. After this project is completed, this paper will be submitted to publications in transportation/engineering research

*Truck Activity and Wait Times at International Border Crossings*

- A paper based on project results was included in a conference compendium
- A poster presentation was made at a national conference
- An MS thesis is being developed based on aspects of this project

*Research, Education and Outreach from Campus Transit Laboratory*

- Multiple in-person and teleconference discussions on CTL data and insights were held with consultants, campus planners, and bus service administrators developing a long-term transportation and parking plan for the university
- Data were provided to students not affiliated with the project for research and course project purposes
- Technical articles were revised and developed for submission to journals

*Modeling CO2 Emissions as a Function of Transportation, Land-Use, and Regulation Variables*

- Indications suggest that pertinent relationships among transportation supply and demand, population density, and CO2 emissions variables seem to be reflected in non-US urban areas.

**Plans for Next Reporting Period (July – December, 2014)**

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

Develop and refine the methodology to estimate the origin-destination demand matrices that synthesizes multiple sources of data.

- Use field collected data to calibrate and validate the developed model.
- Present the results in outreach conferences.

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

- Continue participant recruitment.
- Conduct the designed experiments using the driving simulator with interactive surveying system.
- Analyze the experiment data to identify factors in traveler decision-making process and the psychological effects of travel information provision.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- Write report based on results

*Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability*

- Because of the lack of next-round funding at the NEXTRANS center, the second phase of this project not being proposed or pursued at the Ann Arbor site -- only Lafayette

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

- Summarize and synthesize the findings from meetings with MPO representatives.
- Continue writing final report.

*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*

- We anticipate continuing to advance refinement of the cartographic techniques developed to date applied to South East Michigan as per original grant proposal (see Part 5 below). At the end of the project period, we anticipate completion of a first series of relational and geospatial representations of the emerging industry sections within the study region, a methodological description of the construction and translational details of the project's production, and the presentation of this work to disciplinary audiences, as well as to industry partner organizations for additional feedback beyond that solicited during the project's development.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Develop an identification and tracking algorithm based on the 3D clustering and constrained EKF. The constraints will incorporate the known properties of the objects' and their motion.
- Test and evaluate the developed identification and tracking algorithm.
- Develop a detailed concept of incorporating video cameras (one or two) to the tracking algorithm.

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- We will complete all phases of the research and publications.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- A comprehensive evaluation of the developed model framework and solution algorithms based on both a hypothetical network and a simplified real road network.
- Summary of the research findings and policy implications in the final report.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Complete the project by the end of August - Deliver final report

*Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems*

- Study the discharging patterns under different traffic conditions for the 5 Indianapolis zones in detail
- Finish Indianapolis transportation network
- Use detailed drive cycle data in different time periods (peak, median, and low) to get more accurate results of energy demand.

*Truck Activity and Wait Times at International Border Crossings*

- Obtain, process, and analyze new data
- Meet with project partners
- Investigate quantitative relations among queuing time, inspection time, and volume data
- Develop relations with expected stakeholders

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

- Next steps for the Markov approach include aggregating the individual driver data to build a general

group model.
- Next steps for the population spline fitting approach include expanding the analysis to include more driver performance variables, cluster analysis, and random forests.
- Preliminary results will be disseminated to peers at meetings/conferences

*Research, Education and Outreach from Campus Transit Laboratory*
- Data collection: Collect automatic vehicle location (AVL), automatic passenger counter (APC), Wi-Fi based flow, and directly observed OD flow data
- Research: Exploit manual, web-based, and automatic data-driven investigations to generate and investigate research hypotheses
- Education: Use CTL-based modules in OSU courses, develop analytical and methodological skills of graduate students, offer data collection opportunities for graduate and undergraduate students
- Outreach and communication: Discuss results and future efforts with transit, transportation, planning, and other agencies, and prepare and submit/deliver articles and presentations

**PART 2: PRODUCTS**

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

Technologies or techniques: Project uses video camera, GPS and Bluetooth to collect traffic data.
Model: The project developed a traffic simulation model in AIMSUN.
Model: The project developed a 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*

