Program Progress Performance Report for University Transportation Centers

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From Concepts to Deployment

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Signed: _____
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PURDUE UNIVERSITY
Discovery Park

From July 1 to December 31, 2013, activities of the NEXTRANS Center focused on fourteen projects at Purdue University, The Ohio State University, the University of Michigan, and the University of Wisconsin-Madison.

PART 1: ACCOMPLISHMENTS

Major Goals

There have been no changes to program goals.

Major Activities

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

- Develop spatial database for Ann Arbor and Lafayette areas Investigate methods of deploying information system/website. Review literature Draft survey questionnaire. Apply for IRB approval.

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

- Develop methodology for case-study selection. Complete four case studies (of eight). Develop graphical approaches to representing and analyzing accessibility. Conduct interviews with planners/decision makers on accessibility-based evaluation.

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

- Developed a protocol and electronic data entry form to conduct coding of 5-second video clips from UMTRI's naturalistic driving database to record indicators of distraction (secondary task engagement, steering wheel hand position) or if no distraction was evident. The protocol was developed using information from the literature review completed during the previous period and a pilot sample of video clips from the UMTRI database.
- Hired and trained two video coders. Finalized a sampling protocol to be used to generate the project dataset of video clips to be coded. Created a project dataset comprised of 16,952 5-second video clips from 68 drivers. Completed coding 14,359 (85%) of the video clips in the project dataset.

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

- Several MARKAL modifications were carried out to better reflect the fleet size effects for transit buses, school buses and garbage truck fleets based on 2010 National Transport Database tables.
- The Elementary/Secondary Information System (ELSi) Database and Hauling & Disposal Ranking survey. Light duty and fleet fueling station costs was updated according to NREL Technical report 7A2-47919, 2010.
- The model was then calibrated to the base year, 2005, to match the model outputs to the electricity outputs, primary energy use, installed technology capacity and sectoral outputs. Then, an iterative calibration process was used to match the projected energy service demands and projected GDP growth rates.

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

- Investigated the LiDAR hardware system (HDL-64E) and achieved its RPM, IP address adjustments. Analyzed LiDAR signals to extract desired information (distance, angle, laser ID) and used Wireshark software to split data into small packages, or choose any desired horizontal field of view.
- Established the coordinate transformation from LiDAR's spherical coordinates to XYZ Cartesian coordinates to generate point cloud in the 3D space.
- Identified background features such as road, buildings or other stationary objects in each point cloud frame. Identified moving objects such as vehicles or pedestrians and isolated them from the background point cloud.
- Developed advanced algorithms to estimate desired features in the point cloud. (E.g. Road plane fitting via RANSAC algorithm, 3D rotation via rotation matrices, drawing a polygon to enclose the area of interest, point clustering to represent moving vehicles etc.)

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

- Built a catalog of data requirements, including identifying which data are reported to other levels of government among local, regional, state.
- Conducted interviews with public officials at various levels of government, including local, regional, and federal, and documented viewpoints on current data requirements and on the possibility of modifying current data to advance accessibility-based evaluation.

Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy

- Examine stages of progression in annual maintenance cycle at state transportation agencies
- Investigate the most commonly relevant parameters in a maintenance cycle

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

- Develop 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 and representation
- 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.
- Undertake 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)

Truck Activity and Wait Times at International Border Crossings

- Received and processed additional CEVA Logistics truck time and location data
- Estimated relations indicating the effect of aggregate truck volumes and inspection times on times trucks incurred in queuing fences ("queuing times") at Ambassador Bridge and Blue Water Bridge crossings in both directions
- Observed additional trends and relations in processed data

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

- Refined experiment design and planning, which include experiment network, experiment scenarios, and online survey system and questionnaires. Upgraded experiment software to improve reliability. Continued developing driving simulator experiment website. Tested the driving simulator experiment. Analyzed the experiment data collected through pilot tests.
- Developed analytical models for data analysis. Revised the experiment protocol to collect biopotential and eye movement data when participants drive the simulator.

