I-235 Corridor Background

- Early 2000’s – Prior to Reconstruction:
  - Conscious Decisions Along Corridor
    - Limited Build Alternative Was Selected
  - Alternative Included
    - TDM-10 (Travel Demand Management)
    - Freeway Incident Management System
  - Ramp Metering was Identified as Potential Strategy
    - Monitor feasibility along corridor over time
I-235 Corridor Background
Study Approach

- Study Sub-Divided into Three Main Components:
  - Existing Conditions Review
  - Ramp Management Strategy
  - Ramp Management Implementation Benefit/Cost
- Compiled into Overall Report
Study Approach

**INPUTS**
- CORRIDOR GEOMETRICS
- TRAFFIC FLOW
- TRAVEL TIME
- CRASH HISTORY
- ENTRANCE RAMP GEOMETRICS
- ITS INFRASTRUCTURE

**STUDY PROCESS**
- EXISTING CONDITIONS REVIEW

**OUTPUTS**
- POTENTIAL ISSUES

**RAMP MANAGEMENT STRATEGY**

**RAMP MANAGEMENT BENEFIT/COST ESTIMATE**
Study Approach

- **INPUTS**

- **STUDY PROCESS**
  - EXISTING CONDITIONS REVIEW
  - RAMP MANAGEMENT STRATEGY

- **OUTPUTS**
  - RAMP MANAGEMENT COST ESTIMATE
  - GROUPING STRATEGY
  - SINGLE LANE VS. DUAL
  - RELEASE STRATEGY
  - FIXED TIME VS. TRAFFIC RESPONSIVE
  - DESIGN CRITERIA
Study Approach

**INPUTS**

**STUDY PROCESS**

**EXISTING CONDITIONS REVIEW**

**RAMP MANAGEMENT STRATEGY**

**OUTPUTS**

- COST INFORMATION
- RAMP MANAGEMENT COST ESTIMATE
- COST INFORMATION
- PLANNING LEVEL COST ESTIMATE
- BENEFIT/COST ANALYSIS
Existing Conditions

- Study Components:
  - Traffic Counts
  - Travel Time Review
  - Traffic Operations Analyses
  - Crash History Review
  - Entrance Ramp Geometric Review
  - ITS Infrastructure Review
Existing Conditions

- Travel Time Review (July 16-17, 2013)
Eastbound/Northbound Direction – AM Peak Period
Existing Conditions

- Travel Time Review (July 16-17, 2013)

Westbound/Southbound Direction – PM Peak Period
Existing Conditions

- Travel Time Review (July 16-17, 2013)

Eastbound/Northbound Direction – AM Peak Period
Existing Conditions

- Travel Time Review (July 16-17, 2013)

Westbound/Southbound Direction – PM Peak Period

SPEED (MPH)

<table>
<thead>
<tr>
<th>Location</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIVERSITY AVE</td>
<td>65</td>
</tr>
<tr>
<td>MLK PKWY</td>
<td>60</td>
</tr>
<tr>
<td>EUCLID AVE</td>
<td>40</td>
</tr>
<tr>
<td>NE MIXMASTER</td>
<td>55</td>
</tr>
<tr>
<td>22ND STREET</td>
<td>50</td>
</tr>
<tr>
<td>42ND STREET</td>
<td>45</td>
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<tr>
<td>63RD STREET</td>
<td>35</td>
</tr>
<tr>
<td>SW MIXMASTER</td>
<td>42</td>
</tr>
</tbody>
</table>

Legend:
- BLUE = LEFT LANE
- RED = RIGHT LANE
- GREEN = SPEED LIMIT
- ORANGE = CONSTRUCTION
Existing Conditions

- Crash History Review

Crash Data Summary (2010 - 2012)

- Total Crashes
- Average Crash Rate

- Eastbound (SW Mix to University)
- Northbound (University to NE Mix)
- Southbound (NE Mix to University)
- Westbound (University to SW Mix)
Existing Conditions

- Crash History Review

RED = CRASH RATE ABOVE AVERAGE
Existing Conditions

- Entrance Ramp Geometric Review
  - 36 Entrance Ramps
  - Example Items Reviewed Included:
    - Longitudinal Lengths
    - Cross Section Widths
    - Ramp Grades/Superelevations
    - Shoulder Structures
    - Potential Right-of-Way/Constructability Constraints
Existing Conditions

