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How Can We Best Manage Freeway Congestion?

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HOW CAN WE BEST MANAGE FREEWAY CONGESTION?

Researchers from Portland State University evaluate Oregon's Implementation of System-Wide Adaptive Ramp Metering (SWARM).

Issue

As one of the few freeway management tools available, effective ramp metering has the potential to improve traffic flow, safety and air quality; reduce congestion and fuel consumption; and manage demand by discouraging short trips. In Oregon, ramp meters have been in use since the early 1980s.

Optimal ramp metering strategies are often debated, but all involve tradeoffs between vehicles on the freeway and those attempting to enter. The amount of delay imposed at onramps is often constrained by queue storage limitations. Early ramp metering systems in the United States were pre-timed (or fixed-rate) systems, whereby ramp meter activation and deactivation times and the metering rates throughout the day were pre-determined based on historical data. This metering strategy was designed to cope with "typical" traffic conditions and did not incorporate real-time variations in freeway conditions. Consequently, the effectiveness of the fixed-time system deteriorated substantially with large variations in freeway conditions or during non-recurrent conditions (e.g., incidents).

With improved sensing and communications technology, this strategy has been replaced by more sophisticated algorithms that account for real-time traffic conditions. One of these algorithms, System-Wide Adaptive Ramp Metering (SWARM), has recently been deployed by the Oregon Department of Transportation (ODOT) in the Portland metropolitan area, replacing a pre-timed strategy. Many state departments of transportation use SWARM or similar adapive metering strategies.

Research

ODOT, in conjunction with researchers from Portland State University's Intelligent Transportation Systems (ITS) Lab, recently analyzed the impacts of SWARM in the Portland region. The results could determine how to best improve ramp metering, an essential freeway management tool.

THE ISSUE:

Can smarter highways manage congestion better?

THE RESEARCH:

Dr. Christopher Monsere and Dr. Robert Bertini (Portland State University) used archived data from freeway ramp meters to evaluate adaptive ramp metering.

- **3.7%** - travel time saved on I-205 during the morning peak
- **18.1%** - improvement in delay on I-205 during the morning peak
- **55%** - increase in delay on OR-217

THE IMPLICATIONS:

System-wide adaptive ramp metering produced mixed results. The contrasting outcomes on I-205 and OR-217 suggest that operating strategies must be tailored to each facility.

When applied appropriately, adaptive ramp metering can be used to reduce delay and improve reliability.

MORE PROJECT INFORMATION:
www.otrec.us/project/190

Photo: An active ramp meter in Portland, Oregon

PROJECT INFORMATION

TITLE: Using Archived ITS Data to Measure the Operational Benefits of a System-Wide Adaptive Ramp Metering System

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PROJECT #: 2008-190

PARTNER: Oregon Department of Transportation Research Unit

COMPLETED: December 2008

WEBSITE: otrec.us/project/190

The project's main objective was to compare selected freeway and ramp performance metrics under SWARM versus pre-timed operations. To facilitate this, ramp meters operated for two consecutive weeks under each configuration. At the end of the study period, researchers conducted an empirical analysis of the archived ITS data from the Portland Oregon Regional Transportation Archive (PORTAL). Designed as the official ITS data archive for the Portland metropolitan region, PORTAL has archived 20-second speed, count and occupancy data from dual loop detectors positioned in each mainline lane just upstream of onramps since July 2004. Vehicle miles traveled, vehicle hours traveled and delay were selected as the three primary measures of mainline freeway performance. Variation in delay also was computed.

SWARM in the Portland metropolitan region produced mixed results. For one of the corridors (Interstate 205), the results were generally positive. In the morning peak period, SWARM resulted in decreased mainline delay and decreased delay variability. On OR-217, however, significant increases were found in overall average delay. Reliability also decreased under SWARM for this corridor.

The contrasting results for SWARM performance between the two freeways can partially be explained by the general differences in the two facilities. In all cases, the SWARM algorithm allowed more vehicles to enter the freeway mainline. The higher per-lane flows, combined with less optimal geometry on OR-217, may explain why higher metering rates produced a significant increase in mainline delay.

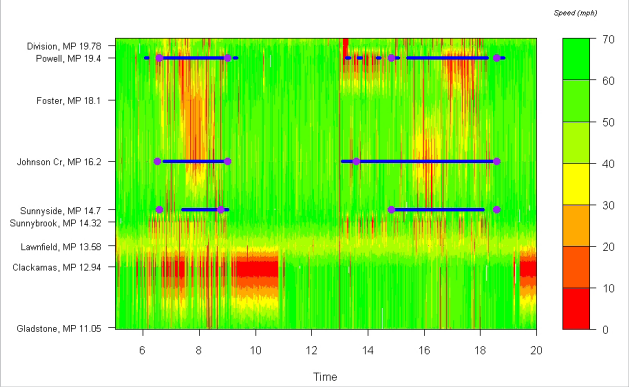

Figure: Speed Contour with Meter Activation Times

The figure above illustrates the speed of traffic on northbound I-205 by location (y-axis) and time of day (x-axis). As the legend (right) indicates, red areas of the graph indicate slowing. The horizontal blue bars superimposed on the graph illustrate when the adaptive ramp meters were active at each exit and the purple dots show when the fixed time meters would have operated. For example, the ramp meter at Johnson Creek (Milepost 16.2) was on from about 6 to 9 am and from about 1:30 to 6:30 pm.

Implications

To improve system operations, the researchers recommended that SWARM parameters be fine-tuned to account for traffic volumes and queue capacity on each onramp. Another important finding was that the SWARM algorithm resulted in significantly more data communications failures. While this outcome is specific to ODOT's communications infrastructure and hardware, it was not anticipated. These failures have the potential to impact other traveler information programs that depend on the freeway surveillance data as well as the SWARM algorithm. Following this study, ODOT implemented communications improvements.

Finally, the project has encouraged ongoing evaluation and continuous improvement of the ramp metering system and the overall freeway management system. It is clear from the analysis that meter activation times and rates are necessary to evaluate system performance. Incorporating additional logging capabilities into SWARM would make it easier to automatically evaluate system operations on an ongoing basis.