Adaptive Ramp Metering
on I-80 in the San Francisco Bay Area

Presented by: Travis Low, EIT
Advisor: Anurag Pande, PhD
Department of Civil and Environmental Engineering
Cal Poly San Luis Obispo

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Outline

• Introduction to Project Corridor
• Background on Ramp Metering
• Introduction to 80 SMART Corridor Project
• Operations/Travel Time Reliability Analysis
• User Satisfaction Survey Design
Introduction to Project Corridor

• San Francisco Bay Area
• I-80 in Alameda and Contra Costa counties
• 20-mile freeway corridor
  – Parallel arterial: San Pablo Avenue
• 8 to 10 lanes
• HOV lanes
• Over 270,000 vehicles per day
Ramp Metering Background

• First implemented: 1963 on Chicago’s Eisenhower Expressway

• Goals:
  – Control on-ramp flows during congestion
  – Break up platoons
  – Smoothly convert multiple on-ramps lanes to one
  – Avoid queues spilling back onto arterials

• Observed Benefits:
  – Reduction in ramp-related collisions
  – Speeds increase; Corridor Travel Times decrease
3 Types of Ramp Metering

(1) Fixed Time
- Metering rate programmed by time-of-day
- Simpler equipment but less optimization
- Highest violation rate

(2) Local Traffic Responsive
- Detectors in ramp vicinity determine discharge rate
- Treats ramps as discrete units
- Appears more intelligent; lower violations
• (3) Adaptive
  – Algorithm calculates optimal metering rate for each ramp in real time
  – Upstream and downstream detectors
  – Managed remotely from central communication center

*All types can be made responsive to queue spillback*
The Case for Active Traffic Management on I-80

• One of the Bay Area’s most congested and heavily traveled

• Widening is not an option
  – Environmental sensitivity
  – Fully developed communities
  – Cost prohibitive

• Carpool lanes are already 3+
• Unreliable travel times

• 4-5 collisions per day

• Secondary collisions lead to additional congestion

• 25% of congestion is incident-related

• Detouring motorists often stay on local streets

• 16,000 vehicle-hours of delay each day
System Goals

• Optimize corridor performance
• Provide real-time information
• Improve Travel Time Reliability
• Impove access for first-responders
• Reduce secondary collisions and related congestion
System Components

• Lane Use Signs
• Variable Advisory Speeds
• Trailblazer Signs
• Traffic Signal Management
• Traffic Information Boards
• Adaptive Ramp Metering
I-80 Adaptive Ramp Metering

• August 2016: Ramp Meters turned on in Local Traffic Responsive mode
• April 2017: Adaptive metering begins
• Installed on 43 on-ramps
• Some provide HOV lane
• End of Queue detectors
• Controlled from Caltrans/CHP TMC in Oakland
• Adaptive mode only operates 6am to 6pm due to staffing constraints
Operations/Travel Time Reliability Analysis

• Before: May 2016 (No Metering)
• After: May 2017 (Adaptive Metering)
• Tuesdays, Wednesdays, Thursdays
• Eastbound direction
Corridor Speed Comparison
Travel Time Reliability
Travel Time Reliability Measures

Free-flow travel time = 11.5 minutes
Average travel time = 15.9 minutes
95th percentile travel time = 22.7 minutes

Buffer time = 6.8 minutes

**Reliability Measures**

**Planning time** = 22.7 minutes

**Planning time index** = \( \frac{22.7}{11.5} = 1.97 \)

**Buffer index** = \( \frac{(22.7 - 15.9)}{15.9} = 0.396 \)

State Route 520 Eastbound, Seattle, Weekdays from 4 to 7 pm

(FHWA)
Buffer Index

\[
\frac{\text{95}^{\text{th}} \text{ Percentile TT} - \text{Average TT}}{\text{Average TT}}
\]
Buffer index for I-80 Eastbound between Powell St and Pomona St
Averaged by 1 hour in May 2016 (every Tue, Wed and Thu) and May 2017 (every Tue, Wed and Thu)

* Eastbound

* These missing segments are a result of 0 MPH measurements. Buffer index cannot be calculated when the historic average speed or 95th percentile speed for a road segment is 0 mph or not available.

