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 (VRU's) near intersections in real time by using advanced sensors like Light Detection and Ranging (LiDAR) devices.

Advanced Research

MAY 2025

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

Task Number: 4166

Start Date: May 14, 2024

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WHAT IS THE NEED?

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 Technologies (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, large 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?

Summarize any completed research milestones or accomplishments to date for this task. Describe the immediate next step for this task.>

The research team has collected relevant information via literature research, including traffic signal priority, infrastructure-based freight vehicle detection, FSP system design/integration, performance metrics/evaluation, and example FSP projects. These tasks have been documented and delivered to Caltrans in a report.

With the support from Caltrans DRISI and D1, the research team conducted a site visit to multiple intersections along SR29 and SR53 and selected two intersections. Here is the deployment plan: 1) two solid-state LiDARs will be deployed at Intersection 2 (SR29 & Highland Springs Road) to cover opposing directions. 2) One solid-state LiDAR will be installed at Intersection 6 (SR53/Dam Road), and one mechanical LiDAR will be placed at the midblock. The researchers then performed sensor testing and selection. After comprehensive testing, the Livox TELE-15 was selected as the solid-state LiDAR, and the Robosense Ruby Plus was chosen as the

mechanical LiDAR. The researchers developed a long-range object detection (e.g., trucks and cars) algorithm using a conventional method and without relying on labeled datasets. Objects are classified based on the height and distribution characteristics of the point cloud along the z-axis. The research team developed three other algorithms: Freight Signal Priority (FSP), queue estimation, time of arrival based on average speed of the detected truck over several frames.

The upcoming tasks involve sensor implementation. The researchers will plan and execute the field deployment of sensors, edge computing units, and wireless communication devices to support real-time data processing and connectivity. After installation the next step is to calibrate our sensors in terms of both the relative positions between sensors and their absolute geographic locations to ensure accurate data alignment and spatial consistency. Then, the researchers will perform data collection and test and refine the long-range detection algorithm. The plan involves collecting sample data at various times of day to account for lighting and traffic variations and continuing to refine the long-range detection algorithm for improved accuracy and robustness. Regarding the Freight Signal Priority (FSP) algorithm refinement and testing, the developers will make sure it in compliance with local traffic controller protocols (e.g., NTCIP 1202). Then the researchers will conduct testing on real-world traffic controllers, including corner cases, to ensure stability, accuracy, and real-time performance under diverse conditions.

IMAGES

The figure below 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.

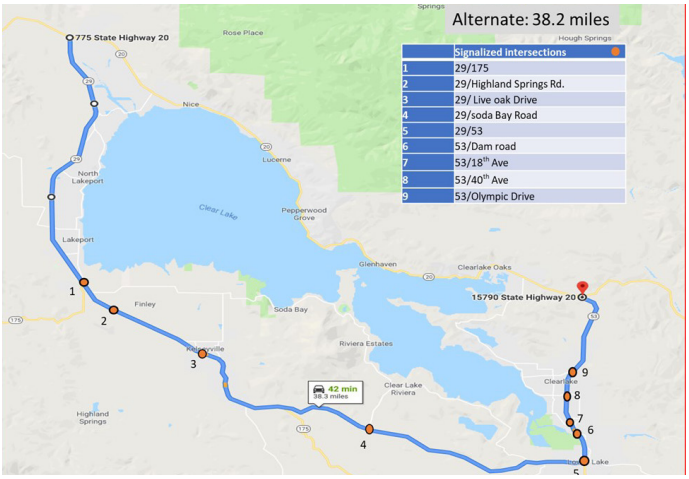

Image 1: Target truck route in Lake County, California to deploy and evaluate adaptive freight signal priority.

Image 2: Candidate location showing poles for LiDAR sensor deployment, near Clear Lake, CA.