Websites: Experiment website is available at: www.purdue.edu/drivingsimulator

*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*

Publications, conference papers, and presentations: SMART has referred to the work at numerous events and within presentations. The work is also referred to in the final internal report on the recently completed Rockefeller Foundation-funded project "Catalyzing the New Mobility in Cities" as well as in the recently completed Alcoa Foundation funded project "New Mobility Solutions for Detroit and Beijing regions, and Fostering New Mobility at the Ross Business School"
Website: SMART has referred to the work on the SMART blog / e-news; as well as in the new "SMART AT ROSS" website created for the Alcoa Foundation funded New Mobility Solutions project
Educational aids or curricula: Courses on MetaShed and Cartographic Methods
Data and Research Material: (Regional Industry Agent Data Gathering / Database design)

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

Publications, conference papers, and presentations: Presentation on the NATMEC Improving Traffic Data Collection, Analysis, and Use conference
http://onlinepubs.trb.org/onlinepubs/conferences/2014/NATMEC/Tarko.pdf

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

Publications, conference papers, and presentations: Conference proceedings of The 12th International Conference on ITS Telecommunications (2012 IEEE ITST), November 5-8, 2012, Taipei, Taiwan.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

Technologies or techniques: An innovative method of identifying factors affecting efficiency of resource allocation in maintenance of transportation infrastructure.
Databases: Database of parameters for each asset type in a maintenance cycle. The database and all the metadata will be included in the final report.
Models: The nonparametric statistical models of data envelopment analysis based from the case studies will be included in the final report.

*Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems*
Models: A residential electricity demand model has been built based on a exist model. The model is created in AnyLogic. An integrated model has been creating based on the residential electricity demand model, the EV energy consumption model (ADVISOR), and an Indianapolis transportation network model.
*Truck Activity and Wait Times at International Border Crossings*
Conference paper: McCord, M.R., N.L. Sell, and J. Zaetz, "Aggregate Truck Queuing Time Relations at the Ambassador Bridge and Blue Water Bridge Border Crossing Facilities," 93rd Transportation Research Board Annual Meeting, compendium of papers, January 2014
Presentation: McCord, M.R., J. Zaetz, and N.L. Sell, "Aggregate Truck Queuing Time Relations at the Ambassador Bridge and Blue Water Bridge Border Crossing Facilities," presentation at the 93rd Transportation Research Board Meeting, Washington, DC, January 14, 2014
Technologies or techniques: Vehicle location and timing technologies in use on operating trucks and virtual geo-fences 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.
Models: Contingency tables relating disaggregate queuing times to average daily truck volumes and to inspection times were developed. Longitudinal time-series models of truck queuing times and inspection times were developed
*Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving*
Database: A database has been created for this study that contains the following variables for 10,498 video clips: secondary tasks engaged in (case clips and non-control matched clips only), hand position on steering wheel (left only, right only, both hands, no hands), eyeglance location, average speed, headway, minimum deceleration, maximum deceleration, number of lane deviations, braking, acceleration, lane boundary encroachment. With data analysis ongoing, this database has not yet been shared.
*Research, Education and Outreach from Campus Transit Laboratory*
Website: 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 provided data that were regularly downloaded and stored. Systematic data collection using mobile-based Wi-Fi sensing technologies was conducted, and techniques were 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 were updated.
Educational aids or curricula: Data obtained from the CTL, as well as the physical infrastructure, were used in a mixed undergraduate/undergraduate course taken by civil engineering and city and regional planning students
Data and Research Material: Data that include bus location, position, and speed data, bus passenger boarding and alighting data, estimated and observed bus passenger origin-destination flows were updated.
Models: Models to investigate the effect of removing a bus on passenger loads and wait times were revised.

## 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*

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

*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, 461 Burroughs St., Detroit: SMART collaborates closely with NEXT Energy, Michigan's Clean Tech / Energy industry accelerator supported by MEDC. We have had ongoing discussions with NEXT Energy regarding this project and its value to Michigan. The nature of the collaboration has involved data sharing related to the Power Electronic Sector in Michigan, Clean Tech. Industry sector, and in-kind support related to staff time.

