CONTINUOUS FLOW METERING (CFM) TO ALLEVIATE CONGESTION ON INTERSTATE 70 (I-70) EISENHOWER JOHNSON MEMORIAL TUNNEL (EJMT)

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Overview

- Part 1 - Background History, Why Metering, & Model Development
- Part 2 - CFM VS Traditional Metering, Calibration & Analysis
- Part 3 - CFM Implementation, Benefits & Lesson Learned
Causes of Congestion

- US 6/Loveland On-ramp Volumes (only winter)
- US 40/Empire Junction On-ramp Volumes
Historically High Sunday Volumes

2010 Eastbound Traffic Volumes between Idaho Springs and Twin Tunnels

Time in a Day (pm)

Total Volume (vph)

> 3200 vph

Jan. 03, 2010
Jan. 17, 2010
Jan. 24, 2010
Feb. 07, 2010
Feb. 21, 2010
Feb. 28, 2010
Average
Winter Weather and Poor Road Conditions
Incidents east of the Eisenhower Tunnel
Why Metering?

Safety concern regarding EB queues backing into the tunnel, and creating stop & go conditions.

Traffic stopped on west side to clear queue in the Tunnel. This results in major queues on steep uphill, on the west side.
Micro-simulation Analysis
(Stochastic Model)

Why “VISSIM”?

- Robust, widely accepted and versatile
- Ability replicate actual condition (upstream/downstream queuing, metering events, incident, etc.)
- Better representation of real life traffic - traffic Behavior
- Visual representation of performance in 3D
- Ability to examine efficiency of control system
VISSIM Model Development

- Simulation parameter - driving behavior: car following, lane changing, acceleration, deceleration, safety factor, etc.
- Desired speed distribution: mainline freeway, ramps, and tunnel.
- Vehicle Class
- Scaling background images
- Links and connectors
- Vehicle Inputs
- Routing Decisions

![Eastbound Overall Truck Traffic % On Sundays](image)

97% cars
3% trucks
CFM vs Traditional Metering
Metering Schemes

(a) Traditional Metering

(b) Continuous Flow Metering
To prevent queues from extending into the tunnel.
Completely stop traffic at the west entrance
Often times, stop periods exceed 10 minutes
Creates major queues on the steep uphill
Causes tractions issues in bad weather
Traditional Metering Stoppage Times

Traditional Metering Log on January 30, 2011

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration (Minutes)</th>
</tr>
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<tbody>
<tr>
<td>13:16 - 13:41</td>
<td>25</td>
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<tr>
<td>13:41 - 14:10</td>
<td>15</td>
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<td>14:53 - 15:12</td>
<td>9</td>
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<tr>
<td>15:12 - 15:37</td>
<td>9</td>
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<tr>
<td>15:37 - 16:05</td>
<td>9</td>
</tr>
<tr>
<td>16:05 - 16:37</td>
<td>9</td>
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<td>16:37 - 17:17</td>
<td>9</td>
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<tr>
<td>17:17 - 17:35</td>
<td>8</td>
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</table>
**Capacity**

- Tunnel capacity is estimated 1600 vehs/hr/ln (3200 vph for two lanes in each direction)

### Table - CFM Cycle Rate Plan

<table>
<thead>
<tr>
<th>Plan</th>
<th>Green Time per phase (seconds)</th>
<th>Red Time (seconds)</th>
<th>Cycle Rate (seconds)</th>
<th>Capacity (vph)</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>10</td>
<td>24</td>
<td>600</td>
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<td>2</td>
<td>2</td>
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<td>3</td>
<td>2</td>
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<td>16</td>
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<td>7</td>
<td>2</td>
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Study Area

- Eisenhower Tunnel (MP 215.0)
- Silverthorne (MP 205.0)
- Bakerville (MP 221.2)
- Lower Truck Ramp (MP 208.7)
- Upper Truck Ramp (MP 211.8)
- EJMT West Portal (MP 213.3)
- Herman Gulch (MP 218.7)
- US 6 - Loveland (MP 216.7)

16 Miles
Calibration

• Calibrate capacity at key bottlenecks

• Calibrate traffic volume

• Calibrate system performance
Congestion happened
Speed dropped
Metering Applied
Time: Noon – 6 pm

Existing Condition to replicate into the model

Incident happened at 12:34 PM
## Speed - GEH Statistic

\[ GEH = \sqrt{\frac{(E - V)^2}{(E + V) / 2}} \]

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>Description</th>
<th>11AM</th>
<th>12AM</th>
<th>1PM</th>
<th>2PM</th>
<th>3PM</th>
<th>4PM</th>
<th>5PM</th>
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<tr>
<td>SILVERTHORNE</td>
<td>Observed Points Data (V)</td>
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<td>68.10</td>
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<td>70.40</td>
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<td>69.82</td>
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<td>69.40</td>
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<td>60.60</td>
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<td>1.58</td>
<td>1.73</td>
<td>1.28</td>
<td>0.53</td>
</tr>
</tbody>
</table>
SUMMARY TOTAL WEIGHTED AVERAGE TRAVEL TIMES FROM 11AM TO 8PM