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

- Refined and organized data generated from 56 electric vehicles Geo-mapped the GPS data using Tableau maps. Reviewed literature for existing battery models and identified the gaps
- Prepared detailed research work plan

Research, Education and Outreach from Campus Transit Laboratory

- Continued collecting automatic passenger count (APC) and automatic vehicle location (AVL) data on a regular basis. Began collecting Wi-Fi data on a regular basis. Continued collecting directly observed passenger origin-destination (OD) flows. Summarized directly observed OD flows for stakeholders and research efforts. Processed APC data for research and outreach efforts. Processed Wi-Fi data for research efforts. Estimated bus route origin-destination flows from processed APC data. Explored estimating bus route origin-destination flows from Wi-Fi data. Investigated the reliability of Wi-Fi based OD flow estimates.
- Summarized APC-based estimated OD flows and APC boarding and alighting count data for outreach efforts. Used CTL-based education modules and activities in a large undergraduate civil engineering core course. Responded to multiple stakeholder requests for CTL data and information.

- Summarized ridership levels on portions of an off-campus route for which service cuts were being considered (in response to request from OSU Transportation and Traffic Management)
- Investigated likelihoods and spatial-temporal patterns of passengers' being left behind at stops because of bus overcrowding, and changes in the likelihoods and spatial-temporal patterns over the course of two years (in response to request from OSU Transportation and Traffic Management)
- Began developing approaches to model the effects of bus service frequency reduction on passenger level of service (in response to request from OSU Office of Chief Information Officer)
- Began summarizing bus route OD passenger flows 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)
- Met with CampusParc management to discuss possibilities to extend the CTL concept to campus parking issues. Produced empirical and analytical results and interpretations of results related to bus route passenger flows for an externally funded "companion project"

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

- Continued to write 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.
- Acquired and organized similar data on non-US urban areas around the world from multiple sources.
- Began "cleaning up" and processing these non-US data for analysis and modeling purposes.

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

- New models for bus route-level transit passenger origin-destination (OD) flow estimation using automatic passenger count (APC) data capturing temporal patterns across different groups of travelers are being developed.
- Numerical investigations and assessments of new models are carried out.
- Empirical evaluations are conducted.

Specific Objectives

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

- Create an analysis dataset to be used for the model development in Aims 3-5. The analysis dataset will be comprised of clips where drivers are engaged in cell phone use and possibly additional secondary tasks (cases; representing varying levels of distraction) and 1 - 5 matched clips for each case where the driver is not demonstrating distraction (controls). The control clips are matched to the case clips on the following characteristics: same driver, same solar conditions (day/night), same roadway, and same traffic density.

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

- 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 were 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.

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

- Minimize the size and processing time of LiDAR data but without losing any useful information.
- Achieve the automatic detection of vehicles, pedestrians, road, buildings or other features in point clouds.
- To estimate any dimension or distance in point clouds and track the trajectories of desired objects in continuous frames.
- To output results in standard formats that can be used by existing simulation tools and engineering analysis tools, e.g. SSAM.

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

- To propose and investigate how accessibility-related data might be provided, and to recommend the data and means of reporting that ought to occur.
- Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy
- Establish a cycle of maintenance process (called a 'cost-condition cycle') based on the common maintenance practices. Determine data needs and availability.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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)

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

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.

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

- Use refined data to develop a microscopic battery state-of-charge model
- Use the battery state-of-charge model to understand the variability in range of electric vehicle under different traffic and weather conditions
- Provide insights about power grid of 5 Indianapolis zones due to increase in regional energy consumption because of electric vehicles Develop a battery state-of-health model to look into (warranty) policies related to vehicle value (battery life) Develop a flexible framework to study various car designs using realistic drive cycles

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.

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

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

Significant Results

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

- To minimize the size and processing time of LiDAR data but without losing any useful information.
- To achieve the automatic detection of vehicles, pedestrians, road, buildings or other features in point clouds.
- To estimate any dimension or distance in point clouds and track the trajectories of desired objects in continuous frames.
- To output results in standard formats that can be used by existing simulation tools and engineering analysis tools, e.g. SSAM.

