UTC Project Information	
Project Title	Exploring Weather-related Connected Vehicle Applications for Improved Winter Travel in Pacific Northwest
University	Washington State University
Principal Investigator	Xianming Shi
PI Contact Information	xianming.shi@wsu.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	University of Washington PacTrans $180,000 Washington State Department of Transportation $175,000 Washington State University $5,000
Total Project Cost	$360,000
Agency ID or Contract Number	69A3551747110
Start and End Dates	August 16, 2017 – August 15, 2019
Brief Description of Research Project	The objectives of this project are to investigate how connected vehicle data (CV) such as images and friction coefficients could be integrated with data from road weather information system(RWIS) stations and other infrastructure; and how the integrated data could be used to improve decision making for highway operations and enhance traveler information during inclement winter weather events.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The WSU team conducted a nationwide survey of maintenance departments to assess the application of CV technologies to improve safety and mobility during winter. This work then presents the potential application and operational scenarios of CV technology for improving winter travel. In the Concept of Operations, maintenance departments would use mobile road weather-related route-specific data to obtain advanced maintenance strategies; subsequently, they provide to road users the travel alerts and advisories. The UW research team demonstrated the proposed road surface condition prediction algorithm in Washington State. Two RCM 411 sensors were installed on maintenance trucks for data collection (see Figure 1), and the data is transmitted to the DRIVE Net platform for analysis and visualization (Figure 2 shows the conceptual architecture). The proposed prediction algorithms are integrated with the DRIVE Net platform to predict the future road surface condition based on historical measurements. Finally, the predicted road surface condition is visualized on a map using geospatial data from Open Street Map (OSM) (see a screen shot in Figure 3). The platform is user-interactive that the user select date to visualize road surface data, either historical or predicted data.  **Figure 1** RCM 411 Sensors on Maintenance Truck of WSDOT

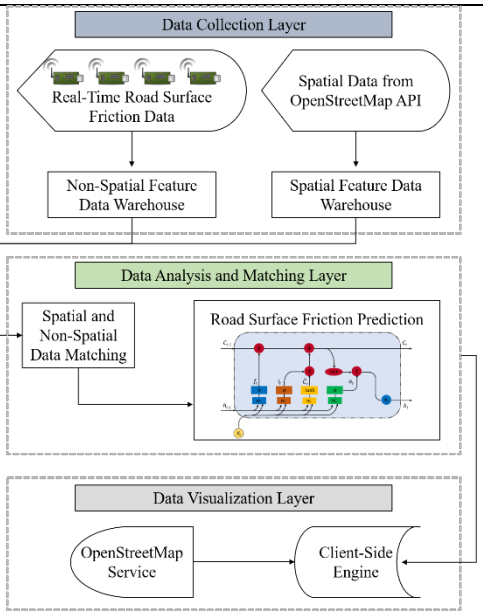


Figure 2 Road Surface Condition Platform Prediction and Visualization Platform

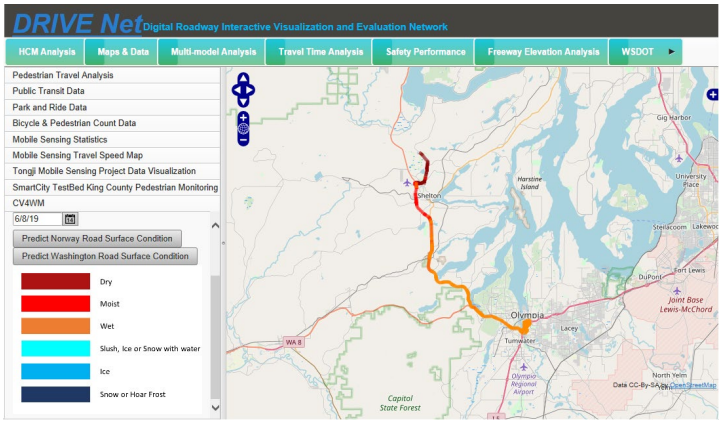
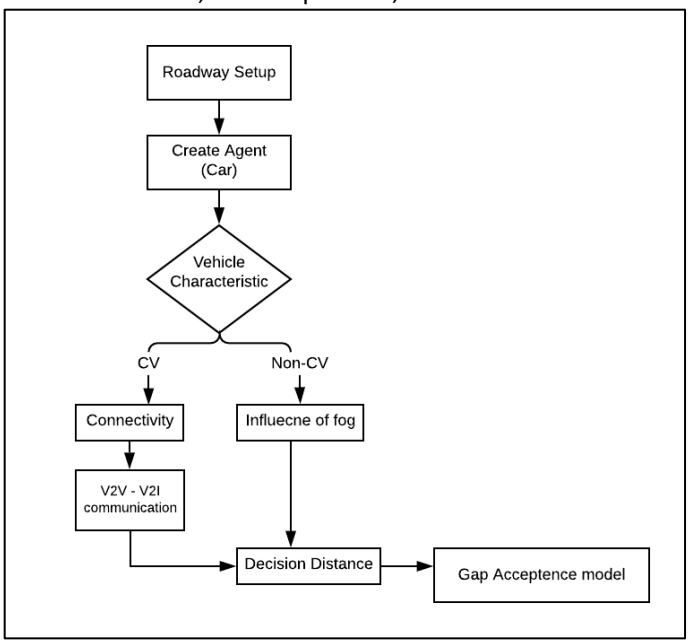


Figure 3 User Interface of Road Surface Condition Prediction and Visualization Platform

The OSU team developed an agent-based modelling (ABM) framework that can be applied to better capture the effect of inclement weather on drivers' behavior and the potential impact of CAVs on highway traffic performance under different MP levels. Parameters embedded in the simulation platform can be calibrated against different dataset to address different driving (i.e., human driven vehicles and connected vehicles) condition.

Developed methodology as outlined in Figure 4 is implemented through a simulation testbed to evaluate the efficacy of CV technology during the adverse weather. The simulation framework is divided into three phases. The first phase consists of basic simulation and roadway configuration and settings where the number of lanes, speed limits, and MP levels are defined; the second phase consists of non-CAV and CAV behaviour models that includes the car-following and lane-changing behaviour models, in addition to the logical constraints that simulates the vehicle communication

	behaviour during the inclement weather; finally, the third phase consists of the simulation execution, data acquisition, and results extraction.  **Figure 4** Simulation Framework to characterize CAV behavior during adverse weather
Impacts/Benefits of Implementation (actual, or anticipated)	This work is anticipated to produce intellectual merit relevant to the PacTrans theme of " *Providing Data Driven Solutions for Diverse Mobility Challenges in the Pacific Northwest*", with the focus on "Inclusive Accessibility for All: Mobility Benefits of Connected Vehicles". The results will allow State DOTs and other agencies in the region to achieve better understanding of how CV technologies will benefit road weather management. With additional phases, this research will ultimately translate to informed decision-making and evidence-driven management practices with respect to providing efficient, reliable, and safe winter highways for the travelers.
Web Links • Reports • Project Website	Not applicable.