DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Congestion-Responsive On-Ramp Metering: Before and After Studies – Phase 1

Freeway corridor site selection criteria were developed and several sites in Caltrans District 3, 4, and 11 were considered through extensive analysis of PeMS and INRIX data.

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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WHAT WAS THE NEED?

Freeway ramp metering (RM) is the most widely used strategy to manage congestion on freeway facilities. Metering traffic at the on-ramps may preserve the freeway capacity, improve freeway travel times and discharge flows. Several RM algorithm strategies have been developed and tested ranging from fixed-time strategies to local traffic responsive strategies to system-wide adaptive strategies.

Currently, most of the California Department of Transportation (Caltrans) districts operate a Local Mainline Responsive Ramp Metering (LMRRM) strategy that determines the metering rate at an onramp entrance based on the mainline freeway detector occupancy value at its immediately upstream location. RM operation is typically activated regularly on a time-of-day basis regardless of traffic conditions. RM is switched on even if there is no traffic congestion during the scheduled RM operation hours, and it is switched off even if there is traffic congestion outside the scheduled operation hours (AM peak, PM peak, or both). Some Caltrans Districts operate RM for extended hours beyond the critical peak periods.

Since the infrastructure is already available, it might improve operational efficiencies to update the current RM strategies under certain circumstances during specific time periods. However, before Caltrans adopt a statewide implementation of revised RM operating policies/strategies, there is a need to systematically evaluate the need and potential benefits of extending the current (weekday) peak period RM policy to 24-7 metering operation.

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WHAT WAS OUR GOAL?

The goal of this project is to evaluate the validity of enacting freeway RM in direct response to the varied start and end times of recurrent freeway congestion. The evaluation shall be done by means of "before" and "after" field studies on a real-world freeway section supplemented by simulation modeling.

WHAT DID WE DO?

Freeway corridor site selection criteria were developed and several sites in Caltrans District 3, 4, and 11 were considered through extensive analysis of The Freeway Performance Measurement System (PeMS) and INRIX data.

The most promising site for testing was found to be: US 101 North Bound (NB) Corridor (11.2 miles) in the San Francisco Bay Area. The selected NB101 corridor has two regularly active (recurrent) bottlenecks. The upstream most bottleneck is a weave bottleneck bounded by the Hillsdale Blvd. on-ramps and the State Route (SR) 92 off-ramps. The second bottleneck, a merge (and lane drop) bottleneck, is downstream of the SR-92 on-ramps. The typical weekday congestion patterns and mainline detector occupancies showed that the demand for on-ramp metering extends well beyond the normal 6:00 AM to 10:00 AM morning peak period, and starts in the afternoon prior to the 3:00 PM beginning of the PM peak metering period.

Data on traffic characteristics was obtained from the freeway performance measurement system (PeMS) to establish the baseline operating conditions at the selected site. The following types of data were collected:

- Arrival flows and demands at all onramps and at the upstream-most freeway link,
- Exit flows via all off-ramps and at the freeway's downstream-most bottleneck,
- Flows, detector occupancies and speeds from all loop detectors along the test site.

Additional data collected included:

- On-ramp metering system characteristics (RM strategy and parameters, hours of operation),
- Probe vehicle based travel times in the test section from INRIX and other available sources, and
- Incident data, used to explain unusual traffic patterns in the data.

Traffic operations at the selected site were modeled using the VISSIM microscopic simulation model. The simulation model was calibrated based on the performance data collected to ensure that it faithfully replicated the site's traffic operational characteristics.

The performance measures (MOEs) selected to evaluate the RM operating strategies included the total discharge flows exiting the freeway section, the delays on the freeway and on the on-ramps, and the average freeway mainline travel time and travel time variability.

WHAT WAS THE OUTCOME?

The analysis of the VISSIM simulation model results showed that 24-7 RM could improve the mainline freeway's performance by increasing the average travel speeds (or reducing the overall corridor travel-times), and stabilize flows through the corridor's bottlenecks.