- Entrance Ramp Geometric Review
## Existing Conditions

### Entrance Ramp Geometric Review

<table>
<thead>
<tr>
<th>Entrance Ramp Worksheet</th>
<th>UNITS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td><strong>ENTRY RAMP GEOMETRICS</strong></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Length of Single Lane Ramp</td>
<td>FT</td>
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<td>320</td>
<td>360</td>
<td>1800</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Auxiliary Lane</td>
<td>INcline</td>
<td>5%</td>
<td>8%</td>
<td>8%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
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<td>100 ft</td>
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<td>100 ft</td>
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<tr>
<td>Auxiliary Lane</td>
<td>Length of Physical Zone</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
<td>100 ft</td>
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<td><strong>Entrance Ramp Geometric Data</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Approximate Radius of Control Curve</td>
<td>FT</td>
<td>3175</td>
<td>323</td>
<td>4200</td>
<td>1500</td>
<td>200</td>
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<td>Critical Approach (Upward, Downward)</td>
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<tr>
<td>Downhill</td>
<td>6</td>
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<td>9</td>
<td>9</td>
<td>9</td>
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<td>9</td>
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<td>Uphill</td>
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<td><strong>Entrance Ramp Geometric Design</strong></td>
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<tr>
<td>Ramp Grade (Horizontal)</td>
<td>%</td>
<td>-2.25%</td>
<td>-4.0%</td>
<td>5.0%</td>
<td>-</td>
<td>-4.0%</td>
<td>-5.5%</td>
<td>-6.0%</td>
<td>-6.5%</td>
<td>-7.0%</td>
<td>-7.5%</td>
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<tr>
<td><strong>SHOULDER/LANE DATA</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Presence of Shoulders</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shoulder Width</td>
<td>2 ft</td>
<td>2 ft</td>
<td>2 ft</td>
<td>2 ft</td>
<td>2 ft</td>
<td>2 ft</td>
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</tr>
</tbody>
</table>

**Data Source:** Iowa Department of Transportation

**HRG Green**

**Cambridge Systematics**

**HRGreen 100+ Est. 1913**
Existing Conditions

- Entrance Ramp Geometric Review

---

**ON-RAMP #13**

**EB 2nd AVENUE (NB TO EB)**

- MAINLINE POSTED SPEED LIMIT (MPH): 55
- NUMBER OF MAINLINE-LANE LANE(S): 1
- STORAGE LENGTH (FT): 815
- ACCELERATION LENGTH (FT): 662
- AMHS RECOMMENDED ACCELERATION LENGTH (FT): 880

**ON-RAMP #14**

**EB PENNSYLVANIA AVENUE (NB TO EB)**

- MAINLINE POSTED SPEED LIMIT (MPH): 55
- NUMBER OF MAINLINE-LANE LANE(S): 1
- STORAGE LENGTH (FT): 1,192
- ACCELERATION LENGTH (FT): 908
- AMHS RECOMMENDED ACCELERATION LENGTH (FT): 1,200

**ON-RAMP #15**

**EB E. 15th STREET (NB TO EB)**

- MAINLINE POSTED SPEED LIMIT (MPH): 55
- NUMBER OF MAINLINE-LANE LANE(S): 1
- STORAGE LENGTH (FT): 1,090
- ACCELERATION LENGTH (FT): 1,231
- AMHS RECOMMENDED ACCELERATION LENGTH (FT): 1,300

**ON-RAMP #16**

**NB EASTON BOULEVARD**

- MAINLINE POSTED SPEED LIMIT (MPH): 55
- NUMBER OF MAINLINE-LANE LANE(S): 1
- STORAGE LENGTH (FT): 860
- ACCELERATION LENGTH (FT): 742
- AMHS RECOMMENDED ACCELERATION LENGTH (FT): 742

---

**GEOMETRY REVIEW EXHIBITS**

- I-235 RAMP METERING FEASIBILITY STUDY BETWEEN I-35/60 SYSTEM INTERCHANGES
- FEB 2014
- EXHIBIT II-11
Existing Conditions