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

We've fully decoded the structure of data sent from LiDAR and achieved the automatic transformation from raw data to XYZ point clouds without losing important information. We developed two different approaches, one based on spherical coordinates and the other based on Cartesian coordinates, to identify background and moving objects. The users can make the choice based on their own criteria like processing time, accuracy or space requirement. Through a long time period, the readings of laser distance are observed to follow a normal distribution. Thus we can apply statistical tools to analyze data directly in the spherical coordinate system. We noticed that vehicles may create "shadow" areas on the road since they obstruct laser beams. This phenomenon can be used to significantly improve detection results. We found that due to vehicle's shiny surface (especially the roof), some laser beams hit the car and then go far away. Thus some important laser readings may be lost for those vehicles. The wind may cause a noticeable motion of LiDAR on the support mast. This will introduce errors on all laser readings but it's theoretically solvable. When two vehicles are very close to each other, current point clustering algorithm may merge two vehicles together into one cluster and could be very difficult to be distinguished. The laser points in a point cloud are not evenly distributed. When near the LiDAR, the density of laser points is high while the laser points are rather sparse on further locations. So it is necessary to place the LiDAR with a good position and attitude. We anticipate the processing time of one frame is going to be around 10 seconds based on our current desktop with an i7 core. However, the LiDAR outputs 15 frames per second which means that the processing time is much more than the data collection rate and needs to be improved.

Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy

- Summary of similar maintenance practices and common occurrences between agencies

- Common relevant parameters being used in maintenance of transportation infrastructure

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

- Identification across three historic case studies of parallel relationships between underlying regional assets, extant regional infrastructures, and nascent new mobility opportunities (events) in producing emerging industry clusters.
- Development of standardized visualization formats capable of describing geospatial and relational networks of new mobility cluster agents.
- Application of techniques developed in first phase of project to be applied to Region V / SE Michigan

Truck Activity and Wait Times at International Border Crossings

- An association between queuing times and average daily volumes and aggregate inspection times was demonstrated.
- Elasticities of queuing times with respect to average daily truck volumes that were greater than one were found.
- Effects of infrastructure on relations between queuing times and truck volumes were observed.
- Lower inspection times were found when queuing times were higher in one of the crossing-directions.
- Reasons for observed lower inspection times were hypothesized by data provider.

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

- The driving simulation system was integrated and tested through comprehensive pilot tests. The simulation model was found unreliable to sustain the originally-designed large-scale driving simulator experiment network.
- Weird vehicle movements in driving simulation model were observed during pilot tests which may impact participants' driving and route choice behaviors.
- The driving simulation software was updated to improve its reliability. Weird vehicle movements are reduced after the software update.
- The driving simulator experiment network was divided into sub-networks to reduce computational burden.

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

- Need to integrate microscopic battery state-of-charge model in investigating power systems - Current microscopic battery state-of-charge models do not consider environmental parameters along with driving parameters

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
- CTL-based data and summaries of data were delivered to stakeholders for policy and service deliberations
- CTL-based data and model-based results produced using CTL-developed methods generated requests from OSU and planning consultants to OSU
- Based on proxy measures developed by CTL-researchers and using CTL data, increased likelihood of leaving bus passengers at stops after transition to a semester-based curriculum was observed
- Fairly good correspondence between Wi-Fi-based bus and directly observed passenger OD flows was seen when aggregating across bus trips and time
- An approach was developed to compare estimated to directly observed bus trip OD flows, while controlling for the number of directly observed passengers by OD pair
- Bus trip-level and period-level passenger OD flows were produced using directly observed, APC, and automatic fare collection (AFC) data on Central Ohio Transit Authority (COTA) routes

- Boarding and alighting data at bus stops captured through onboard survey observations and APC data were compared for COTA and OSU CTL routes; much better correspondence was seen on OSU CTL routes
- CTL data and context were successfully used in a 130-student OSU undergraduate civil engineering core course

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

- Initial preliminary 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.
- Differences in the magnitudes of some variables between US and non-US urban areas are present.

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

- Preliminary indications based on numerical and empirical investigations suggest that the model and estimation methods developed to date have merit and good potential to improve upon the state-of-the-practice and art.

Key Outcomes and Other Achievements

Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy

- An established cost-condition cycle with commonly used parameters, based on maintenance practices

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

- We provide an assessment of the impacts of the various policy options described above.

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

- We have started to draft a proposed scheme for how current common data might be standardized across agencies.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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.
- Attraction of major industry player to support expansion of project (Ford. Motor Co.)

