



Caltrans Division of Research,
Innovation and System Information

Research

Notes

Transportation
Safety and
Mobility

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Project Title:
Testing of Combined Variable
Speed Advisory (VSA) and
Coordinated Ramp Metering (CRM)
for Freeway Traffic Control

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Task Manager:
Jose Camacho Jr.
Transportation Engineer (Electrical)
jose.camacho.jr@dot.ca.gov

Combined Variable Speed Advisory and Coordinated Ramp Metering along SR99 Corridor

Field test of combined CRM and VSA, and to evaluate the performance of those two control approaches on freeway corridor traffic.

WHAT IS THE NEED?

Coordinated Ramp Metering (CRM) and Variable Speed Advisory (VSA) are Active Traffic Management (ATM) measures for freeways. The CRM concept is to balance the ramp metering rate (flow) from onramps into the freeway mainline considering the differences of demands and lengths (storage capacity) of all onramps along the corridor to maximize the throughput. However, CRM cannot completely control the traffic since, after the vehicles enter the freeway, they are beyond control in the sense that the freeway mainline traffic will still be dominated by the driver behavior.

Therefore, CRM can only improve traffic from the demand aspect. On the other hand, the VSA concept is to affect the driver behavior on freeway mainline. It would function at a macroscopic level for traffic harmonization and it may reduce the shockwaves and maximize the bottleneck flow, if the algorithm is designed appropriately and if the driver compliance rate is reasonably high.

These two freeway traffic control methods are complementary to each other in function, with the goal of modulating traffic from different aspects. The CRM field test along State Route (SR-) 99 was a success; it showed freeway traffic improvement without any infrastructure addition. Consequently, District 3, requested using the PATH-developed system after the field test was completed. The field test of VSA on SR-78 East Bound (EB) in District 11 was also a success. The combined effect of the two control approaches will need to be investigated quantitatively.



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The following tasks need to be addressed in this project:

- Combine/integrate the previous field-tested CRM and VSA algorithms into one algorithm
- Combine/integrate the previous independently field-tested CRM and VSA systems (hardware and software) into one system
- Improve the systems based on the lessons learned in previous projects when CRM and VSA were tested independently
- Investigate the dynamic interactions of the functionalities of CRM and VSA for real-world freeway corridor traffic
- Quantitatively evaluate the performance improvement for joint function of CRM and VSA
- Investigate the driver compliance to VSA and its influence on traffic

WHAT ARE WE DOING?

The purpose of the project is a field test of combined CRM and VSA on SR-99 North Bound (NB), and to evaluate the performance of the joint effect of those two control approaches on freeway corridor traffic. The tasks that will be completed are described below:

- Task 1: Form a project panel
- Task 2: Refine the concept of operations for combined CRM and VSA including overall control system design
- Task 3: Select hardware and obtain VSA signs
- Task 4: Select trailer; design, obtain, develop, and integrate trailer with VSA sign
- Task 5: Develop software for interfacing with VSA sign
- Task 6: Implement and refine real-time traffic state parameter estimation for a combined CRM and VSA
- Task 7: Develop website for a combined system of VSA and CRM

Task 8: Combine CRM and VSA Algorithm into one algorithm and implement on PATH Real-Time computer

Task 9: Conduct project outreach

Task 10: Collect extensive data for current traffic

Task 11: Integrate system for the combined CRM and VSA

Task 12: Perform field preliminary test of combined VSA and CRM

Task 13: Conduct extensive test of combined VSA and CRM with data collection

Task 14: Conduct data analysis for performance evaluation of combined CRM and VSA

Task 15: Perform project management

WHAT IS OUR GOAL?

The goal is to use combined CRM and VSA to control both the demands from the onramps and affect the driver behavior in mainline for traffic throughput and safety improvement.

WHAT IS THE BENEFIT?

Coordinated Ramp Metering (CRM) and Variable Speed Advisory (VSA) are two complementary control approaches for freeway corridor traffic management: the former controls the demand into the freeway while the latter affects the driver behavior and reduces mainline shockwaves. T

he previous field test of the VSA strategy on SR-78 EB indicated that the traffic throughput could be improved about 8.7% in AM peak traffic. The previous CRM field test in SR-99 NB corridor showed that the performance was improved about 7.25% for congested AM traffic. The combined effect of the two control approaches could be cumulative. If successful, those control approaches can be widely implemented on California freeway corridors for mobility and safety improvement.

WHAT IS THE PROGRESS TO DATE?

Task 1. Continue and maintain operational tests of Combined CRM and VSA along SR-99 NB corridor.

- This Task is underway. We have regular activities as the following:
 - The health conditions of the VSA sign signals were continuously checked remotely via the Amsig system.
 - Automatic data logging to the PATH server, including radar data on VSA signs, and loop detector data from Caltrans D3
 - Continuously maintain the operations of the VSA signs: we replaced the cones upstream of the signs.
 - Analyze the traffic detector data and fixed the connection problems between PATH computer in D3 Rack-Room due to changes of IP address of the detectors.
 - The computer in District 3 Rack-Room was recently changed due to it being out of date.

Task 2. Systematically collect all the required data

- Checking the automatic data logging to PATH data server, which include radar data on VSA signs, loop detector data from Caltrans D3
- Monitoring the data health
- Conducting data analysis including raw data and control data

Task 3. Conduct quantitative analysis for performance evaluation and investigate driver behavior

- Some initial quantitative analysis was performed based on collected PeMS data.

Task 4. Project Management

- We have finalized the Scope of the Work with Caltrans DRISI based on the comments in October 2022.