- Entrance Ramp Geometric Review

**ON-RAMP #6**
**EB 63rd STREET**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainline Posted Speed Limit (MPH)</td>
<td>60</td>
</tr>
<tr>
<td>Number of Mainline/typical Lanes</td>
<td>3</td>
</tr>
<tr>
<td>Typical Ramp Cross Section Width (FT)</td>
<td>26</td>
</tr>
<tr>
<td>Storage Length (FT)</td>
<td>515</td>
</tr>
<tr>
<td>Acceleration Length (FT)</td>
<td>3,555</td>
</tr>
<tr>
<td>AASHTO Suggested Acceleration Length (FT)</td>
<td>1,200</td>
</tr>
</tbody>
</table>
Study Approach

INPUTS

STUDY PROCESS

EXISTING CONDITIONS REVIEW

OUTPUTS

RAMP MANAGEMENT STRATEGY

- GROUPING STRATEGY
- SINGLE LANE VS. DUAL
- RELEASE STRATEGY
- FIXED TIME VS. TRAFFIC RESPONSIVE
- DESIGN CRITERIA

RAMP MANAGEMENT COST ESTIMATE
Ramp Management Strategy

- Ramp Management Strategy Includes Study of:
  - Ramp Meter Operations
    - Isolated vs. Group Strategy
    - Fixed Time vs. Traffic Responsive
  - Ramp Metering Design Criteria
    - Stop Bar Placement
    - Single Lane vs. Dual Lane
    - Pavement Marking/Signing Modifications
    - Additional ITS Installations
Ramp Management Strategy

- Ramp Meter Operations - Existing Traffic Scenarios

- July counts vs. Permanent Count Station near Guthrie Avenue
  - July between Minimum and Maximums, therefore no adjustment for seasonal variation
Ramp Management Strategy

- Existing Facility Operations
Ramp Management Strategy

- Existing Ramp Meter Operations - Outcomes
  - The corridor was divided into two major segments
    - East-west portion and the north-south portion
      - With the split occurring at University Avenue
  
- Conditions in the corridor lend themselves to:
  - A system-wide approach rather than an isolated approach
  - Traffic-responsive timing approach rather than a fixed time approach
Ramp Management Strategy

- Ramp Meter Operations Analysis
  - Three time periods:
    - Existing conditions,
    - 5 year horizon (2019),
    - 20 year horizon (2034).
  - Time periods included three hours in AM and PM peak
  - Scenarios with and without ramp metering in order to compare the effects.
Ramp Management Strategy

- Ramp Meter Operations Analysis – 20 Year Westbound
AM PEAK
Ramp Management Strategy

- Ramp Meter Operations - Outcomes
  - No significant benefits to North-South portion
    - Even in 20-Year timeframe
  - East-West portion
    - Benefits become significant over 20-Year timeframe
    - Westbound direction includes benefits during 5-Year

- Takeaway: Ramp Metering provides increasing operational benefits over time
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Layout
Ramp Management Strategy

- Ramp Meter Design Criteria – Acceleration/Storage
  - AASHTO Table 10-3; 55mph: 960’, 60mph: 1,200’

<table>
<thead>
<tr>
<th>Ramp #</th>
<th>Eastbound/Northbound</th>
<th>Distance Deficit</th>
<th>Note</th>
<th>Ramp #</th>
<th>Westbound/Southbound</th>
<th>Distance Deficit</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>SB-EB Valley West Drive</td>
<td>295’</td>
<td>A</td>
<td>20</td>
<td>WB-SB E. Euclid Avenue</td>
<td>295’</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>56th Street</td>
<td>195’</td>
<td>B</td>
<td>21</td>
<td>EB-SB E. Euclid Avenue</td>
<td>250’</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>SB-EB 42nd Street</td>
<td>420’</td>
<td>A</td>
<td>22</td>
<td>Guthrie Avenue</td>
<td>295’</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>Keosaqua Way</td>
<td>50’</td>
<td>F</td>
<td>25</td>
<td>E. 6th Street</td>
<td>110’</td>
<td>C</td>
</tr>
<tr>
<td>17</td>
<td>Guthrie Avenue</td>
<td>430’</td>
<td>B</td>
<td>30</td>
<td>Martin Luther King Parkway</td>
<td>25’</td>
<td>F</td>
</tr>
<tr>
<td>19</td>
<td>WB-NB E. Euclid Avenue</td>
<td>40’</td>
<td>F</td>
<td>32</td>
<td>42nd Street</td>
<td>315’</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33</td>
<td>63rd Street</td>
<td>325’</td>
<td>E</td>
</tr>
</tbody>
</table>

