



CALTRANS DIVISION OF RESEARCH,  
INNOVATION AND SYSTEM INFORMATION

# Research Results

Traffic Operations

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**Project Title:**

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

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**Task Manager:**

Akm Islam  
Transportation Engineer (Electrical)  
Akm.Islam@dot.ca.gov

## Combined Variable Speed Advisory and Coordinated Ramp Metering along SR99 Corridor

Field test of combined CRM and VSA on SR 99, and to evaluate the performance of those two control approaches on freeway corridor traffic.

### WHAT WAS 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 WAS OUR GOAL?

The goal was 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 DID WE DO?

The purpose of the project was 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 were 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: Hardware selection and acquisition for VSA signs
- Task 4: Trailer selection, design, acquisition, development, and integration with VSA sign
- Task 5: Software development for interfacing with VSA sign
- Task 6: Implement and refine real-time traffic state

parameter estimation for a combined CRM and VSA

- Task 7: Website development 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: Project outreach
- Task 10: Extensive data collection for current traffic
- Task 11: System integration for the combined CRM and VSA
- Task 12: Field preliminary test of combined VSA and CRM
- Task 13: Extensive test of combined VSA and CRM with data collection
- Task 14: Data analysis for performance evaluation of combined CRM and VSA
- Task 15: Project management

## WHAT WAS THE OUTCOME?

Based on the engineering data, it is difficult to quantify the driver compliance rate for all VSA signs since they may be different at different locations.

The major lesson we have learned for the field test is that the VSA signs on the shoulder lane may not be noticed by some drivers, which could significantly affect the drivers' compliance. It is available, overhead gantries would have better view to all the drivers without much distraction. As for the location of VSA signs, we most selected the location about 100~200 m downstream of the onramp considering that the traffic from the onramp could be immediately affected by the VSA. During the test, after several crashes of the driver onto the trailers at least 3 locations of the VSA signs, we recognized that the downstream of the onramp might not be a good location since the drivers may have been paying more attention to the lane merge maneuver to get into the mainline traffic. Therefore, less attention to the VSA sign could possibly lead to some driver crash. Of course, if the overhead gantries are available, there would not be such a problem.



## 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.

## LEARN MORE

TBD- Final report link.

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