As expected, the VISSIM model showed that the 24-7 RM increased the vehicular delays suffered by motorists at the on-ramps. The corridor's overall performance (combining the mainline delay reductions with the on-ramp's increases in delays) could be improved through moderate 24-7 RM, with a mainline detector occupancy threshold in the range of 8% – 10%.

The findings from this research effort were promising in showing that gains could be attained through 24-7 RM practices. Additional data-driven quantitative evaluations should be performed

prior to revising Caltrans state-wide RM operating policies. Real-world traffic data, like that available from the Caltrans PeMS system, could be used to perform a set of "before" and "after" comparisons to facilitate an empirical evaluation (based on directly measured real-world data) where benefits from changes to RM policies and strategies can be directly measured, and potential outcomes of proposed RM strategy/policy changes could be inferred. The RM empirical evaluations should recognize and accommodate the differences between Districts and freeway corridors.

WHAT IS THE BENEFIT?

The research effort successfully showed that potential gains could be realized through the thoughtful implementation of a 24-7 RM strategy. Significant additional work efforts will be required to extend these findings and incorporate them into the state-wide RM policies.

t is expected that the freeway on-ramp metering operation in direct response to the varied start and end times of traffic congestion will improve the freeway system operation by increasing the discharge flow at the bottlenecks. It will improve the travel experience for the freeway users by reducing the congestion delays that improve the average travel times and travel time reliability. These traffic flow improvements contribute to the reduction of excess fuel consumption and air pollutant emissions.

LEARN MORE

View the Final Report
https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca16-2855-finalreport-a11y.pdf

IMAGES

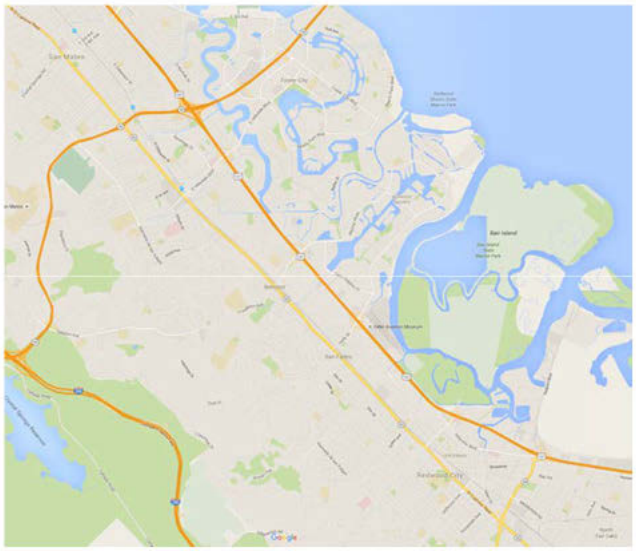

Image 1: US-101 Corridor in San Mateo County

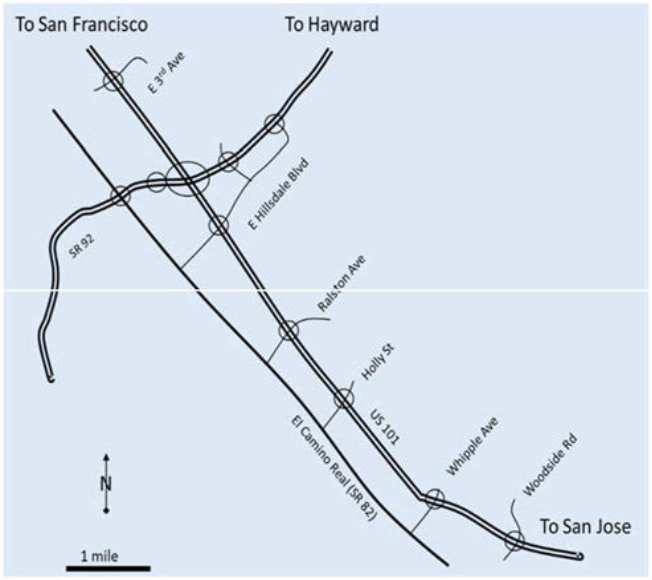

Image 2:
San Mateo US-101 Test Site