Metering on January 30, 2011

- Traditional Metering: Measured 33.5, Modeled 25.3
- Continuous Flow Metering: Measured 20.2, Modeled 24.1

Metering on February 24, 2013

- Traditional Metering: Measured 23.8, Modeled 22.3
- Continuous Flow Metering: Measured 6.1, Modeled 9.3
I-70 Eisenhower-Johnson Memorial Tunnel (EJMT) Hourly Travel Times from Silverthorne to Bakerville EB (16 Miles)

January 30, 2011

Travel Times (Minutes)

11-12PM 12-1PM 1-2PM 2-3PM 3-4PM 4-5PM 5-6PM 6-7PM 7-8PM

Traditional Metering

Continuous Flow Metering
I-70 Eisenhower-Johnson Memorial Tunnel (EJMT) Hourly Travel Times from Silverthorne to Bakerville EB (16 Miles)
February 24, 2013

Travel Times (Minutes)

Time
11-12PM
12-1PM
1-2PM
2-3PM
3-4PM
4-5PM
5-6PM
6-7PM
7-8PM

Travel Times
59
78
91
115
117
125
101
19
17

Graphs:
- Traditional Metering
- Continuous Flow Metering
MAXIMUM QUEUE LENGTH FROM EJMT TO SILVERTHORNE

Metering on January 30, 2011

Metering on February 24, 2013

Measured  Modeled  Modeled  Measured

Traditional Metering  Continuous Flow Metering  Scenarios

Queue Length (Miles)

0.6  0.7  9.7  5.6  5.3  4.7  0.3  1.6
0.4  0.6  7.4  5.0  5.3  4.0  0.0
9.0  9.0  7.5  8.0  8.1
CFM Implementation
The Solution: Active Management

- Incident Mgt, Maintenance Operations, Coord. Mtgs.
- Chain Stations
- Heavy & Light Duty Courteous Patrols, Vendors
- Downhill Warning Systems, RWIS, Speed Radar
- Truck Maps, Parking Sites, Food Services,
- Courtesy Patrols, Vendors
- Variable Speed Limits, Speed Harmonization, CFM
- ITS, Fiber Optics, Travel Time, CCTV’s, 511, CoTrip.Org
- Demand Management Strategies
CFM Initial Tests

- Lower volume (December 8, and 15, 2012)
- Higher volume (December 28, and 29, 2012)
## Conclusion - CFM Benefits

**Numbers show savings**

<table>
<thead>
<tr>
<th></th>
<th>January 30, 2011</th>
<th>February 24, 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begin/end times for CFM</td>
<td>1:15 pm to 6:00 pm (4 hours and 45 minutes)</td>
<td>11:50 am to 6:05 pm (6 hours and 15 minutes)</td>
</tr>
<tr>
<td>Travel Time</td>
<td>15 min (18% decrease)</td>
<td>11 min (15% decrease)</td>
</tr>
<tr>
<td>Hourly travel time</td>
<td>57 min (32% decrease)</td>
<td>17 min (14% decrease)</td>
</tr>
<tr>
<td>Person hours traveled</td>
<td>855 hours (10% decrease)</td>
<td>1134 hours (15% decrease)</td>
</tr>
<tr>
<td>Max. Queue Length</td>
<td>1.0 mi (14% decrease)</td>
<td>2.1 mi (26% decrease)</td>
</tr>
</tbody>
</table>

- Smooth traffic flow through the eastbound tunnel
- Reduce the need for full closures of the EJMT
- Improve safety by reducing “shock absorber”/accordion effect
- Reduce driver frustration
Lesson Learned

- Using the real-time traveler information or variable message sign (VMS) upstream of the metering area helped the drivers when metering was in effect.

- Drivers (especially truck drivers) seem to be timing their approach so that they reach the signal when it turns green and they don’t have to stop (loss of traction when roads are snowy/icy)
Lesson Learned

- Utilization of lanes 1 and 4, then lanes 2 and 3 worked better and minimized driver confusion.
- Heavy vehicles generally stay in the right lane (lane 3).

- The public understood the strategy and driver compliance was good.
- Detailed concept of operations and initial test runs were critical to success.
Latest Improvements

- EB Twin Tunnels have been widened.
- Existing acceleration lanes at US6/Loveland pass has been extended.
- Permanent overhead gantry (signal heads), pavement markings, signing, etc. for CFM will be built next Spring.
Upcoming Improvements

- Additional CFM location and VSL upstream of EJMT, at bottom of 8 mile uphill
- Ramp meters at 3 location upstream
- Full ATM being scoped
Video
Questions?