Program Progress Performance Report for University Transportation Centers

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From Concepts to Deployment

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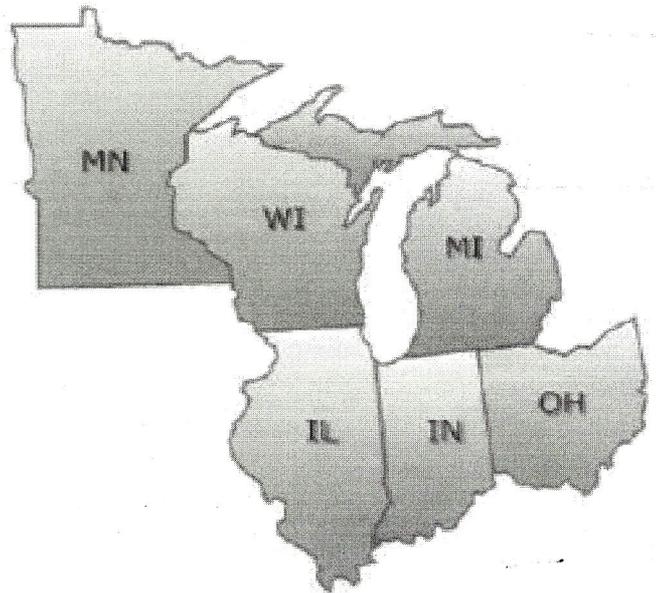**DUNS Number:** 072051394
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Signed: _Ed Howell_

Ned Howell, Managing Director

PURDUE UNIVERSITY
Discovery Park

Part 1: ACCOMPLISHMENTS
Major Goals
There have been no changes to program goals.

Major Activities
Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems
- Developed an agent based model using NHTS travel diary data for Indianapolis
- Integrated the microscopic traffic simulation capability with agent based model
- Extended the work to assess battery health and life-span under different traffic conditions

Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs
- Revised the experiment scenarios based on the observations during the experiments.
- Recruited experiment participants.
- Have had 216 participants completed the driving simulator experiments by July 14, 2015.
- Archived and analyzed the experiment data.
- Procured eye-tracker to trace participant's gaze point during the experiments.
- Have two undergraduate summer interns involved in the research.

Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base
- Gathered and selectively chose appropriate quotations from focus groups and interviews to include in the final report.
- Developed a proposed means for achieving a standardized collection of data to support accessibility metrics.

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- The participants were reached by contacting the employers in the Tippecanoe County area from January 2014 to April 2014 to distribute the recruitment email to the newly hired employee in fall of year 2014. A total of 282 completed responses were collected, including 147 in the experimental group and 135 in the control group.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- (I) Data collection process has been done through open sources and prepared for using in the model (ii) Mixed integer dynamic capacitated intermodal facility location model (IFLM) have been created. (iii) Downside risk constraints are incorporated into the expended IFLM to hedge the risk associated with intermodal facility investment process. (iv) Two separate real world experiments have been settled to evaluate performance of both models and to get insights for intermodal facility investment decision-making process

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior
- Literature review regarding rumor model and epidemic model to address the evolution and propagation of information from different sources across evacuees
- Development of hybrid decision-making model with consideration of the psychological aspects of travelers under real-time information provision
- Collect sample SNS data to analyze the propagation of information under evacuation situations

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning
- We designed an accessibility metric adequate for project-level evaluation of land-use development and transportation investment. We built a website designed to prepare the data needed to estimate this indicator. We estimated the indicator for three developments (both existing and proposed) in

Ann Arbor to explore its properties. We wrote and delivered a conference paper on the work at the Network on European Communications and Transport Activities Research.