NOTES:
A: Not possible due to ramp to ramp spacing requirements
B: Possible with additional pavement and reconfigured sign structure
C: Possible, however would likely be cost prohibitive due to required bridge widening
D: Possible with additional pavement and reconfigured overpass shoulder pavement
E: Recent construction included auxiliary lane – Therefore adequate as is
F: Minor distance deficit – Under 50’
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Cross Sections
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Cross Sections
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Cross Sections
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Cross Sections

- I-235 Corridor
  - Average width: 27’
    - Lowest width ramp: 21’ (WB 73rd Street)
  - All ramps included cross section with over 20’
    - Emergency response vehicle needs
Ramp Management Strategy

- Ramp Meter Design Criteria – Typical Release Strategy
Ramp Management Strategy

- Ramp Management Strategy - Summary
  - Ramp Meter Operations
    - East-West Segment only
    - Isolated vs. Group Strategy
    - Fixed Time vs. Traffic Responsive
  - Ramp Metering Design Criteria
    - Stop Bar Placement: 300’ upstream as starting point
    - Single Lane vs. Dual Lane:
      - Single OK for today’s traffic volumes – Dual lane may be necessary in future – MnDOT style
      - Dual/Simultaneous vs. Alternating Release Strategy
    - Pavement Marking/Signing: Minor modifications
    - ITS Infrastructure: Improvement necessary
Study Approach

INPUTS

STUDY PROCESS

EXISTING CONDITIONS REVIEW

RAMP MANAGEMENT STRATEGY

OUTPUTS

• COST INFORMATION

RAMP MANAGEMENT COST ESTIMATE

• PLANNING LEVEL COST ESTIMATE
• BENEFIT/COST ANALYSIS
Ramp Management Benefit/Cost

- Benefit/Cost Analysis - Overview
  - Utilized TOPS-BC Software Program
  - Analysis included an estimation of the beneficial impacts of ramp metering on:
    - Travel Time Savings
    - Crash Reduction
    - Operating Cost
  - Values were monetized to compare against costs
  - Results from FREEVAL were utilized
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Benefits in Eastbound/Northbound Direction

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>5 year</th>
<th>20 year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>East-West</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>$106,200</td>
<td>$124,130</td>
<td>$1,623,700</td>
</tr>
<tr>
<td>PM</td>
<td>$122,831</td>
<td>$141,003</td>
<td>$790,737</td>
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<tr>
<td>Total</td>
<td>$229,032</td>
<td>$265,133</td>
<td>$2,414,437</td>
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<tr>
<td><strong>North-South</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>$10,036</td>
<td>$11,080</td>
<td>$15,125</td>
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<tr>
<td>PM</td>
<td>$2,466</td>
<td>$4,053</td>
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<tr>
<td>Total</td>
<td>$12,503</td>
<td>$15,133</td>
<td>$336,025</td>
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<td><strong>Eastbound</strong></td>
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<tr>
<td></td>
<td>$241,535</td>
<td>$280,266</td>
<td>$2,750,462</td>
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</table>

- East-West section benefits grow substantially over time
  - Especially the AM peak hour between the 5- and 20-year timeframe
- North-South section benefits grow, however negligible
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Benefits in Westbound/Southbound Direction

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>5 year</th>
<th>20 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM East-West</td>
<td>$160,294</td>
<td>$742,413</td>
<td>$3,734,393</td>
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<tr>
<td>PM East-West</td>
<td>$673,230</td>
<td>$3,915,502</td>
<td>$6,018,417</td>
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<td>Total East-West</td>
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<td>AM North-South</td>
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<td>$24,158</td>
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<td>PM North-South</td>
<td>$659</td>
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<td>Total North-South</td>
<td>$22,541</td>
<td>$24,964</td>
<td>$84,673</td>
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<tr>
<td>Westbound</td>
<td>$856,064</td>
<td>$4,682,879</td>
<td>$9,837,483</td>
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</table>

- Westbound/Southbound direction shows a higher level of potential benefits than the Eastbound/Northbound direction
- East-West section benefits grow substantially over time
  - During both the peak hours between the 5- and 20-year timeframe
- North-South section benefits grow, however negligible
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Both Directions

