Connected Streetcar Project

The long-term vision and promise of Connected Vehicle (CV) technology is to use communications between vehicles and between vehicles and infrastructure to improve the safety and efficiency of our transportation network. This project will deploy the Multi Modal Intelligent Traffic Signal System (MMITSS) — a Dynamic Mobility Application, developed at the University of Arizona through a Connected Vehicle Pooled Fund Project — on the Portland Streetcar and at four intersections along the "Art Museum Corridor" in Southwest Portland. Through this deployment, the project will create a foundation (experience, understanding) for deploying connected vehicle infrastructure in the City and facilitating connected vehicle research in the NITC UTC.

Objective: Create a *foundation for deploying connected vehicle infrastructure and facilitating connected vehicle research* within the NITC UTC.

Potential Benefits to Streetcar & City:

Streetcar has established goals around system performance

- 85% on-time performance
- Less than .65 collisions per 1000 hours of service
- Goal of this project: evaluate if a more extensive deployment of this technology could help improve streetcar system performance

Project is intended to lay a foundation for CV deployment and research in Portland. Potential future work:

- Expanded deployments within the Portland region – streetcar or light rail
- Identification of multimodal CV application opportunities including pedestrians and bicyclists
- Research in integration of bicycles and pedestrians into the CV environment
- Development of (additional) visual analytics and data processing paradigms for CV data.

Planned Project Outcomes:

1. *CV Infrastructure Deployment:* Deployment of the MMITSS CV infrastructure on the Portland Streetcar and at City of Portland signalized intersections.
2. *CV Data Collection and Analytics:* Automated collection and storage of CV data in the PORTAL data archive. Design and development of select visual analytics in PORTAL using CV data, i.e. assessing Streetcar performance with and without CV / MMITSS technology.
3. *Deployment Guidance:* A technology deployment strategy and lessons learned for the deployment of advanced traffic signal control in a CV environment for use by other researchers and public agencies.
4. *Management Policy:* A management policy to allow the operating agency to determine which modes of travel should be given higher priority**.** For example, during commute times, buses, light rail, and bicycles may be given higher priority than passenger vehicles.
5. *Foundation for Future Work:* The project will be designed to support the addition of smartphone capabilities for pedestrians and bicycles and the capture of high fidelity data from connected travelers (pedestrians, bicycles, passenger vehicles, transit, trucks, and emergency vehicles).

Initial Deployment

The project will deploy the Multi-Modal Intelligent Traffic Signal System (MMITSS) on the Portland Streetcar, and will collect data from that deployment and integrate that data into the PORTAL transportation data archive. MMITSS is a Dynamic Mobility Application that provides traffic signal priority for multiple modes of travelers developed by Dr. Larry Head. CV hardware (OBU and RSU) with MMITSS (Multi-Modal Intelligent Traffic Signal Systems) will be installed on two (2) Portland Streetcars and four (4) signal cabinets in the “Art Museum Corridor” located between SW 10th/Alder & SW 10th /Clay for 9 months beginning in early 2019.

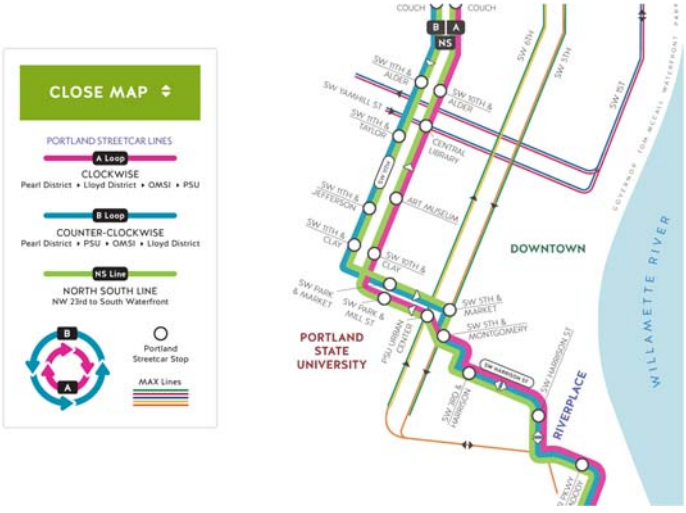

Figure 1 Streetcar Service - Art Museum Corridor [Streetcar Map]