Truck Activity and Wait Times at International Border Crossings
- Received additional geo-fence based time and location data for trucks using the Ambassador Bridge and Blue Water Bridge border crossing facilities
- Continued introducing future graduate research associate and faculty member to project and computer codes

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- Completion of database of New Mobility-allied industry sectors within Southeast Michigan structured by NAICS codes, traded and non-traded relationships.
- Refined Cartographic and Visualization standards for economic cluster description, utilizing customized automation scripts linking database structure through ArcGIS (ArcMAP) platform to regional mapping backdrop.
- Regional mappings were completed for a partial sample of industry types (NAICS code based):
- Finalized relational mapping framework for non-geospatialized data related to cluster formation:

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- Development of GIS techniques for mapping Food, Health and Learning Deserts relative to public transportation network distribution, service and physical urban barriers.
- Assembly and GIS encoding of public, NGO and private agencies providing services and access related to the provision of related services.
- Relational mapping of connections and active projects within Chicago aiming to increase access to Food, Health and Learning.
- Field research to examine key strategic sites identified through GIS and geospatial analysis.
- Inventory of Strategic site locations within existing CTA system for possible prototype development.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Background detection in Cartesian XYZ coordinates
- Object tracking and trajectory estimation
- Preliminary technique developed for estimating dimension of vehicle
- User Interface development for initial setup process

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- The background information and model development are finished.
- Numerical analysis under different test scenarios by simulation experiments are underway.

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II
- The background information and literature review are finished.
- A stochastic programming model for the network origin-destination (O-D) matrix estimation problem is under development.

Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving
- Data analysis continued on both simultaneous approaches: 1) a Markov approach; 2) population spline fitting.
- A first draft of a manuscript presenting analysis results was completed and is currently being prepared for submission to a peer-reviewed publication.

Research, Education and Outreach from Campus Transit Laboratory
- Summarized directly observed CTL OD flows for stakeholders and research efforts
- Refined methodology to translate Wi-Fi data into OD flow estimates

- Collaborated with a company to plan for an approved project that would use the CTL as infrastructure for a sensing technology and analytical validation and conducted preliminary data collection with the company using CTL

LIDAR based vehicle classification
- Work continues on segmenting axles to measure their spacing and using 3D information to improve classification. One key advance since the last report has been improving the speed measurements if there has been a change in relative speed between the probe vehicle and a target vehicle while the target is being scanned. The work now measures relative speed using sub-vehicle features.

Segmenting, grouping and tracking vehicles in LIDAR data
- Since the last report the focus has been on cleaning the extracted data and documenting the processing.

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- 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 continue to be refined.

Specific Objectives

Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems
- Understand the effects of traffic condition on residential household electricity demand
- Understand the impacts of traffic condition and travel demand on battery life-span

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.

Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base
- A primary goal is to propose a means of assembling a reliable and trustworthy data set for evaluating accessibility performance, but to do so while minimizing the burden on current agencies and without suppressing the creativity and distinctiveness of initiatives at the local and regional level.

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- This study's focus on the relocating population offers two principal benefits. First, respondents will make many long- and short-term choices that the research project will be able to observe. Second, transportation decisions are often described as habitual behavior under which even choices that could in principle vary on a day-to-day basis—e.g., getting into a car to drive to work—are rarely meaningfully reconsidered.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- (i) Hedge the risk due to demand uncertainty; (ii) be robust to accommodate different scenarios; (iii) reduce port congestion; (iv) consider possible commodity flow changes due to Panama Canal expansion and/or Canadian and Mexican port expansion.

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior

- Develop a multi-layer information propagation network to capture the effect of interdependencies between sources and corresponding evolution of information
- Develop an evacuation decision-making model under heterogeneous information

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning
- Accessibility-based evaluation and planning is impeded by the lack of project-level tools. Most tools are appropriate for regional level scenarios but do not not connect directly with the point of decisionmaking: land-use regulation/development, and transportation investment. This project aims to develop indicators appropriate to this task that are accessible to local planners in practice, together with tools for data analysis that the can use.

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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- Develop graphical depictions between underlying regional assets, extant regional infrastructures, and nascent new mobility opportunities (events) in producing emerging industry clusters.
- Refine description of specific industry agents within the new mobility economy via existing industry classification structures (NAICS & Others) for the local area of Southeast Michigan

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- Identify key locations, agents and sites of intervention within which to test prototyping concept.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Background detection and removal
- Estimating trajectory from associations obtained via forward tracking
- Obtain dimension information with the help of trajectory knowledge

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- The main purpose of this research is to solve the intersection turning proportion problem by using heterogeneous sensor information for adaptive traffic signal controls.

