Using Archived ITS Data to Measure the Operational Benefits of a System-Wide Adaptive Ramp Metering System (SWARM)

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Friday Transportation Seminar
October 10, 2008
Outline

• Background
  » Ramp metering
  » SWARM

• Methodology

• Results

• Conclusions
Ramp Metering

• Traffic signals located at on-ramps

• Two main goals:
  » 1) limit the amount of traffic entering a freeway
  » 2) break up the platoons of vehicles
Ramp Metering

• Potential to improve
  » traffic flow, traffic safety and air quality; reduce congestion and fuel consumption; and manage demand by discouraging short trips

• Strategies: Fixed or adaptive
  » Tradeoffs between imposing delay on those vehicles already on the freeway and those attempting to enter
• SWARM first implemented by CalTrans in Southern California

• Previous SWARM Evaluations

  » Benefits for mainline travel
  » Queues at 9 busiest on-ramps increased by over 40%
  » Combined local/global strategy most effective
Study Corridors

- I-205 NB
  » Sept/Oct 2007
  » AM & PM Peak

- OR-217 NB
  » Nov/Dec 2007
  » PM Peak
Methodology

• Before and after study
  • 2 weeks pre-timed mode
  • 2 weeks SWARM mode
  • Control for data quality, weather, incidents

• Data sources
  • PORTAL Data Archive: ODOT loop detector data, weather, incidents
  • Measurement of ramp queues
    • Programmable Logic Controllers (PLCs) counting inflow-outflow
Methodology

• **Performance Measures**
  » Vehicle Miles Traveled (VMT)
  » Vehicle Hours Traveled (VHT)
  » Delay

• **Compare like days**
  » Determination of congested conditions was somewhat subjective
  » 1) least, 2) moderately, 3) highly, or 4) very highly congested
## Excluded Days

<table>
<thead>
<tr>
<th>Time</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I205 AM</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I205 PM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>OR217 PM</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Sample Analysis Data

Division, MP 19.78
Powell, MP 19.4
Foster, MP 18.1
Johnson Cr, MP 16.2
Sunnyside, MP 14.7
Sunnybrook, MP 14.32
Lawnfield, MP 13.58
Clackamas, MP 12.94
Gladstone, MP 11.05

Speed (mph)
<table>
<thead>
<tr>
<th>Congestion</th>
<th>Days pre-timed-days swarm</th>
<th>Percent change</th>
<th>Average % Comm Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VMT</td>
<td>VHT</td>
</tr>
<tr>
<td>Least Congested</td>
<td>1-0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Moderately Congested</td>
<td>4-4</td>
<td>+2.2%</td>
<td>+4.7%</td>
</tr>
<tr>
<td>Highly Congested</td>
<td>2-1</td>
<td>-5.5%</td>
<td>-6.6%</td>
</tr>
<tr>
<td>Very Highly Congested</td>
<td>1-1</td>
<td>+7.2%</td>
<td>-14.0%</td>
</tr>
<tr>
<td>Overall</td>
<td>8-6</td>
<td>+1.6%</td>
<td>+0.03%</td>
</tr>
</tbody>
</table>
Moderately congested – I205

Division, MP 19.78
Powell, MP 19.4
Foster, MP 18.1
Johnson Cr, MP 16.2
Sunnyside, MP 14.7
Sunnybrook, MP 14.32
Lawnfield, MP 13.58
Clackamas, MP 12.94
Gladstone, MP 11.05

Change in delay (vehicle-hours)
(1) Metering at Sunnyside & Foster activated later under SWARM than pre-timed but earlier at Johnson Creek. Metering rates under SWARM than pre-timed.

(3) Earlier speed drop in mainline speed.

(4) Peak mainline flow at approximately 3-5 PM (15-17).
Highly & very highly congested
Why better?

(1) Metering activates at earliest possible time (1PM) under SWARM.

(2) Mainline speeds dropped prior to meter activation

(3) Note speed oscillations

Legend:
- Red: Ramp Flow
- Blue: ML Flow
- Orange: ML Speed
## Results – I-205, AM Peak

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<th>Average % Comm Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VMT</td>
<td>VHT</td>
</tr>
<tr>
<td>Least Congested</td>
<td>1-1</td>
<td>-1.0%</td>
<td>-1.9%</td>
</tr>
<tr>
<td>Moderately Congested</td>
<td>6-4</td>
<td>+1.4%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Highly Congested</td>
<td>1-0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overall</td>
<td>8-5</td>
<td>+0.9%</td>
<td>-3.7%</td>
</tr>
</tbody>
</table>
I205NB, AM Peak, Total

Change in delay (vehicle-hours)

Time

Division, MP 19.78
Powell, MP 19.4
Foster, MP 18.1
Johnson Cr, MP 16.2
Sunnyside, MP 14.7
Sunnybrook, MP 14.32
Lawnfield, MP 13.58
Clackamas, MP 12.94
Gladstone, MP 11.05

6:30 AM 7:30 AM 8:30 AM 9:30 AM
## Results – OR217NB, PM Peak

<table>
<thead>
<tr>
<th>Congestion</th>
<th>Days pre-timed-days swarm</th>
<th>Percent change</th>
<th>Average % Comm Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VMT</td>
<td>VHT</td>
</tr>
<tr>
<td>Least Congested</td>
<td>3-0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Moderately Congested</td>
<td>3-3</td>
<td>-4.3%</td>
<td>+3.3%</td>
</tr>
<tr>
<td>Highly Congested</td>
<td>1-1</td>
<td>-2.7%</td>
<td>-3.3%</td>
</tr>
<tr>
<td>Very Highly Congested</td>
<td>1-3</td>
<td>-2.0%</td>
<td>+4.6%</td>
</tr>
<tr>
<td>Overall</td>
<td>8-7</td>
<td>-3.1%</td>
<td>+10.6%</td>
</tr>
</tbody>
</table>
Comm Failures by Day and Station
I-205 NB, Pre-Timed, PM

Comm Failures by Day and Station
I-205 NB, SWARM, PM

Data Quality

Communication Failures (%)
Conclusions

- As currently configured produced mixed results.
  - I-205 - the results were generally positive.
    - AM - SWARM operation resulted in decreased mainline delay and decreased variability in the delay.
    - PM - Improvements were also found with the exception of moderately congested days which saw an increase in mainline delay.
  - OR-217 - significant increases were found in overall average delay. Reliability also decreased under SWARM for this corridor.
Conclusions

- We believe that this can be explained by
  » Higher metering rates (under all conditions)
  » Specific freeway volumes and lanes
- Recommend adjustment SWARM parameters
Conclusions

• Significantly more data communication failures
  » It was not anticipated
  » Could impact other traveler information programs
• Ongoing evaluation
  » Need counts from on-ramp “queue” loop detectors, meter activation times, and actual metering rates set by the SWARM system
Acknowledgements

- Oren Eshel and Robert L. Bertini
- Oregon Technology Research and Education Consortium
- Oregon Department of Transportation (ODOT)
- National Science Foundation CAREER
- Technical advisory committee:
  - Jack Marchant, Galen McGill, Dennis Mitchell, Phuong Nguyen, and June Ross – ODOT; Bill Kloos and Paul Zebell, City of Portland; Nathaniel Price and Amy Mastraccio – FHWA
Questions?

Thank You!
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