Truck Activity and Wait Times at International Border Crossings

- Quantitative queuing time relations were successfully estimated using geo-fence data and aggregate volume data.
- An in-person meeting between OSU and MTRI investigators was held
- A teleconference between including OSU and MTRI investigators and data provider was held to discuss findings and future data collection efforts.

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

- Comprehensive pilot tests were carried out.
- A structural equation model with latent variables was constructed and will be used for analysis based on the revealed preference data from a driving simulator experiment and stated preference data from a survey.
- An analytical framework was developed for evaluating the value of travel information in terms of how it may psychologically influence traveler route choice behavior.

Research, Education and Outreach from Campus Transit Laboratory

- Dissemination of CTL-related research results further established CTL as a platform that supports the development of new research ideas.
- Onboard observations of boarding and alighting data on COTA bus trips, which are more representative of the state-of-the-practice than the carefully controlled observations obtained on CTL routes, were seen to lack the stop-level accuracy that may be required to consider them ground-truth for stop-to-stop passenger flows at the trip-level

- Results of empirical investigations of Wi-Fi based bus passenger flow estimates conducted with CTL data are being used to inform Ohio Department of Transportation personnel about the ability to use this approach on an operational basis
- Three new undergraduate students inquired about participating in CTL activities as a result of exposure, during the present reporting period, to the CTL in a large undergraduate transportation engineering class. Two of these two students were incorporated into regular activities during this period, and one is scheduled to be incorporated in the next reporting period. A fourth student inquired about participation in CTL activities based on "word-of-mouth" and is scheduled to be incorporated in activities during the next reporting period.

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

- Documented the results based on US data.
- Prepared non-US data for analysis and modeling.
- Identified indications of pertinent relationships among variables in non-US data.

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

- Formulated a new transit passenger OD flow model and corresponding estimation methods.
- Coded the methods for numerical and empirical applications.
- Produced numerical results that indicate the promise of the model and methods.
- Produced numerical results that provide preliminary validation of the quality and interpretability of the estimates.

Efforts to Disseminate Results

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

- We have submitted a paper for the national meeting of the US Association of Energy Economists this summer in New York.

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

- SMART has a database of over 16000 transportation professionals and leaders worldwide. We have announced the work through our website (see http://um-smart.org/blog), through our targeted news, and we have held a range of multi-sector meetings where we have referred to the work. 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
- Paper delivered outlining methodological approach across a range of applications including mobility: G. Thün, K. Velikov, D McTavish "The Megaregional Common: A framework for thinking megaregions, infrastructure and 'open' space", at Specifics: European Council of Landscape Architecture Schools (ECLAS) 2013 Annual International Conference, Hamburg DE, Sept 22-25.
- Course developed to train students in the use of methodological approach (which included the mobility application) at Taubman College, University of Michigan: Arch 505_1 'MetaShed'

Truck Activity and Wait Times at International Border Crossings

- A presentation on project results was made at the Ohio Transportation Engineering Conference.
- A technical paper on the estimation of queuing time relations was submitted for possible publication and presentation: The paper received very positive reactions from anonymous reviewers regarding the ability to estimate relations, and the topic was accepted for presentation at the annual Transportation Research Board meeting.
- After receiving review comments, the technical paper was revised and resubmitted.
- A poster presentation at the annual Transportation Research Board meeting was begun.

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

- Prepared and presented results at a national conference.

Research, Education and Outreach from Campus Transit Laboratory

- Two technical papers on project results were revised and accepted for publication
- Presentations on different aspects of project results were made at three conferences
- Focused results were communicated to transit stakeholders through reports and meetings
- Overall activities and results were communicated to university administrators associated with university resource planning and data services
- In-person and teleconference discussions on CTL data were held with consultants hired to develop a long-term transportation and parking plan for the university
- Presentations on overall activities were made to external visitors

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

- Completed the preparation of two papers describing methods and results based on US data.

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

- Outlined two papers aimed at describing the model, methods, and numerical and empirical results.