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II
- The main goal of this research is to estimate a set of stochastic network O-D demands using a multi-sensor information fusion method under traffic uncertainties.
- Another goal is to conduct sensitivity analysis on the budget constraint and network topology issues for a systematic evaluation for a cost-effective implementation in the field.

Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving
- Finish data analysis
- Publish the results in a peer-reviewed journal

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

LIDAR based vehicle classification
- Continue to investigate the possibility of axle based classification

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- Improve transit passenger OD flow representation and estimation.

Significant Results

Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems
- For the city of Indianapolis, 90% of the EVs have battery life-span of more than 5 years and 50% have more than 7.5 years

Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs
- The experiment reliability has been improved significantly after redesigning the experiment scenarios and recalibrating the settings of the simulation software packages.
- Participant's gaze point is an important parameter to model a traveler's physiological burden when facing real-time travel information from multiple sources.
- It may require more comprehensive biosensors, including electroencephalogram (EEG), to evaluate a traveler's physiological burden precisely.
- Other types of travel information, such as customized travel information, could be integrated into the driving simulator experiments.
- The driving simulator experiment data have been carefully archived. Team members in the Driving Simulator Lab are analyzing the experiment data.

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- Two outcomes are related residential location choice and the other two are related to travel behavior: (i) the level of importance for factors affecting residential location decision; (ii) the chosen residential location's accessibility to different trip purposes; (iii) weekly drive-alone trips, measured in minutes travelled; and (iv) the share of trips by multiple transportation modes.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- Incorporating risk management tool (downside risk analysis) into intermodal facility investment process at national level
- *Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning*
- An accessibility elasticity indicator does a good job of capturing both the mobility and proximity dimensions of accessibility. Appropriately, it is highly sensitive to the location of the development.
- Publicly available data (Google Maps and possibly Open Street Map) can serve as a basis for queries to prepare the data needed for these analyses.

Truck Activity and Wait Times at International Border Crossings
- Obtained new data with refined geo-fences to be used in future project
- Determined that new graduate research associate would rewrite codes to process new geo-fence data in future project, rather than try to update old codes

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- Completion of 350+ layered thematic industry geospatialization mappings, localized cluster analyses for presentation and discussion with project partners.
- Finalization of standardized visualization formats capable of describing geospatial and relational networks of new mobility cluster agents.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability

- Development of geospatialization mappings describing extents of underserved locations, and distribution of agents working to deliver elevated access to Food, Health and Learning.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections

- LiDAR sensor noise estimated and incorporated into Forward tracking
- Estimation of initial orientation of LiDAR from IMU data
- Identification and removal Background in Cartesian coordinates
- Data collected at intersection with several obstructions (poles and trees) and non-sparse traffic to simulate a worst case scenario
- Data collection at US 231 and Cumberland intersection
- User Interface development for initial setup process.

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

- Heterogeneous traffic information provides better results on the time-dependent intersection turning proportions.
- The partial deployment strategy of video sensors is better than the full deployment scenario; indicating that the strategic deployment of video sensors has advantages over centralized deployment of video sensors in the turning proportion estimation problem.
- The heterogeneous traffic sensor deployment strategy is associated with a higher cost than that of a pure VD sensor deployment plan.

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

- There are no new findings beyond those reported previously. The analysis completed during the current period confirmed the findings reported previously.

Research, Education and Outreach from Campus Transit Laboratory

- Observed OD flow data were summarized; results were also provided to researchers evaluating the performance of OD estimation models
- CTL physical and institutional infrastructure was used to conduct preliminary data collection for an externally funded SBIR pr
- CTL infrastructure and concepts were used in an externally funded project

LIDAR based vehicle classification

- Lee, H., Coifman, B., "Using LIDAR to Validate the Performance of Vehicle Classification Stations," [in press] Journal of Intelligent Transportation Systems.

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

- Results based on further numerical investigations confirm that the developed cluster-based modeling approach and estimation methods determine overall flow patterns that are superior in accuracy to those determined by state-of-the-practice and art methods.

Key Outcomes and Other Achievements

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

- The driving simulation experiment scenarios were updated.
- Participants register and schedule the driving simulator experiments through the experiment website.
- The driving simulator experiments are being carried out.
- Preliminary research findings have been summarized into research papers.
- Our research experience and preliminary research findings will be presented at international research conferences.