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>5 year</th>
<th>20 year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM</td>
<td>PM</td>
<td>Total</td>
</tr>
<tr>
<td>East-West</td>
<td>$266,494</td>
<td>$796,061</td>
<td>$1,062,555</td>
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<tr>
<td></td>
<td>$866,544</td>
<td>$4,056,504</td>
<td>$4,923,048</td>
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<tr>
<td></td>
<td>$5,358,093</td>
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<tr>
<td>North-South</td>
<td>$31,918</td>
<td>$4,859</td>
<td>$420,698</td>
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<td>$35,238</td>
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<tr>
<td></td>
<td>$98,314</td>
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<tr>
<td></td>
<td>$3,125</td>
<td>$40,097</td>
<td>$420,698</td>
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<td></td>
<td>$4,859</td>
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<tr>
<td></td>
<td>$322,385</td>
<td></td>
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<tr>
<td>Both Directions</td>
<td>$1,097,599</td>
<td>$4,963,145</td>
<td>$12,587,945</td>
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</tbody>
</table>

- East-West section benefits grow substantially over time
- North-South section benefits grow, however negligible
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Cost Information

<table>
<thead>
<tr>
<th></th>
<th>Capital</th>
<th>Maintenance</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-South</td>
<td>$724,500</td>
<td>$108,675</td>
<td>$36,225</td>
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<tr>
<td>East-West</td>
<td>$3,001,500</td>
<td>$450,225</td>
<td>$150,075</td>
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</table>

Percent of Capital | Percent of Capital
--- | ---
Life Cycle (Years) | 10 | 15%
Discount Rate | 3% | 5%

- Capital cost estimated from ramp metering/ITS infrastructure needs and necessary signing/pavement marking modifications
- B/C ratios of at least 2 or 3 to 1 are desired due to intangible nature of benefits (i.e. travel time)
Ramp Management
Benefit/Cost

- Benefit/Cost Analysis – Summary for East-West Segment
  - B/C ratio exceeds 1.0 at the outset
  - B/C ratio of 5.2 five years out
  - B/C ratio of 12.8 twenty years out
  - Overall B/C ratio over 20 year period is 7.5

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Benefits</th>
<th>Annualized Cost</th>
<th>Net Benefits</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$1,062,555</td>
<td>$952,167</td>
<td>$110,864</td>
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<tr>
<td>2015</td>
<td>$1,834,654</td>
<td>$952,167</td>
<td>$882,962</td>
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<tr>
<td>2016</td>
<td>$2,606,752</td>
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<td>$1,655,061</td>
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<tr>
<td>2017</td>
<td>$3,378,851</td>
<td>$952,167</td>
<td>$2,427,159</td>
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<td>2018</td>
<td>$4,150,949</td>
<td>$952,167</td>
<td>$3,199,258</td>
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<tr>
<td>2019</td>
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<td>$952,167</td>
<td>$3,971,356</td>
<td>5.2</td>
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<tr>
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<td>$5,405,995</td>
<td>$952,167</td>
<td>$4,454,303</td>
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<tr>
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<td>$5,888,941</td>
<td>$952,167</td>
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<td>$6,371,888</td>
<td>$952,167</td>
<td>$5,420,196</td>
<td>6.7</td>
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<tr>
<td>2023</td>
<td>$6,854,834</td>
<td>$952,167</td>
<td>$5,903,143</td>
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<tr>
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<td>$7,337,781</td>
<td>$952,167</td>
<td>$6,386,089</td>
<td>7.7</td>
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<td>2025</td>
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<td>$6,869,036</td>
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<td>2026</td>
<td>$8,303,674</td>
<td>$952,167</td>
<td>$7,351,982</td>
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<tr>
<td>2027</td>
<td>$8,786,620</td>
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<td>$7,834,929</td>
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<tr>
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<td>$9,269,567</td>
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<td>$8,317,876</td>
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<td>$8,800,822</td>
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<td>2030</td>
<td>$10,235,460</td>
<td>$952,167</td>
<td>$9,283,769</td>
<td>10.8</td>
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<tr>
<td>2031</td>
<td>$10,718,407</td>
<td>$952,167</td>
<td>$9,766,715</td>
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<tr>
<td>2032</td>
<td>$11,201,353</td>
<td>$952,167</td>
<td>$10,249,662</td>
<td>11.8</td>
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<tr>
<td>2033</td>
<td>$11,684,300</td>
<td>$952,167</td>
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<td>$12,167,246</td>
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<tr>
<td>TOTAL</td>
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<td>$19,995,515</td>
<td>$129,770,595</td>
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</tbody>
</table>
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Summary for North-South Segment
  - B/C ratio below 1.0 at the outset
  - B/C ratio of 0.2 five years out
  - B/C ratio of 1.8 twenty years out
  - Overall B/C ratio over 20 year period is 0.8