Plans for Next Reporting Period (January – June, 2014)

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

- Deploy website Recruit survey participants Invite use of the system

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

- Complete case studies Complete interviews/focus groups Complete graphical approaches Integrate findings with other project "Standardized Metrics for Accessibility: Establishing a /federal Policy-Relevant Knowledge Base" Present at conference: NECTAR (Network on European Communications and Transport Activities Research), Seville, Spain

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

- Coding of the remaining video clips in the project dataset will be completed.
- The model development in Aims 3-5 will be conducted. Those plans include: development of an algorithm to identify distracted driving and estimate the level of distraction using kinematic indicators; validation of the algorithm using telematic data from instrumented vehicles; and, analysis to determine the potential ability of the algorithm to identify cognitive distraction.

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

- We intend to finish the policy analyses and prepare a journal paper summarizing the findings.

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

- Summarize all previous progresses and develop a software platform to achieve the tasks in simple clicks.
- Further develop the point clustering algorithm to isolate vehicles more accurately.
- To solve the issue of missing points and extract shadow information for accurate detections.
- Develop methods to compensate the LiDAR motion due to wind or human operation.
- Track objects in continuous frames and generate their trajectories.
- Investigate the possibility of integrating LiDAR and cameras.

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

- Corroborate and get feedback on our proposed scheme for how current common data might be standardized across agencies, by meeting with several agency representatives.

Use of Comparative Efficiency Analysis to Optimize Transportation Infrastructure Maintenance Strategy

- Categorize the commonly used parameters from the cost-condition cycle based on asset type, input output features and other characteristics, and assemble a database of parameters including all these attributes
- Study the interaction between the parameters in the database, and develop 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
- Begin the analysis phase, which involves running the different case studies through data envelopment analysis (DEA) modeling as an implementation of comparative efficiency analysis method

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

- We anticipate continuing to advance refinement of the cartographic techniques developed to date through the Case Study efforts, and continuation of the assembly of industry data within the study region identified in the 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.

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 further
- Develop relations with expected stakeholders

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

- Procure electroencephalography and eye-tracking devices to collect biopotential and eye movement data.
- 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.
- Analyze the experiment data to identify factors in traveler decision-making process and the psychological effects of travel information provision.
- Refine analytical models using the collected experiment data.

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

- We plan to develop a microscopic battery state-of-charge model considering both environmental and driving parameters.
- We also plan to study in detail the discharging patterns under different traffic conditions for the 5 Indianapolis zones.

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 an OSU course, develop analytical and methodological skills of research engineers and graduate investigators, offer data collection opportunities for research engineers, graduate students, and undergraduate students
- Outreach and communication: Discuss results and future efforts with transit, transportation, planning, and other agencies, disseminate information through CTL website, and prepare and submit/deliver articles and presentations

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

- Investigate further the presence of pertinent relationships among the variables of interest in the non-US data.
- Explore the differences found in some variables between the US and non-US urban areas.

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

- Continue refining the model and methods based the numerical and empirical results.
- Continue further empirical validation and investigation of the interpretability of the estimates.

- Begin writing the outlined papers.

PART 2: PRODUCTS

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

- Databases: We have reviewed the literature on quality of life metrics and developed spatial databases for the Ann Arbor and Lafayette areas to incorporate these metrics. The databases also incorporate auto and transit network information.

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

- Models: We have a new version of the MARKAL-Macro model including the CNG transportation options.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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 "G. Thün, K. Velikov, D McTavish "The Mageregional Common: A framework for thinking megaregions, infrastructure and 'open' space", at Specifics: European Council of Landscape Architecture Schools (ECLAS) 2013 Annual International Conference, Hamburg DE, Sept 22-25.
- Websites: 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. http://www.um-smart.org/
- Curricula: (MetaShed course) techniques developed through this grant form part of the analytical framework in Prof. Thun's ARCH505 MetaShed Seminar Course at Taubman College, University of Michigan
- Data and Research Material: (Regional Industry Agent Data Gathering / Database design) Data structure has been shared with other researchers at U-M through the SMART Network and in SMART Steering Committee Meetings. Once grant is complete these will be disseminated through Peer-Reviewed Publications

Truck Activity and Wait Times at International Border Crossings

Publications, conference papers, and presentations:

- 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;" submitted to Transportation Research Record; revision under review.
- 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," included in 93rd Transportation Research Board Annual Meeting Compendium of Papers.
- Presentation McCord, M.R., N.L. Sell, J. Zaetz, and P.K. Goel, "Exploiting Geo-fences to Document Truck Activity Times at the Ambassador and Blue Water Bridge Gateways,"
- Presentation at the Ohio Transportation Engineering Conference, Columbus, OH, October 23, 2013.