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- The interactive online accessibility mapping application proves to be an effective information-delivery strategy capable of affecting residential location choice and downstream travel behavior; it would be readily replicable throughout a range of metropolitan contexts.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- The proposed model can be used to evaluate efficiency of U.S. maritime highways for container transportation by U.S. Maritime Administration and to determine the optimal pricing policy by fleet operators. (ii) The model can be used either for global decision process by the public sector or for local decisions by private companies that factor in future demand uncertainty. (iii) Evaluation of possible commodity flow changes due to adding capacity to the existing ports or adding a new port in Canada or Mexico.

Truck Activity and Wait Times at International Border Crossings
- Additional data were obtained
- The transition to a new graduate research associate was continued

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- Composite completed mappings in animation for dissemination to project partners, governmental agencies, and publics.
- Database structure now linked to automated geospatial and relational diagram techniques.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- Production of spatial assets to describe extents of potential intervention
- Development of techniques of intervention (beta versions and draft responses)

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Determined a possible method for removing background from LiDAR data
- Extended forward tracking algorithm to estimate trajectory, instantaneous velocity and acceleration and dimension of vehicles.

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- The preliminary results have been presented at an international conference (IEEE ITST 2012) to gather more inputs in the later stage of this research.
- A draft paper will be ready to be submitted to a quality journal for consideration of possible publication.

Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving
- The findings reported previously 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
- CTL infrastructure and concepts were used in an externally funded project
- Three presentations incorporating CTL-data and concepts were made at two national conferences
- Two papers using CTL-data and concepts was accepted for publication in an archival journals

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.

Efforts to Disseminate Results

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

- Oral presentation in Nov 2015 at AIChE 2015 Meeting (American Institute of Chemical Engineers)

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

- Presentations at international conferences
    a. 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).
    b. 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).

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

- Abstract is accepted at the hEART conference in Copenhagen, Denmark, 2015. The final paper is used to compete for the Best Ph.D. paper award, instituted by hEART,
  Website: http://web.ics.purdue.edu/~guo187/mp/nextrans.php

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness

- Partial results have been presented at the conference INFORMS in November, 2014. (ii) Two papers are in progress and planned for submission this year. (iii) Partial results will be presented at the conference INFORMS in November, 2015.

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning

- Conference paper and presentation on the topic. Currently preparing paper for journal submission.

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- 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.
- Preliminary findings and visualizations presented to New Mobility thought leaders at U-M in March 2015.
- Team is currently completing papers for submission to Journals: target Sept. 2015. Subjects of dissemination will include (i) methods as differentiation from previous economic cluster mapping techniques, (ii) specific findings for this project in SE Michigan, and (iii) participatory process of development with project partners.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability

- Public exhibition of early mapping work in progress, development of article currently underway.
- Work in process. Dissemination effort will be intensified in Fall of 2015 when work is more mature / completed.

Research, Education and Outreach from Campus Transit Laboratory

- Two articles were revised and accepted for publication in peer reviewed journals
- Three technical presentations were made at two national conferences

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

- Wrote and submitted a paper for presentation at an international conference and possible publication in the conference proceedings

Plans for Next Reporting Period (January – June, 2015)

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

- Understand the detailed effect of temperature, traffic conditions and travel demand on residential energy demand and battery life-span

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

- Continue participant recruitment. Recruit participants among the staff and students in Purdue University and people living in West Lafayette, Lafayette, and Indianapolis, IN.
- Conduct the designed experiments using the driving simulator with interactive surveying system.
- Integrate the eye-tracker into the driving simulator experiments to trace participant's gaze point and provide more data for analyzing driver's physiological burden when receiving real-time travel information.
- Analyze the experiment data to identify factors in traveler decision-making process and the psychological effects of travel information provision.

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

- Review relevant literature on performance metrics and add to the introduction section of the final report.
- Identify all interviewees and focus group contacts who will need to be contacted for permission to quote.

