DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Leveraging Advanced Detection and Adaptive Signal Priority to Improve Freight Movement Efficiency along SR 29 – SR 53 Corridor

Enhancing the safety of vulnerable road users (VRUs) near intersections in real time by using advanced sensors like Light Detection and Ranging (LiDAR) devices.

Advanced Research

MAY 2026

Project Title: Leveraging Leveraging Advanced Detection and Adaptive Signal Priority to Improve Freight Movement Efficiency along SR 29 – SR 53 Corridor

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WHAT IS THE NEED?

The California Department of Transportation (Caltrans) sees the need to advance the livability of disadvantaged communities. One method to satisfy this need is to reduce the negative impacts on such communities. Truck routes bordering Clearlake, California, currently encourage freight trucks to travel through disadvantaged communities, while a second route, which is safer and more equitable, is available. This second route is greater in mileage and takes a longer drive time. This research project uses technology to make the second, longer route more attractive to freight trucks.

WHAT ARE WE DOING?

As part of the Interregional Transportation Strategic Plan-2021, Caltrans District 1 aims to encourage freight traffic to take the State Route (SR) 29 – SR 53 route around Clear Lake to the south, instead of SR 20 on the north shore of the lake that traverses disadvantaged communities. However, traffic signals along the SR 29 – SR 53 corridor, under current settings, introduce delays and stops to truck movements, which makes this route less attractive. The district is interested in a pilot project that will deploy Intelligent Transportation Systems (ITS) technologies to minimize the impact of these traffic signals and enable efficient, 24/7 freight movement along this corridor in a reliable manner. In doing so, the rolling terrain, bi directional truck traffic, significant separation between signals, and lack of continuing maintenance presence on the corridor all need to be considered.

Caltrans

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

The Contractor will identify the most suitable solution to advanced truck detection and freight signal priority (FSP) implementation for the target truck corridor (as shown in the figure below) in order to increase the number of freight vehicles that take State Route (SR) 29 – SR 53 route around Clear Lake to the south by at least 15 percent. "Freight vehicle" means commercial trucks such as semi-trailer, flatbed trucks, and single-unit trucks that are used for transporting goods over short and long distances.

WHAT IS OUR GOAL?

The anticipated outcome will be twofold. First the project develops a pilot deployment of a system consisting of advanced truck detection and adaptive freight signal priority technologies on the SR 29 – SR 53 corridor near Clearlake. Second, the project looks to evaluate the efficacy and reliability of the system by investigating different methods for truck detection.

Further anticipated outcomes will include: a) a comprehensive review of candidate technology solutions to FSP, including advanced truck detection, communications (if any), information processing, and signal priority strategies; b) a prototype of reliable FSP system deployed at the selected intersection(s); c) performance evaluation for the deployed FSP system in terms of both freight movement and traffic impacts along the target corridor; and d) a final report summarizing all the project efforts, findings from the field implementation, as well as recommendations for project transferability and scalability.

WHAT IS THE BENEFIT?

The outcome of the project will directly address the concern from Caltrans District 1 on goods movement along the designated corridor and help carry out the Interregional Transportation Strategic Plan by increasing the number of freight vehicles that take State Route (SR) 29 – SR 53 route around Clear Lake to the south by at least 15 percent.

Also, the proposed research aligns with the Caltrans Strategic Management Plan (SMP), aiming to improve freight operational efficiency in the Lake County by accelerating advanced truck detection technology, deploying adaptive freight signal priority (FSP) in field, and evaluating the FSP impacts on both trucks and other road users. The proposed work will enhance the operation of the multi-modal transportation network and improve system performance in terms of mobility, efficiency, environmental sustainability, and reliability. Moreover, concerns about intensive truck activities across disadvantaged communities will be largely mitigated, thus enhancing transportation equity to Californians.

WHAT IS THE PROGRESS TO DATE?