Buffer index: The buffer index is expressed as a percentage and its value increases as reliability gets worse ((95% Travel Time - Average Travel Time) / Average Travel Time).

- May 2016 (every Tue, Wed and Thu) - INRIX
- May 2017 (every Tue, Wed and Thu) - INRIX
Travel Time Index

TT / Free-Flow TT
Travel time index for I-80 Eastbound between Powell St and Pomona St
Averaged by 1 hour in May 2016 (every Tue, Wed and Thu) and May 2017 (every Tue, Wed and Thu)

Eastbound

Travel time index: Travel time represented as a percentage of the ideal travel time (Travel Time / Free-flow Travel Time).

- May 2016 (every Tue, Wed and Thu) - INRIX
- May 2017 (every Tue, Wed and Thu) - INRIX
Planning Time
(or 95\textsuperscript{th} Percentile TT)

Average TT + Buffer Time
Planning time for I-80 Eastbound between Powell St and Pomona St
Averaged by 1 hour in May 2016 (every Tue, Wed and Thu) and May 2017 (every Tue, Wed and Thu)

Eastbound

* These missing segments are a result of 0 MPH measurements. Planning time cannot be calculated when the 95th percentile speed for a road segment is 0 mph or not available.

Planning time: How much total time a traveler should allow to ensure on-time arrival (Average Travel Time + Buffer Time).
Planning Time Index

95th Percentile TT / Free-Flow TT
I-80 Adaptive Ramp Metering User Satisfaction Survey Design
Survey Contents

• Travel Characteristics
• Driving Habits
• System Perspectives
• Demographics
• Qualitative Comments
System Perspectives

Please answer the following questions about the highlighted section of I-80:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Too soon to tell/No opinion</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
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</thead>
<tbody>
<tr>
<td>○</td>
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</tbody>
</table>

On this section of I-80, congestion is a problem.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
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<th>Slightly Agree</th>
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</tbody>
</table>

On this section of I-80, ramp metering is a good idea.
Please answer the following questions about the results of the new ramp metering on I-80:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Too soon to tell/No opinion</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is now easier to merge onto the freeway.</td>
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<td>There is now less congestion on the freeway.</td>
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<tr>
<td>There is now less stop-and-go traffic on the freeway.</td>
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<td>Traffic now flows smoother on the freeway.</td>
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<tr>
<td>The morning commute now takes less time overall.</td>
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<td>The afternoon commute now takes less time overall.</td>
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<tr>
<td>Statement</td>
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<tr>
<td>My travel time is now more predictable.</td>
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<td>Collisions are now less severe.</td>
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<td>I now feel safer.</td>
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<td>The surface streets now have more congestion.</td>
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<td>I am now more likely to take surface streets instead of I-80.</td>
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</tbody>
</table>
Please answer the following questions about the new ramp metering on I-80:

<table>
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<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
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<tr>
<td>The speed of the metering lights adjusts correctly for the current conditions.</td>
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<td>Buses and carpools should receive priority when possible.</td>
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<td>I would prefer to have more delay at the ramp meter so I could have less delay on the freeway.</td>
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<tr>
<td>Other drivers usually obey the metering lights.</td>
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<tr>
<td>The new ramp meters were well explained to the public.</td>
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<tr>
<td>Overall, the new ramp meters are beneficial.</td>
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<td>More ramp meters should be built in the Bay Area.</td>
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Observations and Conclusions

• Local users dislike ramp metering
• Possible confounding effects of other components
• Encouraging signs during worst hours for speed and travel time reliability
• Likely not dramatic enough for public to perceive
• More time needed to adjust and optimize
• Continued research: Compare with Local Traffic Responsive
Thank You!