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

The PI and current PhD student are developing data analysis from novel sources and plan to reconcile their data into model development.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness

- Two papers are planned for submission: - Risk Management in a Dynamic Model of Intermodal Facility Investment with Uncertainty - Scenario-based Dynamic Model of Investment Decision-Making Process in Intermodal Facilities under Demand Uncertainty (ii) Benedyk will defend an MA Thesis in 2015

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior

- Collect SNS data under evacuation situations (using APIs and developing tools)
- Explore the dynamic evolution and propagation of evacuation information disseminated through multiple sources
- Develop a multi-layer network to capture the dynamic evolution and propagation of evacuation information from the multiple source of information
- Calibrate behavior models of evacuation travel decision-making with the consideration of heterogeneous information
- Analyze the traffic network-level interactions of drivers and pedestrians based on the evacuation-related decisions

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning

- Refine web tool, port to Open Street Map.
- Develop sample analyses of transportation projects, incorporating their land use aspect. This will involve use of integrated land use-transportation models.
- Submit article on land use analysis for journal publication.

Truck Activity and Wait Times at International Border Crossings

- Obtain new data. Transition to follow-on project

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- We aim to finalize project papers for dissemination.

- We aim to complete project report for submission to Nextrans.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability

- We aim to develop a series of New Mobility Hub descriptions / designs / at three cascading scales as illustrations of the project methods hypothesized in the original proposal.
- Method and process will be documented for dissemination.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections

- Implement Backtracking to obtain the following results
- Best possible dimensions of the vehicle from point cloud, trajectory information
- Trajectory of the bounding box of the Vehicle in the intersection as opposed to point cloud of the vehicle

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

- Model verification and numerical analysis based on simulation experiments.

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II

- A multi-sensor information fusion model for the stochastic network O-D matrix estimation will be developed in the next stage of this research.

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

- Finish manuscript preparation and submit to a peer-reviewed publication
- Present results to peers at meetings/conferences

Research, Education and Outreach from Campus Transit Laboratory

- Use CTL-based modules in OSU courses
- Continue using CTL physical and institutional infrastructure for externally funded project
- Discuss results and future efforts with transit, transportation, planning, and other agencies, and prepare and submit/deliver articles and presentations

Segmenting, grouping and tracking vehicles in LIDAR data

- continue to improve the segmenting and tracking

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

- Conduct additional numerical investigations and start conducting empirical investigations to further validate the quality and interpretability of the flow estimates determined by developed model and estimation methods.

PART 2: PRODUCTS

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

- Journal paper is under review
  - W. Sun, X., Zhang, S. Peeta, X. He, Y. Li, S. Zhu, "A self-adaptive dynamic recognition model for fatigue driving based on multi-source information and two levels of fusion".
- Website: Experiment website is available at: www.purdue.edu/drivingsimulator. The experiment website provides participants a brief description of the driving simulator experiment, an online survey, and an experiment registration and scheduling system

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

- Guo and Peeta (2015). The Impacts of Interactive Accessibility Information on Residential Location Choice and Travel Behavior: An Experimental Study. Accepted for presentation.

- Website: Interactive accessibility map. See also: http://web.ics.purdue.edu/~guo187/mp/nextrans.php

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness

- Mixed integer dynamic capacitated intermodal facility location model (IFLM). Expended IFLM with downside risk constraints.

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior

- A conference paper is presented in 14th International Conference on Travel Behaviour Research (IATBR 2015) regarding development of hybrid decision-making model with consideration of the psychological aspects of travelers under real-time information provision (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")

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning

- Levine, Jonathan, Louis Merlin, and Joe Grengs. (2015) Project-Level Accessibility Analysis for Land-Use Planning. Presented at XIII conference of the Network on European Communications and Transport Activities Research.

Truck Activity and Wait Times at International Border Crossings

- 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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- Publications, conference papers, and presentations: Aspects of the cartographies were submitted for publication in the following book volume: G. Thün and K. Velikov, "Shed Cartographies: A Methodology for Regional Research" in Third Coast Atlas, D. Ibañez, C. Lyster, C. Waldheim, M. White eds: (in pre-press). Book will be published in Aug-Sept 2015
- Database: Composite Database assembled for geospatial, organizational, and traded relationships between New Mobility Industries in Southeast Michigan.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability

- Public Exhibition Presentation of preliminary mapping undertaken at Liberty research Annex (Ann Arbor), March 2015.

