



Traffic Operations

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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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## Evaluation of Different Coordinated Ramp Metering Systems in Caltrans

Evaluate the different CRM used in Caltrans, determine the best performing system, and provide a CRM recommendation to the Districts that have ramp meters.

### WHAT WAS THE NEED?

Coordinated Ramp Metering (CRM) has potential to further improve the freeway performance compared to existing ramp metering algorithms. CRM can be implemented in the Advanced Traffic Management System (ATMS) of most Caltrans districts but is currently operational on two corridors in two different Caltrans districts.

Each of the implemented CRM systems has its own unique algorithm characteristics and implementation protocols. There is no current information based on field data on the performance of each system, and there is no guidance on which CRM should be recommended for implementation in other Caltrans districts.

There is a need to evaluate the different CRM systems to provide a better understanding for needed corridor/system wide improvements and strategies with the purpose of improving corridor safety, efficiency, and reliability.

### WHAT WAS OUR GOAL?

The end-product of the project was the evaluation reports on algorithm performance for each Caltrans District, and recommendations for CRM implementations in Caltrans Districts.

### WHAT DID WE DO?

Freeway on-ramp metering (RM) has been extensively used as a traffic control strategy to regulate the entry of the on-ramp vehicles to prevent congestion at the freeway merging areas and preserve the freeway capacity. Benefits of RM include improved freeway travel times, improved travel time reliability, and



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accident reductions. Fixed-rate ramp metering strategies are based on historical data and implemented by time of day. Traffic responsive RM strategies are based on real time freeway traffic data provided by loop detectors at the vicinity of the on ramp. Coordinated RM determine the metering rates at the ramps along a freeway corridor to minimize the delays or maximize the freeway throughput. The objective of this research was to evaluate the traffic performance of coordinated traffic responsive systems (CRM) currently implemented by Caltrans based on field data.

An empirical performance evaluation on two freeway corridors was performed comparing the freeway's performance "before" and "after" the CRM implementation. The selected corridors with operational CRM were the I-80 Smart Corridor, which extends from the Carquinez Bridge to the MacArthur Maze (I580/80/880 freeway interchange) in Caltrans District 4, and the SR-99 corridor, from the Grant Line Road interchange at absolute post-mile 284.62 to the US-50 freeway interchange at absolute post-mile 298.38 in Caltrans District 3. The CRM strategies implemented (along with the corridors "Before" conditions) were:

- SR-99: Local Adaptive Ramp Metering vs. CRM
- I-80: No Metering vs. CRM Fuzzy logic

A thorough review was performed of the implemented CRM strategies implemented along the two selected study corridors. The I-80 corridor's on-ramp metering system is a coordinated ramp metering algorithm based on fuzzy logic control and is active from 5:00 AM to 8:00 PM every day. The ramp metering algorithm also combines coordination with its nearby parallel arterial San Pablo Avenue to best optimize corridor level performance in the event of an incident. The SR-99 coordinated ramp metering algorithm uses a simulation model to determine the traffic speed and density on each freeway section at each time step. The simulation model is based on the cell transmission macroscopic model that estimates the number of vehicles in each cell (segment of freeway) using density in each time step.

The primary source of field data used in the analysis was Caltrans PeMS detector data and INRIX Analytics travel time /speed data to establish performance along the freeways mainline. An analysis methodology was also developed and implemented to quantify the changes in delay and reliability for similar levels of freeway utilization, measured using Vehicle Miles Travelled (VMT).

## WHAT WAS THE OUTCOME?

The evaluation of the implementation of CRM on the selected corridors was based on "before" and "after" days where the average VMT was balanced. The results showed a 3-4% reduction in AM and PM Peak Period Vehicle Hours of Travel (VHT) for Eastbound I-80, with a 2-9% reduction in Westbound VHT for the peak periods. Overall, the I-80 study corridor showed about a 4-5% reduction in VHT. In District 3, the Northbound SR-99 study corridor showed about an 8% decline in VHT during the AM peak period. The reductions in corridor travel time reliability were 18-28% for the Planning Time Index (PTI) and in the 2-15% range for the Travel Time Index (TTI).

Both CRM strategies improved the corridor traffic performance and can be implemented in the existing Caltrans traffic management centers. However, there is not sufficient evidence to determine which strategy performed best based on the selected performance measures because of the differences in operating characteristics and "before" conditions in each corridor. The I-80 corridor was operating with no metering in the "before" period and operating a CRM Fuzzy logic strategy during the "after" period. Furthermore, CRM implementation was a component of a larger I-80 ICM implantation, which included other strategies (changeable message signs and variable speed control). The SR-99 corridor was operating a local adaptive ramp metering in the "before" period and a CRM strategy developed by UC Berkeley PATH in the "after" period.

CRM implementations will deliver sufficient gains to warrant continued study and deployment by Caltrans. There is a need to develop statewide

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guidelines for selecting the most suitable CRM strategy for candidate freeway corridors and the associated CRM implementation plans and performance evaluation. Further, there is a need to be aware and monitor the advances in existing and emerging CRM technologies and their underlying algorithms given the continuous developments in data sources and software.

## WHAT IS THE BENEFIT?

The research team recommended the best CRM Caltrans should use to reduce the amount of time the motoring public is on the roadway. The results of the research could lead to the implementation of standardized CRM in other districts that have ramp meters.

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Link will be provided later when available.