DRISI
Caltrans Division of Research, Innovation and System Information

# Research Results

## Safe Operation of Automated Vehicles in Intersections

Research to find framework in which an AV has a separate automated vehicle system (AVS) for each Operational Design Domain (ODD) (e.g. freeway driving, auto-parking, etc.), together with the ODDs Object and Event Detection and Response (OEDR) capabilities.

Transportation Safety and Mobility

**MAY 2019**

**Project Title:**
Safe Operation of Automated Vehicles in Intersections

**Task Number:** 3134

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**Task Manager:**
Asfand Siddiqui
Transportation Engineer
Asfand.siddiqui@dot.ca.gov

## WHAT IS THE NEED?

Intersections are generally considered unsafe when compared to streets primarily because intersections do not have markers in the pavement that separate users and movements. The paths of vehicles, bicyclists and pedestrians cross each other within intersections, creating 'conflict zones' and the potential for crashes. Avoidance of crashes requires the movements of different agents to be separated in time or space. It is impossible to fully achieve this separation and so the risk of intersection crashes remains.

An intelligent intersection could solve this issue by the acquisition and processing of appropriate sensor data that can generate Infrastructure to Vehicle (I2V) messages that give complete phase information, predict the signal phase and timing in the next cycle, accurately assess the occupancy of blind zones, and warn of the danger from traffic signal violators.
Upgrading to an intelligent intersection costs between $25K and $100K, depending on what sensors are already in place. Traffic data collected at an intersection can be analyzed to estimate how many crashes can occur. Intersections can be ranked accordingly and limited funds can be directed at the most unsafe intersections.

## WHAT WAS OUR GOAL?

The overall purpose of this project is to describe the technology needed for safe and efficient operation of signalized intersections in the presence of automated vehicles.

## WHAT DID WE DO?

The following three areas were explored in this project:

1. It was demonstrated that an automated vehicle with vision and radar sensors but without infrastructure assistance can encounter hazardous situations that could lead to crashes
2. It was shown that the hazardous situations can be avoided by appropriate infrastructure sensors
3. Demonstrate #1 and #2, listed above, in the real-world environment

## WHAT WAS THE OUTCOME?

Outcome of the project was to develop methodologies to identify those intersections whose instrumentation is critical or, at least, is desired to ensure safe and efficient AV operation.

## WHAT IS THE BENEFIT?

Identification of intersections where proper instrumentation could improve safety and mobility of the travelers is critical for not only Caltrans but also for Department of Motor Vehicles (DMV). Caltrans and DMV are unavoidably getting more engaged in the regulation (i.e. design, testing and modifying the rules of deployment) of AVs in California. In regulating AVs on freeways, Caltrans can rely on the on-board sensing and control capability of AVs. However, in the complex environment of urban intersections this on-board capability alone will not be sufficient except in the simplest intersections, e.g. where no turns are permitted and where the AV can view all approaches with no obstruction. But in most intersections safe operation of AVs will require augmentation of their capabilities with infrastructure-based sensing. Such sensing capability must be provided by Caltrans and local transportation authorities both because they own and operate the intersection and because this capability will be provided to all AVs. The proposed research is a step towards specifying what these sensing capabilities should be? The proposed effort will bring them to the foreground. At the same time, the research will have immediate value in terms of calibrating intersections in terms of safety and suggesting directions to improve safety.

## IMAGES

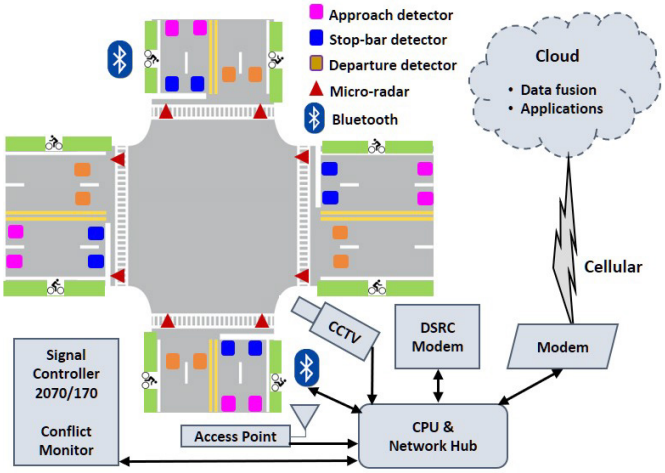


FIGURE 1: Schematic of reference intersection instrumentation