Research Notes

Advanced Research

November 2025

Project Title: Connected and Autonomous Vehicle (CAV) Application Development

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DRISI provides solutions and knowledge that improves California's transportation system.

Connected and Automated Vehicle (CAV) Application Deployment Roadmap

Developing uniform standard system architecture for deploying Connected & Automated Vehicle (CAV) application use cases statewide.

WHAT IS THE NEED?

California Department of Transportation (Caltrans) needs a uniform standard system architecture for deploying Connected & Automated Vehicle (CAV) application use cases statewide. Adopting a common nomenclature and the standard underlying system architecture (hardware, software, data and communications requirements) for each CAV application use case will enable Caltrans to ensure uniformity in deployments of CAV use cases statewide.

Caltrans is actively piloting the deployment of Vehicle-to-Infrastructure (V2I) equipment such as Roadside Units (RSUs) & Roadside Processors (RSPs) on select State Highway Systems and arterial corridors. This equipment will communicate with after-market Onboard Units (OBUs) installed on Caltrans fleet vehicles. V2I equipment will interface with traffic control systems and backhaul communications infrastructure for management by CAV software platforms at Transportation Management Centers (TMCs).

Currently, all existing and future planned deployments of CAV use cases are being implemented on an ad-hoc basis and utilizing non-standard or proprietary system architectures. Deploying non-standard or proprietary system architectures for CAV use cases without minimum standard guidelines will cause long-term design and deployment challenges. It would require design engineers to develop new standard specifications or add additional hardware at each location to comply with the non-standard CAV application use cases' requirements. It will also create challenges in operating and maintaining different software versions of similar CAV application use cases at each intersection within the district. Without minimum safety standard requirements for each CAV application, some vendor-specific applications might not perform as intended and could provide undesirable results or underperform the desired outcome.

WHAT ARE WE DOING?

This research leverages proven practices and accelerates advanced technology to enhance the safety and mobility of the transportation network. The developed CAV Application Deployment Roadmap aims to improve the integrity and installation of V2I equipment and CAV applications, providing the highest safety and operational benefits to the traveling public. A standard roadmap for near-term deployable CAV applications will provide consistent experience statewide to the traveling public. It will benefit Caltrans design engineers to utilize a standard use case deployment kit in their Districts without duplicating efforts. It will also assist in maintaining similar hardware and software throughout the state and eliminate training maintenance staff on different technologies for the same CAV use case.

Breakdown of Tasks

To achieve the stated goals of the project, a total of 5 tasks are proposed:

Task #1: Project Management

- Goal:
- The primary purpose of this task is to facilitate communication with Caltrans and provide periodical reporting of project progress through quarterly reports and meetings. This task also includes financial management to ensure delivery within budget.

Task #2: Development of a common nomenclature for CAV applications of Caltrans' interest

- Goal:
- Develop a common nomenclature for the CAV applications of Caltrans' interest.

Task #3: Development of a designer toolkit for an essential set of CAV applications

- Goal:
- Develop a designer toolkit that consists of specifications of minimum required technical details for an essential set of CAV applications.

Task #4: Development of webpages to host the CAV Application Deployment Roadmap

- Goal:
- Develop webpages for Caltrans' internal use to search for CAV applications, their associated architecture, hardware and software needs, deployment status, etc.

Task #5: Final report and workshop

- Goal:
- Submit a final report and conduct a workshop for knowledge transfer.

WHAT IS OUR GOAL?

This research will develop a roadmap for deploying CAV applications to operationalize multiple CAV transportation use cases of Caltrans' top priority. A well-established and significant set of CAV applications will help achieve strategic safety and mobility goals and ensure that all deployed applications follow a pre-defined system architecture statewide.

The final product of this research will generate a Caltrans CAV Application Deployment Roadmap to follow by all Districts, which consists of the following key components:

- A common nomenclature for CAV applications of Caltrans' interest.
- A toolkit with minimum required technical details for multiple CAV use cases to support consistent and predictable statewide deployment.
- Webpages for Caltrans' internal use to search for CAV applications, their associated architecture, hardware and software needs, deployment status, etc.

WHAT IS THE BENEFIT?

The CAV Application Deployment Roadmap delivered in this research project will guarantee all Districts that their deployments meet all federal safety and mobility standards. This roadmap will

reduce duplication efforts in Districts with a standard use case deployment kit. It will significantly reduce the cost in maintaining and training through the deployment of similar hardware and software throughout the state for the same CAV use case.

For future implementation, the office of Ecosystem Delivery in the Division of Traffic Operations at Caltrans Headquarters will be responsible for maintaining the roadmap and keeping it up to date. The office will: (i) work with Districts to standardize their deployments of CAV use cases to align with national standards; (ii) upload all related standard deployment guidelines developed by Districts to the toolkit, which other Districts can reference for quick deployment in their Districts; (iii) work with California PATH to integrate this roadmap into the CAV training courses to improve employee knowledge, skills, and abilities.

WHAT IS THE PROGRESS TO DATE?

Project progress July 1, 2025 – September 30, 2025

Task 1: Project Management

- The project team submitted the Quarterly progress report – FY25/26 Q1 on 11/11/2025.
- The project team will schedule a progress update meeting in December 2025.

Task 2: Development of a common nomenclature for CAV applications of Caltrans' interest

- The project team is updating the Excel Spreadsheet, which summarizes a list of CAV applications that are related to Caltrans. Updates will be shared with Caltrans before the next quarterly progress meeting.

Task 3: Development of a designer toolkit for an essential set of CAV applications

- The project team received the system design documents for 10 CV applications to be piloted in District 12, which were shared by Ahmad Sadegh (Project Lead of the ATTAIN Grant in D12). The project team is reviewing these useful materials to support the development of specifications for the selected CV applications: Queue Warning, Curve Speed Warning, Intersection Safety Warning and Collision Avoidance, Vulnerable Road User Safety, Eco-Approach and Departure at Signalized Intersections, Transit Signal Priority, Freight Signal Priority, Emergency Vehicle Preemption, Wrong Way Vehicle Detection and Warning.

- The project team is currently working on two CV applications: Queue Warning, Intersection Safety Warning and Collision Avoidance.

- For Queue Warning, the project team is adding the design of Network Communications (e.g., via the AT&T network) into the system architecture, which is lacking from the one in ARC IT 9.3.

- For Intersection Safety Warning and Collision Avoidance, the project team is adding the component of advanced traffic detection devices like AI-powered Cameras and LiDAR into the system architecture, which is also lacking from the one in ARC IT 9.3.

- The project team aims to submit the draft of specifications for these two applications to the project panel for review by the end of December 2025.

Task 4: Development of webpages to host the CAV application deployment roadmap

- The project team hired an outstanding undergraduate to help with website development. The official start date for the student is December 1st, 2025.

Task 5: Final Report and Workshop

- N/A