

# JERSEY DOT'S

"TURNING PROBLEMS INTO

## Tech Brief

### Evaluation of the Potential for Using Ramp Metering in the ATMS of the I-80 Showcase Corridor

FHWA-NJ-2001-013

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#### SUMMARY

Ramp metering was proven to be a viable form of freeway traffic control strategy, which could eliminate, or at least reduce, freeway congestion. In this study, general and technical requirements, ramp metering control strategies and models, and constraints (e.g., meter locations, ramp storage capacities, lower and upper bounds of ramp metering rates) were discussed in detail. Based on the collected geometric and traffic data, the CORSIM model was developed and used to simulate traffic operation of the study site. The pre-timed and demand/capacity metering control strategies were evaluated, while the potential metered ramps were determined. A dynamic multi-ramp metering control model with SPSA algorithm, which maximized the total throughput subject to a number of constraints, was developed and applied on single and multiple ramps of the study site. The potential benefit of the dynamic multi-ramp control model under time varying traffic demand was tested, simulated, and evaluated. The increased total throughput and reduced total delay were observed, while the traffic conditions suitable for implementing ramp metering control were suggested.

#### INTRODUCTION/BACKGROUND

Urban freeways often suffer heavy congestion during peak hours, in which capacities decrease and delays increase, and the level of service deteriorates. Moreover, the congestion may cause side-swipe and rear-end types of accidents that are associated with the disturbed traffic flow due to traffic merging from entry ramps. Ramp metering control is regarded as one of most effective freeway traffic management strategies for alleviating congestion. Currently, there is no ramp meter operating in New Jersey. The overall goal of this project is to evaluate the potential use of ramp metering control and its effectiveness on Route I-80, one of the most heavily used corridors in New Jersey. The objectives of this project include:

- Evaluating the effects of "short ramps" on local traffic congestion,
- Developing a methodology for evaluating freeways with both un-metered ramp and alternative ramp metering control systems,
- Developing real-time multiple-ramp metering control systems, and

- Developing procedures for quantifying benefits of ramp metering control.

## **RESEARCH APPROACH**

To achieve the objectives, a state-of-the-art simulation approach, rather than actual field studies, was applied to analyze various metering control strategies (e.g., pre-timed and demand/capacity control). A dynamic multi-ramp metering control model and an effective solution algorithm, simultaneous perturbation stochastic approximation (SPSA) were developed and integrated for optimizing time-varying metering rates. The potential benefits of increased throughput and reduced delay after implementing the proposed ramp metering control were quantified subject to various geometric and traffic constraints.

## **FINDINGS**

- Unrestrained merging traffic on eastbound I-80 frequently resulted in bottlenecks during peak hours.
- A computerized CORSIM simulation model was successfully developed based on the real world data collected from the study site on I-80. The model was satisfactorily calibrated and validated. Various simulated MOEs (e.g., total throughput and delay, etc.) were generated for benefit analysis.
- Under existing traffic demand, the reduced total delay or the increased total throughput was observed after metering control. However, the optimal metering control could not simultaneously minimize the total delay and maximize the total throughput.
- The developed dynamic multi-ramp metering control model was applied to single and multiple ramps while considering the peak demand of 4160 vph on the mainline. While optimizing single ramp control, simulation results showed that the maximum total throughput could be increased by 8.14%. While optimizing multiple ramp control, the total throughput was increased by 9.05%.
- Considering time-varying traffic conditions under the single ramp control situation, simulation results showed that the total throughput and delay could be increased by 6.63% and reduced by 9.58%, respectively. While under multi-ramp control situation, the total throughput was increased by 8.07%, and a considerable reduction of 9.73 % in total delay was achieved.
- The dynamic multi-ramp metering control model was more efficient to increase total throughput when the mainline traffic entry flow ranged from 3360 vph to 4560 vph, and was more efficient to reduce total delay when the entering volume of the mainline was from 4360 vph to 5760 vph.

## **CONCLUSIONS**

- Subject to the ramp storage constraint, short ramps would affect the performance of ramp metering control. However, ramp metering can provide a higher and more predictable level of service on the freeway. It also improves the efficiency of freeway operation by smoothing flow on freeways.

- The developed multi-ramp control model was suitable to implement at the study site under peak demand condition. The multi-ramp control outperformed the single ramp control in maximizing the total throughput at the study site.
- The developed dynamic multi-ramp metering control model could capture dynamic traffic flow contraction over time and space. The developed solution algorithm (SPSA) could jointly optimize metering rates for multiple ramps in real-time by maximizing the total throughput.
- In developing the dynamic multi-ramp metering control model, the large-scale non-linear relationship among control parameters increased the level of difficulty in optimizing the ramp metering control problem. The developed simultaneous perturbation stochastic approximation (SPSA) algorithm demonstrated significant advantages in solving the multivariate optimization problem formulated in this study.

## **RECOMMENDATIONS**

- The potential ramps connecting Howard Boulevard (MP 30.6), Howard Boulevard (MP 30.7), Mount Hope Avenue (MP 35.6), Hibernia Avenue (MP 37.6) and East Main Street (MP 39.5) were recommended to apply ramp metering control.
- The developed dynamic multi-ramp metering control model was suggested to simultaneously control multiple ramps of the study site, which would ultimately improve traffic operations on I-80.
- In this study, the use of ramp metering control to maximize the total throughput worked well only within some traffic situations (e.g., the mainline entry flow within 3360 vph and 4560 vph). Therefore, the traffic conditions such as mainline entry flow and traffic demand on ramps should be accurately detected, and then the decision of metering control could be made.
- In this study, the optimal metering rates were determined based on the data collected from simulation results of the previous time interval. The real-time and predicted traffic data could be applied to the developed model for advancing the developed ramp metering control model.

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