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

- IEEE ITST 2012 Taipei Conference
- The integrated heterogeneous sensor deployment model for an ATSC system

Research, Education and Outreach from Campus Transit Laboratory

- McCord, M.R., R.G. Mishalani, M. Ettefagh, 2015. The Effect of Real-time Passenger Information Systems on the Perceptions of Transit's Favorable Environmental and Traffic Reduction Roles. Accepted for publication in Transportation Research Record (acknowledgement of support: yes)
- A website includes among other things, activities and results from this project: http://transitlab.osu.edu/campus-transit-lab
- Technologies or 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 update
- 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
- 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

Segmenting, grouping and tracking vehicles in LIDAR data
- Coifman, B., An Overview of the On-Going OSU Instrumented Probe Vehicle Research, January 9, 2015 revision

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

PART 3: PARTICIPANTS & COLLABORATING ORGANIZATIONS
Partnership Organization Information
Truck Activity and Wait Times at International Border Crossings
- Michigan Tech Research Institute
  In-kind support, Facilities, Collaborative Research - Yes
- CEVA Logistics: Financial support In-kind support - Truck location and timing data

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- NEXT Energy, 461 Burroughs St, Detroit, MI 48202. 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.
- We also collaborate with Michigan based NGO's including Michigan Environment Council and Trans4M, a coalition of Michigan based sustainable transport efforts.
- This project is now also supported with an active URP project from Ford Motor Company.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability

- SMART, University of Michigan Transportation Research Institute 2901 Baxter Rd., Rm 104 Ann Arbor, MI 48109-2150. SMART has enabled discursive exchanges with Midwest thought leaders on approaches and methods developed through project to date.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Collaboration with professor Kartik Ariyur from the School of Mechanical Engineering

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- National Cheng Kung University, Tainan, Taiwan.
  - Partially financial support, Facilities, Personnel exchange

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II
- National Cheng Kung University, Tainan, Taiwan.
  - Partially financial support, Facilities, Personnel exchange

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
Financial Collaboration

Research, Education and Outreach from Campus Transit Laboratory
- Org name: (1) The Ohio State University Department of Transportation and Traffic Management (2) Clever Devices (3) Ohio Department of Transportation (4) Mid-Ohio Regional Planning Commission (5) Central Ohio Transit Authority (6) Intelligent Automation, Inc.
- Location: (1) Columbus, Ohio (2) Woodbury, NY (3) Columbus, OH (4) Columbus, OH (5) Columbus, OH (6) Rockville, MD

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- The Ohio State University Department of Transportation and Traffic Management

Other Collaborators and Contacts
Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems
- Mechanical Engineering Department, Purdue University, battery health related research

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- The Co-PI is Assistant Professor, Chongqing University of Posts and Telecommunications, Chongqing, P.R. China

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- Collaboration with Professor Ananth V Iyer, Krannert School of Management, Purdue University

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior
- Yu-ting Hsu, Professor, National Taiwan University
- Jin-Hyuk Chung, Professor (Co-PI), Department of Urban Planning and Engineering, Yonsei University, Seoul, Korea. Collaborative research – Pedestrian behavior and flow modeling in evacuation situations

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning
- Southeast Michigan Council of Governments, Detroit, MI. Data sharing.

Truck Activity and Wait Times at International Border Crossings
- 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

- Initiatives related to sustainable transportation at the University of Michigan. The departments represented in the other related studies specifically (and collaborate to inform this project) include: College of Engineering, Institute for Social Research, Psychology, UMTRI, School of Natural Resources & Environment, and the Ross Business School. 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 industry analysis and consumer uptake, sponsored by Ford Motor Company. As mentioned above one of the Ford sponsored projects has specifically grown out of this NEXTRANS project and will develop applications of the methodologies and cartographic methods for application in other global regions and megaregional contexts apply the approach to other regions globally.

Part 4: IMPACT

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

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

- It will help the planners to strategize plans to achieve system-level objectives esp. related to environment and electricity demand.

