1. Project Information:

1a. Project No. and Title:

141OSUY2.1 – Research, Education and Outreach from Campus Transit Laboratory

172OSUY2.2 – Campus Transit Laboratory: Infrastructure for Research, Education, and Outreach

1b. Principal Investigator(s): Mark McCord and Rabi Mishalani, The Ohio State University

1c. Start Date:

141OSUY2.1 – Feb. 1, 2012

172OSUY2.2 – July 1, 2015

1d. End Date: Dec. 31, 2017

1e. Report Date: March 13, 2018

2. Project Benchmarks:

2a. Students:

<table>
<thead>
<tr>
<th>Name</th>
<th>Undergrad/Graduate</th>
<th>Male/Female</th>
<th>US/Foreign</th>
<th>Ethnicity</th>
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<tr>
<td>Paul Beck</td>
<td>Undergrad</td>
<td>Male</td>
<td>US</td>
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<tr>
<td>Victoria Bias</td>
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<td>Serkan Bicici</td>
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<td>Jason Biltz</td>
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<td>Josh Bradford</td>
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<td>Brad Brickman</td>
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<td>Gregory Burch</td>
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<td>Bryan Check</td>
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<td>Aijing Chen</td>
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<td>Cheng Chen</td>
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<td>Shanshan Chi</td>
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<td>Mariel Colman</td>
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<td>Mahsa Ettefagh</td>
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<td>Sarah Fox</td>
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<td>Nick Goodman</td>
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<td>Sydney Gravitt</td>
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<td>Hafiz Gulam</td>
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<td>Andrew Gyde</td>
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<td>Giovani Hansel</td>
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<td>Jiecheng Huang</td>
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<td>Rashed Islam</td>
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<td>Tatjana Kotauta</td>
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</table>
2b. Presentations (Title, Date, Authors, Event):


3. Mishalani, R.G., McCord, M.R., April 20, 2012. Overview of Campus Transit Lab (CTL) at The Ohio State University. Presentation to Xerox, Columbus, OH.


5. Mishalani, R.G., McCord, M.R., Goel, P.K., April, 9, 2012. Overview of Campus Transit Lab (CTL) at The Ohio State University. Presentation to EU COST project team representative, Columbus, OH.

7. McCord, M.R., and Mishalani, R.G., August 27, 2012. The OSU Campus Transit Lab (CTL) and Transit-related Activities at The Ohio State University. Presentation to Federal Transit Administration representative, The Ohio State University, Columbus, OH.

8. Ettefagh, M., September 24, 2012. Effect of Passenger Information System (TRIP) on OSU Travelers' Attitudes and Perceptions. Presentation to OSU donor and development personnel, The Ohio State University, Columbus, OH.


14. McCord, M.R., Mishalani, R.G., June 3, 2013. OSU Campus Transit Lab (CTL): Background, Data, Applications, and Outreach. Presentation to OSU Chief Data Officer, The Ohio State University, Columbus, OH.


18. McCord, M.R., Mishalani, R.G., August 2, 2013. OSU Campus Transit Lab (CTL): Background, Data, Applications, and Outreach. Presentation to OSU Chief Data Officer Team, The Ohio State University, Columbus, OH.

19. McCord, M.R., Mishalani, R.G., November 13, 2013. Overview of Campus Transit Lab related activities at OSU. Presentation to Catherine Ross, Professor, City and Regional Planning and Director, Center for Quality Growth and Regional Development, Georgia Institute of Technology.


Estimation and Characteristics Expansion. Research Review Presentation to the Ohio Department of Transportation, Columbus, OH.


Socioeconomic and Travel Characteristics. National Science Foundation Mobility Workshop, Columbus, OH.


37. Mishalani, R.G., June 8, 2017. The Road to Autonomous Vehicles: A Transportation Systems Perspective. Panelist, invited by the Harvard Business School Club Columbus and hosted by the Center for Automotive Research, The Ohio State University, Columbus, OH, June 8, 2017.