Tasks, Schedules, Product

This project will be conducted in three phases: Phase 1: Test & Develop Prototype System; Phase 2: Initial Portland Streetcar Deployment; and Phase 3: Expanded Deployment. At a high level, the project timeline will be: Fall 2108: Phase 1 develop prototype system, including prototype data collection environment; Winter-Spring 2019: Phase 2: Initial Deployment, with a goal of deploying devices by March 2019; Summer-Fall 2019 Expanded Deployment with a goal of deploying devices by October 2019.

Task 1: Concept of Operations: *(Phase 1, July-Oct 2018) (Lead: Dr. Larry Head)*

A concept of operations will be developed that includes review of the current system, needs identified by the project stakeholders -- the City of Portland and the Portland Streetcar, needs and opportunities for data analytics using CV data, operational constraints such as pedestrian signal timing, use cases and capabilities of the MMITSS prototype, and strategies for operating and maintaining a CV traffic control system by the City of Portland. To support the operational understanding, a VISSIM simulation model will be developed and installed using the University of Arizona CV simulation platform that implements the MMITSS software components in Docker containers on a Linux server. The simulation model will be used to study the potential for operational improvement and to provide simulated data, that can include different CV market penetration rates, to the data analytics team. *Outcomes:* Concept of Operations and Simulation Model. Note: minor updates to the Concept of Operations may be made in Phases 2 and 3.

Task 2: Design and Develop Prototype CV Infrastructure System: *(Phase 1, Aug-Oct 2018) (Lead: Dr. Larry Head)*

CV Infrastructure Prototype: A prototype CV system design will be designed and developed based on the MMITSS prototype, traffic signal controllers used by the City of Portland, and the Streetcar operating schedule. The design will include architecture diagrams to support the installation and deployment, configuration data for MMITSS and the signal controllers, and other features identified during the development of the ConOps. The RSU and OBU operations will be tested in the laboratory and in the CIty of Portland Traffic Signal Shop. Then a test intersection near the PSU campus will be selected and equipment installed for field testing. A dummy signal controller will be used and a test vehicle (not a Streetcar) will be equipped with an OBU to test sending and receiving messages. *Outcomes:* Architecture diagrams, configuration data and tested OBUs and RSUs.

Task 3: CV Data Collection and Storage Design: *(Phase 1, Aug-Oct 2018) (Lead: Dr. Kristin Tufte)*

This task will use sample data from existing MMITSS CV systems and use cases developed in Task 1 to design and prototype CV data storage in the PORTAL system. This task includes defining the database schema, meta-data format, protocol and format for transferring data from the RSU to Portland State, the Extract-Transform-Load process for loading data into PORTAL, any data cleaning necessary and an API for making CV data accessible to researchers. Data privacy and sanitization issues will be addressed by using a temporaryID that changes every 5 minutes to protect privacy and any other necessary actions as identified by the latest privacy research. This task will also investigate the establishment of a secure, remote connection so that University of Arizona staff can access the MMITSS system to support operation, testing and evaluation. *Outcomes:* Design of the CV Data Collection and Storage System.