PolymerOhio, Inc. 155 Commerce Park Drive, Suite 8, Westerville, OH 43082 PolymerOhio is a not-for-profit organization aimed to help catalyze growth of Ohio's Polymer cluster. The agency has shared a portion of their Partner Database to assist this project in developing cluster representation techniques, in exchange for sharing project outcomes.

Michigan-based NGOs including Michigan Environment Council and Trans4M, a coalition of Michigan based sustainable transport efforts.

Ford Motor Company. NEXTRANS work inspired Ford to support a 3-year URP project to apply aspects of this project effort to other global regions.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

National Cheng Kung University, Tainan, Taiwan: Partial financial support for graduate students and facilities

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

University of Michigan Risk Science Center, School of Public Health; financial, collaboration.

*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. Clever Devices, Woodbury, NY In-kind support. Ohio DOT, Columbus, OH, In-kind support. Mid-Ohio Regional Planning Commission, Columbus, OH, In-kind support. Central Ohio Transit Authority, Columbus, OH, In-kind support.

### Other Collaborators or Contacts

*Research, Education and Outreach from Campus Transit Laboratory*

| Interdepartmental or interdisciplinary collaborations | Collaborations or contact with others outside the NEXTRANS Center | Collaborations or contacts with others outside the United States or with an international organization. |
|---|---|---|
| Civil Engineering, City and Regional Planning, and Statistics researchers and students collaborate on various project activities. | 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. | A faculty member at Tongji University (China) 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. |

*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 representing the full range of departments, institutes, and

initiatives related to sustainable transportation at the University of Michigan. SMART also has its own global network of city leaders involved in the SMART Systems network, consisting of over 50 city leaders from 5 continents.

**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.
- Introduce a new data fusion method to synthesize multiple sources of data.
- The new methodology synthesizes multiple sources of data and thus provides better estimation than existing approaches.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- Urban transportation planning: promoting paradigm shift to accessibility-based planning

*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*

- The principle disciplinary groups participating in this project are urban and regional design and planning, and geospatial and relational data visualization. To this end, the techniques developed through this project to date include a number of novel methods not previously deployed in transportation economic planning. We anticipate that 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. The visualizations produced through this project are a novel contribution aiming to produce new graphical products to inform the ways in which multiple disciplinary experts are able to understand sector development and agent composition structured geospatially and across time.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- Collection and analysis of safety and traffic data at intersections in a cost-effective manner. It will help develop and evaluate better methods of rapid safety measurement via surrogates.

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- There is a much better understanding of the possible role of natural gas in our transportation system.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Using comparative efficiency analysis method to identify significant factors/parameters in a maintenance unit's history of maintenance cycle helps maintenance managers understand better how their systems work, allows maintenance managers to review efficiency of prior work, makes it easier for the maintenance managers to plan better resource allocation strategy in subsequent maintenance cycles, and enables maintenance managers to establish efficiency guideline to estimate the outcome of a maintenance cycle

*Truck Activity and Wait Times at International Border Crossings*

- Results from project activities provide unique information on times trucks incur when crossing two of the busiest and highest valued freight border crossings in North America.

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

- The work accomplished to data shows promise in leading to the development of algorithms for global identification of distracted driving, as well as those that are specific to the individual driver. These could be used in tandem for both research and practical purposes to enhance driver awareness and safety.

*Research, Education and Outreach from Campus Transit Laboratory*

- Results from project activities 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.

**Impact on other Disciplines**

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- Similar transformation for transportation engineering, economics

*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*

- We expect that the work produced through this grant project will be of particular significance to industry development and economic development (especially jobs / workforce development in a changing, urbanizing, technology-driven landscape). The types 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.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- The heuristic integration of LiDAR and video data will be replaced by rigorous sensor integration with guarantees, likely using few and less expensive sensors.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Using comparative efficiency analysis method to identify significant factors/parameters in a maintenance unit's history of maintenance cycle:- Helps maintenance managers understand better how their systems work- Allows maintenance managers to review efficiency of prior work- Makes it easier for the maintenance managers to plan better resource allocation strategy in subsequent maintenance cycles- Enables maintenance managers to establish efficiency guideline to estimate the outcome of a maintenance cycle

*Truck Activity and Wait Times at International Border Crossings*

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

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

- The ability to identify events of distracted driving would allow the first large-scale epidemiologic studies of driver distraction to be conducted, and the population characteristics and correlated of distracted drivers and their driving behavior to be described, quantified, and understood in a manner that could lead to public health and technologic interventions to enhance safety.