2c. Journal Papers/Reports (full citation):


Transit Passenger Trips: Investigations of OSU’s Intra-campus Transit Demand. M.S. thesis, The Ohio State University, Columbus, OH.
7. Reinhold, H.E., April 2013. Combining Transit Route Origin-Destination Passenger Flow Matrices into Integrated Area or Corridor Matrices: Evaluating Flow Patterns on the OSU Campus and along a Columbus Corridor. M.S. thesis, The Ohio State University, Columbus, OH.
13. Shay, N.M., 2016. Investigating Real-Time Employer-Based Ridesharing Preferences Based on Stated Preference Survey Data. M.S. Thesis, Graduate Program in Civil Engineering, The Ohio State University, Columbus, OH.

2d. New Courses (Title, Undergraduate/Graduate, Date):

We added CTL-based modules to several transportation courses, as follows, because of the developments that allowed using the Campus Transit Laboratory infrastructure for instructional purposes:

1. CIVILEN 3700 Transportation Engineering and Analysis: Undergraduate Civil Engineering students must choose six “select core” courses from a set of eight courses, which includes CIVILEN 3700. Typically, 150-200 students per year take this course. Some undergraduate students take additional transportation courses after CIVILEN 3700, but this is the only transportation course taken by the majority of the students. A module on scheduled transit
services is included, where the Campus Transit Lab (CTL) is highlighted. We recently added a module on sustainability in transportation related applications that focuses on CTL applications in an attempt to provide readily interpretable examples. Assignments involve the processing of APC and AVL data automatically collected as part of the CTL and a manual data collection exercise, as well as the interpretation of the processed and manually collected data.

2. CIVILEN 5720 Transportation Engineering Data Collection Studies: This course is typically taken by 15-25 students per year and is comprised of undergraduate and graduate Civil Engineering students and graduate City and Regional Planning students. It is a required course in the Dual Civil Engineering – City and Regional Planning M.S. Program in Urban Transportation Planning. We introduced a module on estimating traffic flows from a modified moving observer method we developed with the vision of collecting data from transit buses. We include an assignment where students board CABS buses to collect traffic data and process the data to produce traffic flow estimates.

3. CIVILEN 5770 Urban Public Transportation: Like CIVILEN 5720, CIVILEN 5770 is a required course in the Dual Civil Engineering – City and Regional Planning M.S. Program in Urban Transportation Planning and is taken by undergraduate and graduate Civil Engineering students and graduate City and Regional Planning students. It is a required course in the Dual Civil Engineering – City and Regional Planning M.S. Program in Urban Transportation Planning. Typically, more than 30 students take this course in a year. A major course requirement consists of a semester long project based on CTL carried out in teams of three to four students. Students collect field data on CABS vehicle and passenger movements and use these data along with CTL’s automatically collected APC and AVL data to analyze and model various aspects of the supply of and demand for service. Based on the results, students comment on performance and make recommendations to the operators of CABS.

4. CIVILEN 7730 Urban Transportation Forecasting: This course is offered once every two years. Like CIVILEN 5720 and 5770, it is a required course in the Dual Civil Engineering – City and Regional Planning M.S. Program in Urban Transportation Planning. It is not open to undergraduate students. Over the duration of this project, approximately 10 students have taken the course on average. Students conduct a term project, which is generally presented to others in the class. Approximately one quarter of the students use data from the Campus Transit Lab in their project.

5. Individual Studies: Several students undertook independent studies for credit that relied on automatically collected CTL data or data they manually collected as part of their independent study course and on methods we developed to process the data into estimates of vehicle or passenger movements. In addition, CTL infrastructure and data formed the basis of a summer-long study of one Summer Research Opportunities Program (http://www.btaa.org/resources-for/students/srop/introduction) student. Furthermore, one student in the Dual Civil Engineering – City and Regional Planning M.S. Program in Urban Transportation Planning conducted his required “practicum” course – consisting of an internship at a transportation agency or company and regular academic reporting on the experience to the course instructor – at OSU’s TTM, where he provided an interface between CTL activities and TTM needs.

2e. Outreach Conference (Title, Location, Type of Audience, Total Participants):

Conference, Columbus, OH.


3. Project Impacts:

3a. USDOT Priorities:

In general, improved transit services result in improved overall transportation performance across all modes and, as a result, improved traveler mobility.