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Benefits</th>
<th>Annualized Cost</th>
<th>Net Benefits</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$35,043</td>
<td>$229,834</td>
<td>-$194,790</td>
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<tr>
<td>2015</td>
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<td>$229,834</td>
<td>-$193,779</td>
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<td>2016</td>
<td>$37,065</td>
<td>$229,834</td>
<td>-$192,768</td>
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<td>2017</td>
<td>$38,076</td>
<td>$229,834</td>
<td>-$191,758</td>
<td>0.2</td>
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<tr>
<td>2018</td>
<td>$39,087</td>
<td>$229,834</td>
<td>-$190,747</td>
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<tr>
<td>2019</td>
<td>$40,097</td>
<td>$229,834</td>
<td>-$189,736</td>
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<td>2020</td>
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<td>$229,834</td>
<td>-$164,363</td>
<td>0.3</td>
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<td>$229,834</td>
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<td>2025</td>
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<td>-$37,496</td>
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<tr>
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<td>$229,834</td>
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<td>1.5</td>
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<tr>
<td>2032</td>
<td>$369,951</td>
<td>$229,834</td>
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<td>1.6</td>
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<tr>
<td>2033</td>
<td>$395,325</td>
<td>$229,834</td>
<td>$165,491</td>
<td>1.7</td>
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<tr>
<td>2034</td>
<td>$420,698</td>
<td>$229,834</td>
<td>$190,865</td>
<td>1.8</td>
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<tr>
<td>TOTAL</td>
<td>$3,871,689</td>
<td>$4,826,504</td>
<td>($954,815)</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Ramp Management Benefit/Cost

- Benefit/Cost Analysis – Summary Over Time
Ramp Management Benefit/Cost

- Benefit/Cost Analysis - Summary
  - Ramp metering would yield significant benefits for the east-west segment
  - 13:1 B/C ratio achieved in 20-year timeframe
  - The north-south segment does not achieve a 1:1 B/C ratio until 10 years out and benefits are limited thereafter
Ramp Management Study

- **Recommended Next Steps**
  - Further engineering analysis of ramps in the east-west segment of the corridor that have physical limitations or limited storage capabilities
  - Microsimulation analysis of the east-west corridor to identify potential queue spillbacks or impacts on surface street intersections
  - Resolve any institutional issues including operating policies and requirements for memoranda of understanding with municipalities
  - Develop initial timing plans
  - Develop specifications for design
Thank you!

Questions ??

Contact Information:

Tyler Wiles, P.E., PTOE
HR Green
twiles@hrgreen.com
(515) 657-5294
I-235 Corridor Background

- Predicted Traffic Volumes vs. Actual Volumes
  - 1999 Environmental Impact Statement Projected 2020 AADT Volumes
  - 2012 Actual AADT Volumes
- 2020 projected volumes have been exceeded west of 63rd Street
Existing Conditions

- Travel Time Review (July 16-17, 2013)

Eastbound/Northbound Direction – PM Peak Period

BLUE = LEFT LANE
RED = RIGHT LANE
GREEN = SPEED LIMIT
Existing Conditions

- Travel Time Review (July 16-17, 2013)

Westbound/Southbound Direction – AM Peak Period

BLUE = LEFT LANE
RED = RIGHT LANE
GREEN = SPEED LIMIT
ORANGE = CONSTRUCTION
Existing Conditions

- Travel Time Review (July vs. September – 7-8am)

Eastbound/Northbound Direction – AM Peak Period
Existing Conditions

- Travel Time Review (July vs. September – 5-6pm)

Westbound/Southbound Direction – PM Peak Period
Existing Conditions

- Crash History Review

Approximate Crash Rates Along EB/NB I-235

Approximate Crash Rates Along WB/SB I-235
Existing Conditions
- Crash History Review

Approximate Crash Rates Along EB/NB I-235

Approximate Crash Rates Along WB/SB I-235
Existing Conditions

- Travel Time Review (July 16-17, 2013)
- Eastbound/Northbound Direction – PM Peak Period
Existing Conditions

- Travel Time Review (July 16-17, 2013)
  Westbound/Southbound Direction – AM Peak Period
FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 1.0

What would you like to do today?