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.

Educational aids or curricula: Results from model estimations were presented in a 130-student, undergraduate class introducing Civil Engineering students to transportation engineering and analysis

and in a 25-student, mixed undergraduate and graduate class of Civil Engineering and City and Regional Planning students on traffic engineering studies.

Data and Research Material

- Unique aggregated longitudinal and disaggregated, truck trip-level data are amassed. Models
- Regression models relating average daily truck volumes and aggregate inspection times to queuing times in peak periods were estimated.

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

Publications, conferences

- Song, D.Y., and Peeta, S. (2013) Psychological benefits of real-time travel information on route choice behavior – preliminary insights from driving simulator experiment data. Presented at INFORMS 2013 Annual Meeting, Minneapolis.
- Song, D.Y., Hsu, Y.-T., and Peeta, S. (2013) Value of travel information: Exploring psychological effects of real-time travel information on traveler decision-making behavior. Presented at INFORMS 2013 Annual Meeting, Minneapolis.

Research, Education and Outreach from Campus Transit Laboratory

Publications, conferences

- Ji, Y. R.G. Mishalani, and M.R. McCord, "Estimating Transit Route OD Flow Matrices from APC Data on Multiple Bus Trips Using the IPF Method with an Iteratively Improved Base: Method and Empirical Evaluation," ASCE Journal of Transportation Engineering, awaiting publication acknowledgement of federal support: yes)
- Ji, Y. R.G. Mishalani, and M.R. McCord, "Iteratively Improving the Base Matrix of the IPF Method For Estimating Transit Route-Level OD Flows from APC Data," Select Proceedings of the World Conference on Transportation Research, Rio de Janeiro, Brazil, 2013, awaiting publication (acknowledgement of federal support: yes)

Other publications, conference papers and presentations:

- McCord, M.R., and R.G. Mishalani, "Using APC Data for Estimating Boarding to Alighting Bus Passenger Flows," American Public Transportation Association 2013 ITS Transit Best Practices Workshop, Detroit, Michigan, November 13-14, 2013 (acknowledgement of federal support: yes)
- Ettefagh, M., R.G. Mishalani, M.R. McCord, "Effects of Transit Passenger Information System on User and Nonuser Preferences and Perceptions," Ohio Transportation Engineering Conference, Columbus, OH, October 22-23, 2013 (acknowledgement of federal support: yes)
- Ji, Y., R.G. Mishalani, and M.R. McCord, "Iteratively Improving the Base Matrix of the IPF Method For Estimating Transit Route-Level OD Flows from APC Data," 13th World Conference on Transport Research, Rio de Janeiro, Brazil, July 15-18, 2013 (acknowledgement support: yes)
- McCord, M.R., and R.G. Mishalani, "OSU Campus Transit Lab (CTL): Background, Data, Applications, and Outreach," Presentation to OSU Chief Data Officer Team, The Ohio State University, Columbus, OH, August 2, 2013 (acknowledgment of federal support: yes)

Website: activities and results from this project: http://transitlab.osu.edu/campus-transit-lab

Technologies, Techniques

- Commercial-grade state-of-the practice automatic vehicle location technologies, passenger information systems, and automatic passenger counter technologies implemented on an operational bus service provided data that were regularly downloaded and stored.
- Systematic experiments using mobile-based Wi-Fi sensing technologies were designed and implemented.
- Database: 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

Physical collections

- Bus passenger origin-destination flows were manually collected.
- Manually assisted, Wi-Fi based flow data were collected

Software or NetWare

- Various codes for archiving, processing, and analyzing the rich and large datasets collected through the Campus Transit Lab were developed. Educational aids or curricula,
- Data obtained from the CTL, as well as the physical infrastructure, were used in a transportation civil engineering course. Hands-on experience in transit data collection was provided to graduate and undergraduate students associated with the project. Experience with practical transit planning and operations issues was provided to graduate students through the outreach activities

Instruments, Equipment

- Work with bus service operators continued 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, estimated and observed bus passenger origin-destination flows were updated.

