MPC-469
April 1, 2014- July 31, 2017

Project Title:
Improving Efficiency and Reliability of Bus Rapid Transit

University:
University of Utah

Principal Investigators:
Dr. Milan Zlatkovic (PI), Research Assistant Professor, Department of Civil and Environmental Engineering, University of Utah
Email: milan@trafficlab.utah.edu
Phone: 801-819-5925

Dr. Xiaoyue Cathy Liu (co-PI), Assistant Professor, Department of Civil and Environmental Engineering, University of Utah
Email: cathy.liu@utah.edu
Phone: 801-587-8858

Dr. Richard J. Porter (co-PI), Assistant Professor, Department of Civil and Environmental Engineering, University of Utah
Email: richard.jon.porter@utah.edu
Phone: 801-585-1290

Research Needs:
Bus Rapid Transit (BRT) is an innovative, high capacity, lower cost public transit solution that can significantly improve mobility (National BRT institute, 2014). It is usually defined as an integrated system with a strong, transit-oriented identity, which consists of running ways (very often exclusive lanes), specially designed rail-like stations, high-capacity low-floor vehicles, improved services, and state-of-the-art Intelligent Transportation Systems (ITS) (Levinson et al., 2003). It provides similar quality of service as rail transit, at much lower construction and operational costs to the transit organization, and retains the flexibility of buses. BRT has the potential to significantly improve efficiency and reliability of public transit, which leads to an increase in the ridership. Certain *operational strategies* significantly help BRT in improving travel times, speeds and headway adherence, with the most beneficial seen from the implementation of Transit Signal Priority (TSP) and off-board fare collection (Zlatkovic et al. 2010). ITS technologies, such as GPS tracking devices, Automated Passenger Counters (APC), Ticket Vending Machines (TVM), advanced detection systems, signal performance monitoring systems etc., are now widely used by transit and state DOT agencies. These systems, by providing performance-related data, can be used to further improve the efficiency and reliability of these BRT systems. This research will focus on the evaluation and analysis of two operational strategies for improving the efficiency and reliability of BRT system: TSP and fare collection methods. The study will review different TSP systems (conventional detection vs. GPS, conditional active TSP considering ridership and schedule/headway adherence, and adaptive TSP

considering a wide range of traffic and transit operations), and fare collection methods being used (prepaid, tickets sold by the driver, off-board TVMs, on-board TVMs), and quantitative analysis will be performed based on field and simulated data to evaluate the effectiveness of various strategies. The study will be on the basis of Utah Transit Authority (UTA) BRT system, however, the research result is quite transferable to other BRT in the metropolitan areas with similar system design and can serve as a reference for transit planners and engineers on the national level.

Research Objectives:
The main research objectives of this study are as follows:

- Communicate current and future needs related to the TSP system with UTA, Utah Department of Transportation (UDOT), and other interested parties (Wasatch Front Regional Council, cities and public);
- Define alternatives for TSP implementation with a focus on GPS-based TSP systems;
- Define approaches and modeling methodologies for alternative evaluation;
- Create, calibrate and validate microsimulation and other models to be used in analysis;
- Perform evaluations of alternatives that will include needs and inputs from all interested parties;
- Communicate the recommendations and define steps for system implementation; and
- Evaluate and quantify the benefits of TVM along the BRT, with emphasis on the direct benefit in dwell time and operational delay reduction.

Research Methods:
The study will collect and analyze existing field data, such as traffic volumes, travel speeds and corridor levels of service for vehicular traffic and transit, BRT boarding, TVM, farebox recovery, and fare evasion data, traffic signal operations, intersection delays and intersection levels of service for different modes. Traffic modeling and simulation software will be used extensively over the duration of the study. It will enable researchers to assess different aspects of traffic and transit operations, and provide tools for testing different alternatives. The use of high-end applications, such as traffic signal control software-in-the-loop, will ensure the credibility of the used methods and obtained results. It will also provide excellent learning tools for students involved in the project.

Expected Outcomes:
The first outcome of this study will be complete sets of traffic and transit data collected under the existing conditions. The data will be useful for planners, engineers and educators from, and can be used in potential future projects. The second outcome will be the assessment of current traffic conditions for different transportation modes in the analyzed network. The current traffic conditions will be the starting point for comparing different alternatives. It will also provide clues for potential problems in current operations, and the ways to eliminate these problems.

