

Congestion-Responsive On-Ramp Metering: Recommendations toward a Statewide Policy

Identifying the Need

Freeway Ramp Metering (RM) is widely used on California freeways. RM operation is typically activated regularly on a time-of-day basis (e.g., AM peak and PM peak) regardless of traffic conditions. Some Caltrans Districts operate RM for extended hours beyond the peak periods, but there is no guideline for RM activation based on freeway operating conditions. There is a need to systematically evaluate the need and potential benefits of extending the current peak period RM operating policy to a congestion-responsive ramp metering (CRRM) operation.

What is the goal?

The objective of this project was to develop recommendations toward a statewide policy for freeway CRRM operations.

Project Description

The following performance measures were used to evaluate the effectiveness of ramp metering during extended hours: a) mainline freeway bottleneck and discharge flow; b) corridor level vehicle-miles-travelled (VMT); c) total delays and vehicle-hours-travelled (VHT); and d) travel-time reliability: the 80th or 95th percentile of the travel time distribution.

The research was performed in the following approaches: first an empirical “before” and “after” freeway corridor performance evaluation was executed on a selected set of California’s freeway corridors from Caltrans Districts 6, 7, and 8 that had already implemented congestion responsive ramp metering.

Then, important policy and operational factors that impact the effectiveness of extended hours ramp metering were evaluated: traffic detector health and data quality and their potential impact on CRRM operation, immediate operation hours, ramp metering (RM) light setting to “Green-Ball” or “Black”, on-ramp demand, storage capacity effects and some alternative solutions to reduce/avoid queue-override, and properly handling the relevant institutional issues to gain support from local

jurisdictions. The recommendations from the research recognized and accommodated the differences between Caltrans Districts and/or between freeway corridors in the same District.

Projected Benefits to California

The majority of the study corridors showed performance improvements (increases in vehicle throughput and average traffic speeds which is defined as the “efficiency” in PeMS, or VMT/VHT) after implementing the extended hours ramp metering strategies. The increases in the average vehicular speeds concurred with the increases in corridor vehicular throughput vehicle-miles-travelled (VMT) during the peaks and/or the midday time periods.

What is the progress to date?

The research has been completed. This research effort successfully showed that prospective gains could be realized through the thoughtful implementation of a CRRM strategy. Currently, most RM operations in California highways are used during peak hours only, so it would be beneficial to fully use the current infrastructure for RM to address non-recurrent congestions in off-peak hours and on the weekends, provided that the loop detector stations can operate normally in traffic detection. Ramp metering operations cannot be operated on historical data anymore.

This shift should be performed cautiously and progressively depending on the readiness of the real-time traffic data system. Erroneous traffic detection will lead to a) incorrect RM switching on times; and b) inaccurate ramp metering rates, which may have significantly negative impact on the corridor traffic throughput as well as the confidence and support of public drivers.

Other recommendations include an update of the traffic detector system along with a coordinated effort with the corresponding arterial traffic signals control to improve the overall system performance. If budget is available and land-use is feasible, expanding the on-ramp storage of some critical locations may still bring significant benefits in the long run. To successfully implement CRRM it is important to work closely with local jurisdictions such as

government associations and their committees to gain their support, and public outreach is an essential part of the strategy.

This work has been performed by the California Partners for Advanced Transportation Technology (PATH) Program at the University of California at Berkeley, in cooperation with the State of California Department of Transportation (Caltrans), Caltrans Division of Research & Innovation and Systems Information (DRISI).

Final Report

[Congestion-Responsive On-Ramp Metering: Recommendations toward a Statewide Policy \(escholarship.org\)](#)

About the Authors

This research report was drafted by California Partners for Advanced Transportation Technology (PATH).

[Dr. Xiao-Yun Lu](#) is an established Research Engineer with over 30 years of experience in transportation research. Dr. Lu has a large assembly of research interests including systems modeling, simulation, and vehicle and highway automation.

Dr. Zahra Amini is an Assistant Professor in the Department of Civil Engineering at the University of California, Berkeley.

[Dr. Michael Mauch](#) is a Senior Development Engineer and supports all phases of research projects including project management, proposal writing, designing, and crafting complete research reports.

[Dr. Alexander Skabardonis](#) is an internationally recognized expert in traffic flow theory and models, traffic management and control systems, and automated and connected vehicles.