Models to investigate the effect of removing a bus on passenger loads and wait times were developed

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

Databases: Transportation supply and demand, population density, policy, and CO2 emissions in urban areas.

Software or NetWare: Various codes for summarizing and analyzing the various data-sets.

Data and Research Material: Urban transportation supply and demand, population density, policy, and CO2 emissions data.

Models: Models relating CO2 emissions to transportation demand and supply, population density, and policy variables.

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

Technologies or techniques: New techniques are developed that aim to 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 temporal patterns across different groups of travelers.

PART 3: PARTICIPANTS & COLLABORATING ORGANIZATIONS

Partnership Organization Information

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

- 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. 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.

Truck Activity and Wait Times at International Border Crossings

- Michigan Tech Research Institute, Ann Arbor, Michigan: In-kind support, Facilities, Collaborative research
- CEVA Logistics, worldwide offices: In-kind support (Truck location and timing data)

Research, Education and Outreach from Campus Transit Laboratory

- The Ohio State University Department of Transportation and Traffic Management, Columbus, Ohio: Financial support, In-kind support, Facilities
- Clever Devices, Woodbury, New York: In-kind support

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

- The Ohio State University Department of Transportation and Traffic Management, Columbus, Ohio: Financial support, In-kind support, Facilities

Other Collaborators or Contacts

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

- Dr. Kartik B. Ariyur, Assistant Professor with the School of Mechanical Engineering at Purdue University. He contributes his expertise in the area of signal processing to improve the accuracy of Tscan system.
- Cheng Liu, M.S.M.E. graduate from Purdue University. He works on the development and implementation of algorithms.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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. 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 which 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 to apply the approach to other regions globally.
- SMART collaborates with and is supported by Ford Motor Company. The NEXTRANS work inspired Ford to support a 3-year URP project to apply aspects of this project effort to other global regions.
- SMART collaborates on a regular basis with: * the International Transport Forum of the OECD (Organization for Economic Co-operation and Development) * the World Business Council on Sustainable Development * the Global Clean Tech Cluster Association* SLOCAT (A United Nations-affiliated network of sustainable transportation related initiatives world wide). * 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. Work maturing through this project will be presented for feedback to partner organizations listed above.

Truck Activity and Wait Times at International Border Crossings

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

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

- Collaborative research with: - Department of Computer and Information Technology, Purdue University - School of Chemical Engineering, Purdue University

Research, Education and Outreach from Campus Transit Laboratory

Interdepartmental or interdisciplinary collaborations: Civil Engineering, City and Regional Planning, and Statistics researchers and students collaborate on various project activities.

Collaborations or contact with others outside the NEXTRANS Center: 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.

Collaborations or contacts with others outside the United States or with an international organization: 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.

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

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

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

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

PART 4: IMPACT

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

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

- We hope to test the impact of a long- and short-term information provision strategy on people's travel behavior, including residential location choice, auto ownership, parking decisions, and mode choice.

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

- We are seeking to assess: 1. The impact that mobility-based evaluation has on the transportation and land-use built environment; 2. The difference that accessibility-based evaluation would make; 3. Obstacles to the shift to accessibility-based evaluation; 4. Approaches to overcoming those obstacles.

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

- The algorithm to be developed and the information gained from the video coding will help develop a more complete quantitative understanding of driver distraction, and its prevalence, magnitude, and mitigation. Ultimately, this work could potentially prevent motor vehicle crashes and injuries.

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

- MARKAL is one of the key models used to evaluate national energy policy. The CNG transportation options are now included in our version of that model.

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

- There is a considerable potential impact on safety measurement. Too early stage to confirm.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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.

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.

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

- The findings from this research should help the transportation agencies to study the change in drivers' strategic and tactical behavior.
- The detailed vehicle range information under different traffic conditions should help in planning the lane-use for urban and rural areas.

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.

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

- Anticipated project analysis and modeling results are expected to improve the understanding of the nature of the contributions of passenger urban travel to greenhouse gas emissions, which in turn has the potential to inform transportation related policy-making aimed at possibly reducing such emissions.

Transit Origin-Destination 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

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

- 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). 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.

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.