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

- An information-delivery strategy focused on longer-term transportation and locational decision-making holds the promise of affecting sustainability-related behavior by focusing on moments during which choices are made that significantly affect future behaviors and during which transportation habits may be more malleable. New perspectives to fostering sustainable transportation choice can be potentially explored using the notion of information-based models and interventions across timescales. Information can be a political feasible alternative to either regulatory or cost-based approaches to affecting travel behavior.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness

- Expansion of a traditional core topic for transportation network – namely, facility location problem (FLP). Integrating risk management tools (downside risk) into FLP is a useful developing.

Effects of Heterogeneous Information Characteristics and Sources on Evacuation Behavior

- Leverage the understanding of the characteristics of information propagation from different sources and the impact of heterogeneous information characteristics on the evacuee behavior in terms of evacuation-related decision-makings
- Consider latent factors representing evacuee's information perception to illustrate key behavioral attributes related to evacuation (such as herding behavior, time pressure, stress etc.) in evacuation decision-making models under heterogeneous information

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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- 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 as related to region system representation. 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 before 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.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- Disciplinary groups participating in this project are urban and regional design and planning, and geospatial and relational data visualization. The primary discipline impacted is architecture and the design of urban systems through the lens of experiential accessibility. For designers, this work raises questions around existing typologies and points a way to re-conceiving of the design of the physical sites of infrastructure to advance societal goals of mobility beyond movement.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Quantitative safety estimates and predictions will become possible because the availability of real data to test various hypotheses and meet specifications.

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- Based on various data resources from traffic sensors in an urban network, the developed intersection turning proportion estimation model can effectively infer turning patterns without having to manually collect these data, which is expected to save time and monetary cost of data collection
- Turning proportions at intersections represent microscopic vehicular travelling patterns. If such information can be collected or accurately estimated, highway management agencies can monitor traffic network states, such as network loadings, traffic bottlenecks, traffic distributions, etc. The additional benefit from the developed intersection turning estimation model is that it can provide essential inputs to establishing some desirable traffic control strategies.
- The proposed ATSC logic is expected to mitigate traffic jam situations in light of real-time intersection turning proportions given by the estimation model.

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II
- The study will provide a convenient mechanism to explore the stochastic characteristics of travel demand and network state evolution by leveraging heterogeneous traffic information obtained from different sensor data types.

Using Naturalistic Driving Performance Data to Develop an Empirically Defined Model of Distracted Driving
- This work 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.

Segmenting, grouping and tracking vehicles in LIDAR data
- It is anticipated that the trajectory data set will have a large impact on the traffic flow theory community and that it will be widely used

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- Anticipated project model and methods are expected to 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.

Impact on other Disciplines

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

- Insurance companies can use the battery life-span results to develop policies

- Residential electricity demand estimation can help the operators to plan electricity output and reduce wastage, hence reducing the electricity price.

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

- The study can potentially provide policy guidance and directions for convergent goals to multiple agencies/institutions such as the USDOT, HUD, and EPA at the federal level, and area planning commissions and MPOs at the local and state levels. Thereby, the study can bridge some of the methodological gaps in holistically approaching the notion of livability.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness

- Collaboration with colleagues in Operational Research field (Pr.Iyer) is notable and has provided a very solid platform for continuing joint work.

Implementation of Accessibility-Based Evaluation for Transportation and Land-Use Planning

- We aim to develop a tool to replace current modes of analysis in transportation and land use planning.

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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- Key impact on other disciplines: 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). 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

- The work may point to new business and entrepreneurial opportunities for products and services added within the public transportation system and its physical infrastructure.

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.

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

- The results of this research should have policy implications for sensor deployment policy in an urban traffic control scheme.

Estimation of Stochastic Network Vehicular Origin-Destination Demands Using Multi-Sensor Information Fusion Approaches –Phase II

- The outcomes of this study will have implications for sensor deployment policy.

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.

Impact on Transportation Workforce Development

Driving Simulator Laboratory: Traveler Behavior Modeling and Interactive Experiments to Address Mobility and Safety Needs
- 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.
- Undergraduate student were provided the opportunities to improve professional skills in transportation through research and internships.

