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.
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. The 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?

Since the tentative switch on both CRM and VSA on December 22, 2021, PATH have been closely monitoring the system behavior remotely including the data system, algorithm, VSA display at roadside, Amsig Cloud and the website: http://128.32.234.154/VSA_CRM/

In the beginning, the system had some problems in traffic state parameter data and VSA display, PATH has worked and sorted them out, and now the system is running reasonably stable. The operation hours are: 6:00am - 10:00am and 3:00pm - 7:00pm, Monday - Friday.

In addition, we worked closely with District 3 to address the remaining detection issues impacted by construction for the combined CRM and VSA algorithm and implementation in real-time code. Specifically, it seems that we can obtain data from the controllers for 13 sections on NB SR 99. However, there are five onramps that do not have immediate upstream data. The mainline data that are missing are: Elk Grove, Laguna_WB, Sheldon_WB, Florin_WB, Fruitridge_EB, Fruitridge_WB. PATH used the upstream and downstream data to interpolate and to generate the necessary data. PATH continued working with Caltrans traffic operations and D3 to sort out the problems for those 6 locations.

Also, recently, VSA signs at Fruitridge and Mack Road have been hit by cars and damaged. Due to the mangles state of the sign, we asked CT Maintenance Supervisor from District 3 to remove them and put them back in the maintenance yard.