Under the supervision and with input from Caltrans, a literature review was conducted by the university research team on traffic signal priority, infrastructure based freight vehicle detection, Freight Signal Priority (FSP) system design, and performance evaluation. These findings completed the literature review portion of the research. With support from Caltrans Division of Research, Innovation and System Information (DRISI) and District 1 (D1), two intersections were selected for deployment along State Route 29 (SR29) and State Route 53 (SR53) in Lake County. The site at Highland Springs Road and SR29 will use two solid-state Light Detection and Ranging (LiDAR) sensors; The site at Dam Road and SR53 will use one solid-state and one mechanical LiDAR. The Livox TELE-15 and Robosense Ruby Plus were selected after sensor testing.

Completed detector deployments included edge computing units and wireless devices for real-time processing. Sensors were calibrated, and preliminary data were collected to refine detection algorithms. Truck and car classification was achieved using point cloud height and vertical distribution, with additional algorithms developed for queue estimation and time-of-arrival prediction. The detection data gathered during this phase will be organized according to different times of day to account

for variations in lighting and traffic conditions. The resulting dataset will be fully synchronized and multi modal, incorporating both LiDAR and camera data with detailed labeling to facilitate robust algorithm development. For traffic signal control, a method was developed to transmit trigger signals from the computing unit to the controller cabinet.

A follow-up visit to the site at Dam Road and SR53 was conducted for detailed calibration using Global Navigation Satellite System (GNSS) data. Detection data was organized by time of day and fully synchronized across LiDAR and camera sensors to support the development of robust algorithms. The team conducted lab and cabinet testing at the University of California, Riverside, in preparation for full deployment in Lake County. A scholarly paper on the multi-modal detection system was submitted to the American Society of Civil Engineers (ASCE) 2026 Transportation Conference.

The truck detection algorithm was further refined through the incorporation of vehicle length features, and the priority triggering strategy was improved to address both driving and stopping scenarios. A field visit was conducted to evaluate overall system performance, during which signal triggering circuit boards were installed and multi source data were collected with the Freight Signal Priority (FSP) system both enabled and disabled. These data sources included roadside LiDAR (Light Detection and Ranging) devices, roadside cameras, GPS (Global Positioning System), and onboard video. In addition, LiDAR based traffic counting data were gathered to support analysis of traffic volume changes before and after the FSP system installation.

IMAGES

Image 1 shows the target truck route in blue along the south side of Clear Lake. This route is both SR-29 and SR-53 and is 38 miles in length. The alternate truck route is SR-20 and follows the north shore of Clear Lake. Its length is 23 miles.

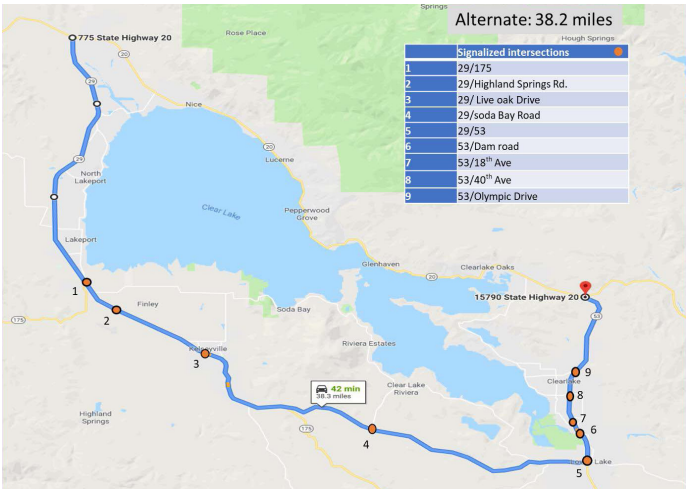

Image 1: Target truck route in Lake County, California to deploy and evaluate adaptive freight signal priority.

Image 2: Field staff installing camera and LiDAR equipment at Dam Rd & CA 53, Clearlake, CA.