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

- The integration of microscopic battery state-of-charge model in estimating change in energy demand will help the authorities to manage power grid. The battery state-of-health using realistic driving cycles should act as a critical input in estimating vehicle value and designing vehicle warranties. The detailed microscopic battery state-of-charge model should provide a qualitative input to the battery manufacturers for designing batteries for different regions and purposes.

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.

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

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

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

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

Impact on Transportation Workforce Development

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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.

Truck Activity and Wait Times at International Border Crossings

- Two graduate students and one undergraduate intern processed and interpreted uniquely collected data. Two graduate students were involved with preparation and revision of a technical paper and with preparing two conference presentations. Two graduate students presented results of the project at a technical conference. Context, technologies, and results were presented to a 130-student undergraduate class and to a 25-student mixed undergraduate and graduate class.

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. Minority and female students were provided the opportunities to improve professional skills in transportation through research and internships.

Research, Education and Outreach from Campus Transit Laboratory

- Two research engineers, four graduate students, and five undergraduate students regularly collected passenger flow information on CTL buses. Two research engineers and one graduate student experimented with Wi-Fi data collection on Central Ohio Transit Authority buses. One summer intern from the University of California – Berkeley was integrated into data collection activities on CTL buses and CTL research and outreach activities. Two research engineers and four graduate students regularly processed and analyzed automatically collected CTL data. Approximately 130 undergraduate students used CTL data to produce empirical estimates of bus passenger OD flows and passenger travel times and were exposed to CTL activities. A former graduate student who worked on CTL activities received a competitive job in transportation management consulting in Washington, DC. A summer intern was hired as a research engineer on the CTL and applied to multiple schools for graduate studies in transportation for next academic year.

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

- One PhD student works directly with urban transportation supply and demand, population density, CO2 emissions, and policy data to identify patterns and relationships pertinent to transportation policy-making.

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

- One PhD students 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

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

- We have to capability to work with others in evaluating a wide range of energy and transportation policy alternatives.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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

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

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.

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

- A refined database required for developing microscopic battery state-of-charge model will be developed during this study.

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.

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

- Project is resulting in the amassing of unique databases that combine data from multiple sources spanning urban areas around the world.

Transit Origin-Destination 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.
- The estimation results arrived at could contribute to improved planning for and designing of transit services, both on campus and eventually more broadly in Columbus and other cities if the model and methods are adopted.

Impact on Technology Transfer

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

- To date, we have not identified specific products that we will be pursuing through disclosure and patent protection; however, the project may lead to new software development. While this is a potential in the work, we have been focusing on methods and are not yet at the stage to develop specific code to automate actions related to the visualization process. The project informs elements of research that have not heretofore been addressed related to non-classified industries and related to relationships across industries and enterprises. Methods developed thus far through this project have been identified as being of interest to corporate partners of SMART (Ford Motor Co.) Methodological uptake and transfer to key industry agents is an anticipated outcome of this project.

Truck Activity and Wait Times at International Border Crossings

- Efforts will be made to communicate results to stakeholders.

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.

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

- The project may lead to enhancement in battery technology for electric vehicles.

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

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

- This project is oriented toward the reform of transportation and land-use planning practice toward an accessibility basis.

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

- Better information on policy alternatives and consequences can lead to better policy.
- Standardized Metrics for Accessibility: Establishing a Federal Policy-Relevant Knowledge Base. By the end of the project, we hope that scholars and public policy analysts, through their research, will be better positioned, by tracking progress over time and across place, to discover new approaches to policy making.

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

- The potential impact on STEM fields is twofold: first, we anticipate that new and novel visualization techniques will be developed through the efforts of this project. The second and likely more impactful outcome relative to STEM fields, lies in the identification of STEM related job opportunities within regions that relate to workforce training and demand prediction. 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.

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

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.

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

- General public will get a better vehicle choice due to enhancement in battery technology and detailed route information to make a route choice.

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.

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

- 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.

Transit Origin-Destination 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

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

- A Co-PI left Purdue for another institution, and that led to some delay in finishing the policy analysis.

Mapping New Mobility Business and Employment Opportunity in Michigan: Developing a Data-Driven Graphic Platform for Assessing and Advancing Industry Cluster Development 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.

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

- The development of battery model is delayed due to unavailability of a rich and periodic electric vehicle log data.