- Investigate Potential Impacts of Strategies
- Estimate Life-cycle Costs
- Estimate Benefits and Conduct B/C Analysis
- Research Available Analysis Methods and Tools
- More Info
Tops BC

- Spreadsheet tool
  - Network represented
  - Travel time savings calculated
  - User costs
I-235 Ramp Metering Feasibility Study

- Results can be communicated easily in graphic format
- Benefit/cost is one consideration in decision-making; not the only one
I-235 Ramp Metering Feasibility Study

- User Benefits
  - Travel time savings
  - Improved reliability (reduction in unexpected delay)
  - Crash reduction
  - Fuel savings

- Costs
  - Capital
  - Operations & Maintenance
I-235 Ramp Metering Feasibility Study

- Inputs to TOPS-BC
  - Roadway segment data including ramps
    - Lanes
    - Distance
    - Volumes
    - Speeds
  - Volume/capacity relationships
    - Can use V/C curves if available from Travel Demand Model
    - Default curves available in TOPS-BC
# I-235 Ramp Metering Feasibility Study

## TOPS-BC User Input for Link Data

<table>
<thead>
<tr>
<th>Impact</th>
<th>User Input</th>
<th>Default</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT Year of Deployment</td>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Length of Analysis Period (Hours)</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Number of Periods per Year</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Freeway Volume</td>
<td>15,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Freeway Number of Lanes</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Freeway Capacity</td>
<td>16,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Freeway Free Flow Speed (MPH)</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Freeway Link Length (Miles)</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Number of Metered Ramps</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT Average Ramp Volume</td>
<td>1,000</td>
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</tr>
<tr>
<td>INPUT Average Ramp Capacity</td>
<td>900</td>
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<tr>
<td>INPUT Ramp Free Flow Speed (MPH)</td>
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<tr>
<td>INPUT Average Ramp Link Length (Miles)</td>
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<tr>
<td>INPUT Level of Metering Sophistication</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **User Input**: The input data provided by the user.
- **Default**: The default values used in the model.
- **Modeled**: The modeled values based on the input and default data.

- **Impact**: Descriptions of the impact of each input parameter on the analysis.
- **Period should match time system is operational**
- **Input = Facility volume for the entire analysis period**
- **Input = Facility capacity for the entire analysis period**
- **Input = Average volume per ramp for the analysis period**
- **Input = Facility capacity for the entire analysis period**
- **1 = Preset Timing**
- **2 = Traffic Actuated**
- **3 = Central Control**
I-235 Ramp Metering Feasibility Study

- Inputs to TOPS-BC
  - Benefit Parameters
    - Change in speed and capacity resulting from metering
      - Will be obtained from FREVAL analysis
    - Crash reduction parameters
      - Use defaults from TOPS-BC
    - Fuel consumption
### TOPS-BC User Input for Travel Time Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Change</th>
<th>Typical Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway Congested Speed - Without Improvement</td>
<td>58.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramp Congested Speed - Without Improvement</td>
<td>20.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Freeway Capacity Resulting from Metering Strategy</td>
<td>14.5%</td>
<td></td>
<td>Typical Range = 5 to 15% increase</td>
</tr>
<tr>
<td>Change in Ramp Capacity Resulting from Metering Strategy</td>
<td>-27.0%</td>
<td></td>
<td>Typical Range = 5 to 45% decrease</td>
</tr>
<tr>
<td>Freeway Congested Speed - With Improvement</td>
<td>60.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramp Congested Speed - With Improvement</td>
<td>13.87</td>
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<td></td>
</tr>
<tr>
<td>% Reduction in Crash Rate in Merge Area</td>
<td>27%</td>
<td></td>
<td>Typical Range = 10 - 35% decrease</td>
</tr>
</tbody>
</table>
I-235 Ramp Metering Feasibility Study

- Inputs to TOPS-BC
  - Monetary value of benefits
    - Travel time based on average wage
  - Crash values Applied
    - Fatality
    - Injury
    - PDO
  - Fuel cost for region
  - Capital and O&M costs for equipment and systems
I-235 Ramp Metering Feasibility Study

- Outputs from TOPS-BC
  - Benefit outputs
    - Travel time saved
    - Crashes reduced by category
    - Gallons fuel
  - Monetized value of benefits (annualized)
  - Annualized costs including capital and O&M
  - Benefit/cost ratios
- Sensitivity analysis of different options