*Research, Education and Outreach from Campus Transit Laboratory*

- Collaboration among Civil Engineering, City and Regional Planning, and Statistics researchers help Civil Engineering and City and Regional Planning students better understand data analysis techniques and Statistics students work gain experience by working in an applied setting.

**Impact on Transportation Workforce Development**

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

- Graduate students were provided the opportunity to work 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*

- Internship opportunities were provided to undergraduate and high school students to work in the Driving Simulator Lab.
- Graduate students were provided the opportunity to work in the Driving Simulator Lab that can lead to multiple dimensions of possible research in the area of traveler behavior and safety.
- Minority and women students were provided the opportunities to improve professional skills in transportation through research and internships.

*Accessibility-Based Evaluation of Transportation and Land Use Planning: From Laboratory to Practice*

- Primer on accessibility-based analysis designed to explain accessibility-based evaluation to practitioners

*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*

- Potential impacts of this research include identification of emerging industry sectors and opportunities for entrepreneurial initiatives, identification of gaps in industry cluster assembly that point to both corporate opportunities, and specific workforce development needs. This work may also ultimately inform policies specific to in-state employment and emerging job creation opportunities.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- Graduate student scholarships at both the master and doctoral levels.

*Truck Activity and Wait Times at International Border Crossings*

- Two graduate students processed and interpreted uniquely collected data.
- Two graduate students were involved with preparation of material for presentation at a technical conference.
- Two graduate students presented results of the project at a technical conference.
- One graduate student is pursuing an MS thesis based on the project.

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

- Technology to enhance driver awareness could be of similar benefit to the transportation workforce.

*Research, Education and Outreach from Campus Transit Laboratory*

- Two research engineers, four graduate students, and three undergraduate students regularly collected passenger flow information on CTL buses using manual methods and a Wi-Fi based sensing technology
- Two research engineers and four graduate students regularly processed and analyzed automatically collected CTL data.
- Twenty-seven students used CTL data and CTL infrastructure to complete a course project
- One CTL research engineer received a competitive transportation consulting job in the Washington, DC area.
- One CTL research engineer was accepted with funding at MIT, the University of California-Berkeley, and OSU, and will join MIT to work with the transit group
- An undergraduate student previously working with the CTL was accepted by the German Academic Exchange Services (DAAD-RISE) program to work in a transportation related summer internship

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

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

The Driving Simulator Lab setup is a state-of-the-art facility at the NEXTRANS Center, Purdue University. The advanced driving simulator has unique capability of replicating/mapping a large city network and creating ambient traffic via integration to micro-simulation software (AIMSUN). This is one of the most advanced driving simulator labs for understanding driver response to real-time information provision across many dimensions that have not been previously addressed in a research setting, but have

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. The driving simulator is connected to three high-performance computers, and other hardware components such as webcams, video capturing devices and high definition multi-media displays. The Driving Simulator Lab represents a unique physical and institutional resource.

*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*

Currently, the project has led to sharing of database information between Planning, engineering and business units at the University of Michigan, and several meetings to discuss methodological variations between disciplinary practices. Database organization, structure and access has been informed through these exchanges. We anticipate that through this project, new database structures related to clean-tech industry clusters like New Mobility will be produced, and that gaps in data acquisition (specifically for non-traded private agents in these sectors) will be identified.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- The developed TScan prototype will serve as a data collection platform for other research projects.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- The international collaboration project has mutual benefits for both the NEXTRANS center and National Cheng Kung University via information and resources sharing and personnel exchange.

*Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy*

- Hopefully this research will encourage other researchers/institutions to do more research about this type of method.

*Truck Activity and Wait Times at International Border Crossings*

- This project results in the amassing of a large and unique dataset on truck times when conducting multiple activities at two major border crossings.

*Research, Education and Outreach from Campus Transit Laboratory*

The Ohio State University 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.