Since the major portion of the study will use microsimulation and traffic control software-in-the-loop, it will equip practitioners with a useful tool for detailed analysis of traffic control and TSP strategies in a high-fidelity simulation environment. The traffic models that will emanate from this study can further be used for many other types of operational analysis. The third outcome of the project is the analytical procedure for measuring the benefits of TVM. The procedure would

encompass comprehensive analysis on operating costs, boarding delay, ridership revenue, and the benefit assessment with regard to operational efficiency and farebox recovery ratio.

Relevance to Strategic Goals:
This project is dealing with the improvement of efficiency and reliability of BRT systems, and it is closely related to the majority of the strategic goals, including *Safety, State of Good Repair, Economic Competitiveness, Livable Communities,* and *Environmental Sustainability*.

A well designed BRT system is capable of improving safety for all users of transportation. With increased ridership resulted from improved transit efficiency and reliability, the BRT system contributes to the reduction of automobile uses in its area of influence. This directly results in less parking spaces needed which can be used for business development, and much less potential conflicts among various modes leading to increased safety. With the upgraded transit stations that BRT can offer, it provides more convenient and comfortable space for waiting passengers. A good public transportation system has the ability to attract more people, which has been proven for BRT. Combining this with the previous potential goal in increasing business development, it has great potential for economic development, making its area of influence more competitive. Also, with increased efficiency, especially through reduced number of stops and less idling time, the BRT system has fewer emissions and helps with improving air quality, which makes the system environmentally friendly. A good BRT system would serve as a strong foundation for Transit Oriented Development (TOD), creating livable communities within its area of influence.

Educational Benefits:
Three graduate students and one undergraduate student will be heavily involved in this research. They will lead the preparation of journal publications resulting from this work, and in most cases, deliver conference presentations. The project will serve as a basis for his/her dissertation work. The undergraduate level course CVEEN 3520: Transportation Engineering, the undergraduate/graduate level course CVEEN 5560/6560: Transportation Planning, and the graduate level course CVEEN 7590 Public Transportation System are the ideal platform to introduce the concept of transit-oriented development, and the operational analysis and statistical modeling used in this project. The traffic simulation software used in this project will provide students hands-on experience for traffic operations and transit system assessment, which will prepare well for their career.

Work Plan:
The work plan is divided in two phases, with each phase consisting of one or more tasks. The phases and tasks are as follows:

Phase 1: Fare collection analysis
This phase will focus on the BRT fare collection analysis, by performing the data collection, analysis and modeling to quantitatively evaluate the benefits for off-board fare collection. The following tasks will be included:

- Data collection on BRT, including but not limited to: travel time data, TVM data, farebox recovery data, boarding data, and fare evasion data;
- Depending on the availability and nature of data, comparison analysis might be extended to equivalent local buses to provide an accurate estimation of time benefits;

- Analysis of operating costs, boarding delay, ridership revenue based on the data collected; and
- Assessment of benefits provided by TVM with regard to operational efficiency and farebox recovery ratio.

Phase 2: BRT TSP analysis

This task will analyze possible TSP system upgrades and provide recommendations for field implementations. The following sub-tasks should be included:

- An overview and evaluation of the current TSP implementations
- A literature review of TSP systems and implementations, with a clear focus on GPS-based and adaptive systems
- Selection of candidate systems to be considered for future evaluation
- Data collection
- Overview of existing practices and implementations by state transit and DOT agencies that can be beneficial for the selected TSP system implementations
- Analysis of candidate systems through modeling or other applicable methodologies
- Defining the steps for system implementation in the field

Project Cost:

Total Project Costs: $259,600
MPC Funds Requested: $129,800
Matching Funds: $129,800 Source of Matching Funds: Utah Transit Authority

TRB Keywords:

Bus Rapid Transit, Transit Signal Priority, Fare Collection, GPS, Ticket Vending Machine, Simulation

References:

1. Levinson, H., Zimmerman, S., Clinger, J., Rutherford, S., Smith, R.L., Cracknell, J. and Soberman, R. (2003) 'Bus rapid transit, Vol. 1: case studies in bus rapid transit', Transit Cooperative Research Program Report, No. 90, pp.10–25, 51–52, Transportation Research Board of the National Academies, Washington, DC.
2. National BRT Institute. http://www.nbrti.org/. Accessed 04/28/2014.
3. Zlatkovic, M., Stevanovic, A., Cevallos, F., and Johnson, H. R. (2010) '35M MAX: the first Bus Rapid Transit system in Salt Lake County', In *World Review of Intermodal Transportation Research*, Vol. 3 No. 1/2, Inderscience Publishers (2010) 103-120.