Short-Term Impacts: CTL data are used to validate rigorous, but presently available or recently developed approaches that can be immediately used with data already being collected by transit agencies to provide improved information for transit planning and operations. In addition to validating approaches with CTL data, the data and the approaches are used to provide information for targeted studies of interest to various stakeholders. CTL data and context are used to support modules and projects in multiple classes, offering students hands-on experience with data-driven analyses in a familiar setting.

Long-Term Impacts: New research questions are developed that can eventually lead to improved methodological approaches and new applications that take advantage of data already being collected by transit agencies and new types of data that could be available to transit agencies in the longer run. The proposed approaches and applications are evaluated in an operating environment. The educational component also has long-term impacts by exposing a large group of students to issues and technologies employed in public transportation and to the concept of learning through the use of a living laboratory infrastructure. The successful demonstration of the transit living lab are starting to motivate living labs in other domains.

Advanced Research: The research tasks are motivated by a desire to take advantage of the advanced technologies that automatically sense passenger boarding and alighting activity, passenger movements, and bus locations, to integrate behavioral and physical data with statistical methods and rigorous models, and to produce numerical results using efficient computational methods.

Please provide description of accomplishments with background and impact or value in terms of its significance to the ultimate customers or beneficiaries, which can be used in NEXTRANS and USDOT publications.
3b. Significant Accomplishments in Research, Education and Technology Transfer (Please list any patents, copyrightable material, new processes, algorithms, textbooks, chapters, etc.):

**Research**

Data collected in the CTL were used to investigate the effect of passenger information on perception of transit services; effect of weather on transit short trips; effect of a base matrix on OD flow estimates using APC data; use of mobile device Wi-Fi signals to determine passenger OD flows; stated preferences for real-time employer-based ridesharing considering personal and travel characteristics; use of OD flows determined from APC and AFC data to correct sample and response biases in transit onboard survey results; sampling biases in transit onboard surveys and associated impacts on resulting passenger socioeconomic and travel characteristics; relationships among transit route-level passenger alighting probability, probability OD flow, and expected OD flow matrices; air quality monitoring from transit buses; traffic sensing from transit buses; and use of data on requests for real-time transit information made through the use of a mobile app.

These investigations are leading to new applications for automatically sensed data for transit systems. The promising results are also leading to new research funding from other sources.

**Education**

CTL data and infrastructure were effectively used in undergraduate and graduate courses through class lectures, assignments, data collection exercises, and exam questions. The exposure of students to state-of-the-art technologies and the reinforcement of basic concepts using real-world data from a familiar operating transit system is seen to be of great value by students and university leadership.

**Technology Transfer**

This report documents the activities conducted within the Campus Transit Lab (CTL) at The Ohio State University for the purposes of research, education, and outreach from Spring 2012 through Autumn 2017. CTL investigators utilized automatically and manually collected data from CABS to support these goals. CTL investigators conducted outreach with CABS to assess night service ridership, support campus planning efforts, fill in and correct ridership reports produced by off-the-shelf software, support campus sustainability policy efforts, advise on the management of the data for a new campus bike-sharing service, provide lessons learned regarding ridership reporting from APC data to Washington Metro, and share extensive documentation of inferring OD flows from APC data with Washington Metro.

The value added to CABS and other transit operators is leading to improved service planning and design tools and customer satisfaction.

**3c. Challenges and Lessons Learned:**

The results reinforce the belief that there is great value in basing research, education, and outreach on a living lab that is geographically and institutionally accessible to researchers and students and offers transit service that is sufficiently complex to capture realistic issues for
urban transit operations but sufficiently contained to allow extensive in situ observations across the system.

The undertaken efforts and results motivate many more research, education, and outreach activities that could be pursued in the near and long term, including use of the campus living lab for applications that go beyond public transportation such as traffic and air quality monitoring. While some of the novel smart transit ideas promoted by CTL investigators are becoming mainstream, developing a plan that allows investment for sustained activities and expansion in using living labs to support smart cities broadly defined is seen as a primary challenge and opportunity.

3d. Photographs for NEXTRANS Publications (please attach separately):

None