**Impact on Technology Transfer**

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

- The results from this study will 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.
- Technical method can contribute to a wide range of applications in transportation planning practice.

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

- The results from this study will 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. This study will 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.

- The 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.

*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*

- Currently, the project has led to sharing of database information between Planning, engineering and business units at the University of Michigan, and several meetings to discuss methodological variations between disciplinary practices. Database organization, structure and access has been informed through these exchanges. We anticipate that through this project, new database structures related to clean-tech industry clusters like New Mobility will be produced, and that gaps in data acquisition (specifically for non-traded private agents in these sectors) will be identified.

*Truck Activity and Wait Times at International Border Crossings*

- Efforts have begun to communicate results to stakeholders.

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

- It could be significant later on in the development of these algorithms and the technology that applies them to enhance safety.

*Research, Education and Outreach from Campus Transit Laboratory*

Amassed data are already leading to results of research and practical value that are communicated via presentations and publications. Ways to possibly broaden this communication will be explored.

**Impact on Society beyond Science and Technology**

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

- The study will help in developing a comprehensive understanding of the mechanism in which more benefits can be derived from real-time traffic information systems.
- This study can 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.
- The study can contribute to the development of better methods to provide information to travelers and enhance the quality and safety of the travel experience. The research accomplishments from this project can help in deciding the content and amount of information necessary for participants to make best route decisions.
- The research findings are expected to improve public access to and awareness of the positive and negative impacts of real-time travel information.
- The driving simulator lab can be used as a platform to educate middle and high school students in various dimensions related to driver performance, behavior, and safety.

*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*

- In order to transform transportation at the order of magnitude required for the current challenges and to take advantage of the emerging opportunities – social, technical, and demographic, an economic conversion is needed, not solely an urban policy or transportation policy approach (which has been the emphasis in urban transport to date). The private sector is already and needs to in the future play an increasing role in the wicked problem of transportation in an urbanizing world. This project aims to produce data-based graphical analysis that enables this type of cross disciplinary / cross jurisdictional discourse and action.

*Stationary LiDAR for Traffic and Safety Applications – Vehicles Interpretation and Tracking*

- This should 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.

*Analysis of Policies Aimed at Increasing Use of Natural Gas in the Transportation System*

- Energy policy makes a difference, as illustrated by these research results.

*Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls*

- The developed ATSC logic should be able to help reduce traffic delays and travel time of motorists at urban signalized intersections.

*Truck Activity and Wait Times at International Border Crossings*

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

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

- This work could help better understand distracted driving behavior and its impact on driving performance with the ultimate goal of reducing distraction-related motor vehicle crashes and the injuries and fatalities resulting from them.

*Research, Education and Outreach from Campus Transit Laboratory*

The overall project is focused on improving transit services, increasing transit utilization, and enhancing transit efficiency, all of which lead to more socially, economically, and environmentally sustainable transportation systems.

**PART 5: CHANGES/PROBLEMS**

*Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability*

- Because of the lack of next-round funding at the NEXTRANS center, the second phase of this project not being proposed or pursued at the Ann Arbor site -- only Lafayette

*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*

- Early in the project, we identified two key challenges to the project's ambitions as stated in the original project description. The first relates to gaps in data availability regarding documentation of non-public agents within industry sectors and a lack of existing databases containing key indicators and relational information. The second is the lack of existing exemplars in distilling and communicating inter-agent relations through visualization techniques. We have addressed the first concern through the development of a new database structure that incorporates existing industry indicators and identifies data collection demands which we are in part assembling manually through research within the project. We have addressed the second issue through the development of a series of Case Studies, examining and documenting existing clusters related to the New Mobility within the region of study across historical timelines. While the case studies were not necessarily anticipated as part of the original project description, they have been an invaluable asset in eliminating uncertainty from the relational data acquisition, and have enabled advancement of the representational techniques relative to historic examples. The project is proceeding based on addressing these two changes. There have been no further changes to the original project description.

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

- Finding matched clips that could be considered controls proved more difficult than expected and over 10,000 matched clips where coded in order to identify a sufficient number of control clips to ensure adequate power for the analysis. As a result more funds were spent on coding than proposed and fewer funds remain for data analysis than proposed.