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Research Results

Guidance on RSU placement for future deployment of CAVs

Planning tool to provide Caltrans Districts' Engineers guidance on RSU placement for CAV applications.

Advanced Research

November 2025

Project Title: Guidance on Roadside Units (RSU) placement for future deployment of Connected and Automated Vehicle (CAV) Applications

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Task Manager:
Nathan Loebs
Senior Transportation Electrical Engineer
nathan.loebs@dot.ca.gov

WHAT WAS THE NEED?

As California and other states continue to invest in connected vehicle (CV) infrastructure, such as Roadside Units (RSUs), there is a growing need to ensure these deployments are strategic, effective, and justified. Many current infrastructure upgrades are being implemented in an ad hoc manner, without a standardized tool to evaluate the performance of CV applications or to determine whether the benefits justify the costs. Transportation agencies like Caltrans face critical questions: Is it worth upgrading infrastructure for specific CV applications? What are the expected safety and mobility benefits? And how do factors like communication latency, packet loss, and CV penetration rates affect performance?

To address these challenges, a robust, replicable, and cost-effective evaluation method was needed—one that could simulate real-world traffic conditions and assess the impact of CV applications without relying on expensive and difficult-to-replicate field tests. This project aimed to fill that gap by developing a microsimulation-based planning tool that could guide RSU placement and CV application deployment decisions.

WHAT WAS OUR GOAL?

The goal was to develop a simulation-based planning tool that enables transportation agencies to evaluate the performance of CV applications and make informed decisions about RSU placement and infrastructure upgrades. The project aimed to support scalable, data-driven deployment of connected vehicle technologies across California.

WHAT DID WE DO?

The project team developed a V2X Microsimulation Platform using Aimsun software to evaluate the performance of five key CV applications: Curve Speed Warning, Queue

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Warning, Speed Harmonization, Intersection Safety Warning, and Collision Avoidance (including Red Light Violation and Pedestrian in Crosswalk Warnings), and Eco-Approach and Departure at Signalized Intersections. These applications were selected based on their relevance to Caltrans' goals and their representation in the ARC-IT 9.3 architecture.

The team created both artificial and real-world test networks, including subnetworks from the I-210 corridor, to simulate various traffic conditions, CV penetration rates, and communication configurations. Each application was rigorously tested under multiple scenarios to assess its impact on mobility and safety. The simulation results were used to develop a sketch-level planning tool and a comprehensive performance assessment report to guide future RSU deployments and CV application rollouts.

WHAT WAS THE OUTCOME?

The project successfully delivered a fully functional V2X Microsimulation Platform with integrated CV applications and a comprehensive final report detailing system designs, simulation results, and deployment recommendations. Key findings include the identification of optimal CV penetration rates for Curve Speed Warning, the limited mobility benefits of Queue Warning and Speed Harmonization under certain conditions, and the strong safety potential of Red Light Violation and Pedestrian in Crosswalk Warnings. The Eco-Approach and Departure application was found to be effective only under low traffic demand and not recommended for coordinated arterial corridors.

The project also laid the groundwork for future research, including the development of an open testing platform for CV applications, feasibility studies on adaptive fixed-time signal control, and training programs to build workforce capacity in CV deployment.

WHAT IS THE BENEFIT?

This project provides transportation agencies with a powerful decision-support tool to evaluate the effectiveness of CV applications before committing to costly infrastructure investments. By simulating real-world traffic conditions and CV behaviors, agencies can identify the optimal conditions for deploying specific applications, estimate their safety and mobility benefits, and determine the necessary CV penetration rates for meaningful impact.

The tool also helps agencies avoid unintended consequences, such as increased delays from poorly timed speed harmonization or eco-driving strategies. It supports more strategic, efficient, and scalable deployment of RSUs and CV technologies, aligning with Caltrans' broader goals for intelligent transportation systems and connected infrastructure.

IMAGES

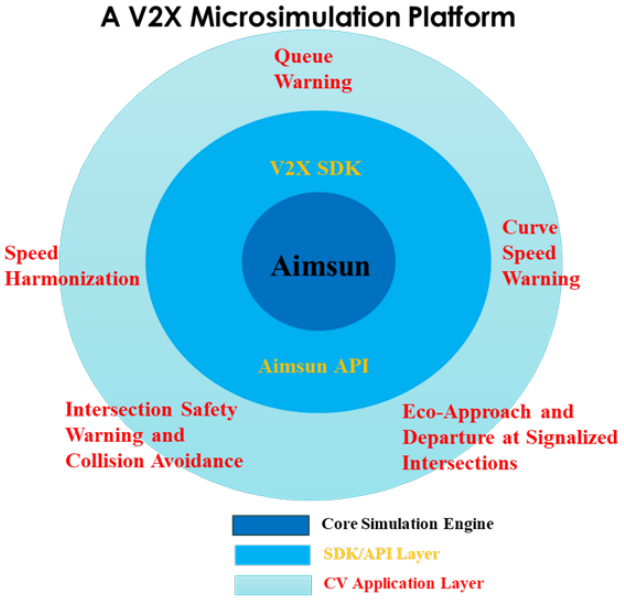

Image 1: A V2X Microsimulation Platform with integrated CV applications in Aimsun

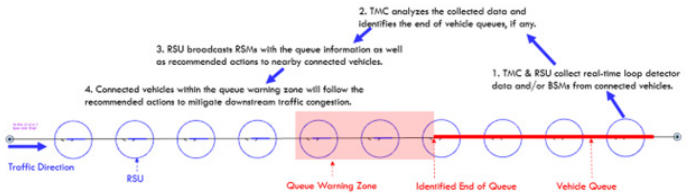

Image 2: System design of Queue Warning in Aimsun