Information and Transportation choice, Long- and Short-Term, that Link Sustainability and Livability – Phase II
- Training one PhD level student.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- Training one MA level students and on PhD level student.

Truck Activity and Wait Times at International Border Crossings
- One graduate student will be applying analytical geospatial skills to a new application area

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- 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 supporting specific policy support to produce personnel in-state to staff emerging job production opportunities.

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- Potential impacts of this research include identification of potential opportunities for entrepreneurial initiatives, identification of gaps service provision, and specific related workforce development needs. This work may also ultimately inform policies regarding service provision and access delivery within cities.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- Will facilitate data collection and several types of studies such as: pedestrian-vehicle interaction studies; traffic signals studies and intersection performance evaluation among others.

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- The outcomes of this research provide transportation professionals with effective sensor deployment strategies for an ATSC system by taking advantage of heterogeneous sensor information.

Research, Education and Outreach from Campus Transit Laboratory
- Multiple undergraduate and graduate students regularly collect passenger flow information on CTL buses using manual methods and a Wi-Fi based sensing technology.
- Multiple graduate students regularly process and analyze automatically collected CTL data

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- One PhD student works directly with APC data and applies data to solve a pertinent transportation flow estimation problem.

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.

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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan

- 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 have been informed through these exchanges. We anticipate that through this project, 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.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections

- We have data that can be used to validate and check various traffic models.

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

- The international research collaboration project provides mutual benefits in personnel and information exchange.

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

- Project activities rely on The Ohio State University Campus Transit Lab (CTL), a unique living laboratory that is used for research, education, and outreach. The value of CTL to this project helps motivate and justify the provision of physical and human resources to develop, sustain, and continue to take advantage of this living lab.

Impact on Technology Transfer

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.

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

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan
- Currently, we have not identified specific products that we will be pursuing through disclosure and patent protection

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- All of the software and details on hardware configuration will be published and supplied free to all transportation departments, starting with INDOT.

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- A cost-effective sensor deployment scheme is expected to help improve traffic operation and save motorists' travel time and/or cost at the societal level.

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 broaden this communication are being explored.

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

Impact on Society beyond Science and Technology

Developing Operational and Policy Insights into Next Generation Vehicle Needs Based on an Integrated Understanding of the Transportation and Energy System of Systems
- The results from this study can help people to reduce their travel costs both operational and maintenance

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.

Intermodal Infrastructure Investment Decisions and Linkage to Economic Competitiveness
- Implication of the model can improve commodity flow distribution at a national level, and thus, reduce costs of transportation.

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

ACCESS-ENABLING ARCHITECTURES: New Hybrid Multi-modal Spatial Prototypes Towards Resource and Social Sustainability
- In order to transform issues of access to needs, it may be necessary to rethink the physical manifestation of transportation infrastructure itself as a site of service delivery. This project aims to point to a method, process, and prototypes for such delivery. As such it has the potential to influence policy and the physical design of cities.

Guaranteed LiDAR-aided Multi-object Tracking at Road Intersections
- 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. This will enable policy makers to design roads and signals on a quantitative basis to meet societal expectations.

Estimation of Time-Dependent Intersection Turning Proportions for Adaptive Traffic Signal Controls
- A cost-effective sensor deployment scheme is expected to help improve traffic operation and save motorists' travel time and/or cost at the societal level.

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.

LIDAR based vehicle classification
- Right now the flows of people and goods over the road network are measured very sparsely- a few hundred permanent classifications per state, supplemented with many more short term counts at discrete locations, sampled once per multi-year cycle. In any event, all of these counts are at a (relatively) small number of fixed locations. The vehicle classification from the instrumented vehicle will bring classification to anywhere on the network, allowing for measurement of classified flows, etc., which in turn will lead to better management and planning of the roadway network to serve travelers and freight movements.

Segmenting, grouping and tracking vehicles in LIDAR data
- The improved understanding of traffic flow that arises from the microscopic data should lead to improvements over a broad range of surface transportation, from short term traffic responsive controls like ramp metering to long term transportation planning applications.

Transit Origin-Destination (OD) Flow Estimation Considering Temporal Variations based on APC Data
- 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
Nothing to Report