Task 4: Install & Deploy CV Infrastructure: *(Phase 2 and Phase 3, Nov 2018-July 2019) (Lead: Dr. Larry Head)*

This task will deploy RSUs at four intersections, including interfacing the units with the signal controllers and the city communications network along the Art Museum Corridor (Figure 1). On-board units (OBU) will be installed on two streetcars. The City of Portland will select the vehicles on which to install the OBUs. This installation will include experimentation with the location of the DSRC antennas and the potential need for multiple antennas per streetcar. Bluetooth sensors will be installed in the corridor to collect vehicle travel time data. This installation will include identification and consideration of antenna locations and power availability. The process will begin with RSUs being installed at the deployment intersections. Once the system has been installed in the deployment intersections, the system will be tested one intersection at a time, for several hours each, to ensure safe and efficient operation. City of Portland Traffic Engineers, Technicians and Portland Streetcar staff will be on-site during the testing phase. After all four intersections and two streetcars will be equipped and tested, a full system test will be conducted over a two week period. The signal operations will be observed and data collected to analyze the operational correctness and efficiency of the system. Results will be compared to the simulation experiments from Task 1. *Outcomes:* CV Infrastructure Deployment. Goal Phase 2: Initial Deployment by March 2019, Phase 3: Expanded Deployment by end of July 2019.

Task 5: CV Data Collection and Storage Implementation: *(Phase 2, Nov 2018 - March 2019) (Lead: Dr. Kristin Tufte)*

This task implements the design developed in Task 3. The result of this task will be an automated process for data to be collected in real time from the RSUs and stored in the PORTAL archive as well as the implementation of an API so researchers can retrieve data. This task includes development of scripts to collect, clean and store the CV data as well as working with City staff to leverage existing network connections between City of Portland and Portland State to allow CV data to be transferred from the City to Portland State. *Outcomes:* Automated process of storage of CV data in the PORTAL archive, documented API.

Task 6: Analytics and Visualizations: *(Phases 2 and 3, Nov 2018-Sept 2019) (Lead: John MacArthur)*

The goal of this task is to design and develop of at least two analytical tools for CV data to enable operations staff to view the CV data and to assess the performance of the Streetcar with and without CV / MMITSS technology. This task will follow on work done in Task 1 to identify use cases and potential visualizations. The development of the analytics and visualizations will follow a three-step process in which users are first engaged to understand how they could use the data, followed by the development of prototype analytics and visualizations using real data to obtain more user feedback, followed finally by final implementation of the analytics and visualization. *Outcomes:* At least two analytical tools for MMITSS data.

Task 7: Training materials & demonstrations: *(Phases 2 and 3, June-Sept 2019)* (Lead: Dr. Larry Head)

Training materials will be developed that explain the operation of the DSRC equipment (OBU and RSU), including how they are configured, managed, and troubleshooting guidance and how the MMITSS system operates, is configured, managed, and troubleshooting guidance. These training materials will be presented to City of Portland and other stakeholders in a one day workshop format. NITC researchers

and students will be allowed to participate, but the focus will be the City of Portland and Streetcar staff. Demonstrations will be provided for key stakeholders. For the purpose of planning and budgeting, three demonstrations will be conducted, but others could be conducted as needed and if requested.
Outcomes: Deployment Guidance, Management Policy, Demonstrations, Training Materials

Task 8: Final Report. (July-Oct 2019) (Leads: Dr. Kristin Tufte, Dr. Larry Head, John MacArthur)

This task will write final NITC report for the project. The final report will be co-written by the project leads with each lead taking responsibility for the portion of the report related to their tasks (as noted above).

City of Portland and Streetcar Team

Project Mgt : Anne Hill, DPT (coordinating with PSU/PBOT)

Streetcar: Kathryn Levine, Erick Moe

Streetlights and signals: Willie Rotich

IT/Data: Michael Kerr, Kirk McEwen

Planning: Eric Hesse

PSU and UA Team:

Kristin Tufte (co-PI) – PSU Assistant Professor, Computer Science, College of Engineering

Larry Head (co-PI) – UA Professor, Systems and Industrial Engineering, College of Engineering

John MacArthur – PSU Research Associate, TREC

Sherilyn Keaton – UA Manager, Systems / Software Engineering

PSU GRA - TBD