Improving Work Zone Safety and Mobility
Background

Motivation
Compliance with Final Rule on Work Zone Safety and Mobility

Funding
In 2013 MD SHA and FHWA funded a project to develop a real time performance monitoring tool for work zones using INRIX probe vehicle data and event data.
Context
Data Sources and Key Definitions

- Active work zone information provided by SHA CHART system in real-time.
- Probe vehicle speed information from INRIX.

**User Delay Cost (UDC)**

Calculated using:
- ADT (AADT with adjustment factor)
- Passenger/commercial vehicle percentages
- Speed reduction factor
- Delay
Audience and Goals

**Audience:** Project Engineers and Managers

**Goals:**
- Real time performance
- Alerts when thresholds exceeded
- Potential actions based on identified performance

**Audience:** Public Relations

**Goals:**
- Real time and historical performance
- Responding to complaints and inquiries

**Audience:** Planners and Decision Makers

**Goals:**
- Closure costs
- Review of previous performance
Work Zone Dashboard

Overview

List

Map

Critical

Delay
## Critical Work Zones

<table>
<thead>
<tr>
<th>SEVERITY/EVENT</th>
<th>TOP CRITICAL WORKZONES</th>
<th>LANE STATUS</th>
<th>QUEUE LENGTH (MI)</th>
<th>USER DELAY COST ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical (1)</td>
<td>I-695 INNER LOOP BETWEEN EXIT 12 AND 372 WILKENS AVE AND EXIT 13 MD 144 FREDERICK RD</td>
<td></td>
<td>2.35</td>
<td>$7,781.00</td>
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<tr>
<td>Major (2)</td>
<td>RIVERDALE RD WEST BETWEEN 67TH PL AND MD 410</td>
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<td>2.51</td>
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<td></td>
<td>I-695 OUTER LOOP WEST OF EXIT 1 MD 173 HAWKINS POINT RD (CURTIS CREEK DRAWBRIDGE)</td>
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<td></td>
<td>$4,020.00</td>
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</table>
Work Zone Dashboard

CURRENT WORKZONES IN MARYLAND

<table>
<thead>
<tr>
<th>REGION/EVENT</th>
<th>J OF NEARBY INCIDENTS</th>
<th>QUEUE LENGTH (M)</th>
<th>USER DELAY COST ($)</th>
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</thead>
<tbody>
<tr>
<td>Allegany (5)</td>
<td>0</td>
<td>0</td>
<td>$9,493.00</td>
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<tr>
<td>Anne Arundel (2)</td>
<td>0</td>
<td>0</td>
<td>$12,780.00</td>
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<tr>
<td>Baltimore (5%)</td>
<td>0</td>
<td>0</td>
<td>$28,495.00</td>
</tr>
<tr>
<td>Prince George (5)</td>
<td>0</td>
<td>0</td>
<td>$58,990.00</td>
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</table>

TOP CRITICAL WORKZONES

<table>
<thead>
<tr>
<th>SEVERITY/EVENT</th>
<th>LANE STATUS</th>
<th>QUEUE LENGTH (M)</th>
<th>USER DELAY COST ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Ager (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2Baltimore (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Prince George (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

USER DELAY COST BY CORRIDOR AND DAY OF WEEK

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Total Day Traffic Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-95</td>
<td>$2,076,358.84</td>
</tr>
<tr>
<td>I-695</td>
<td>$1,702,355.84</td>
</tr>
<tr>
<td>US-50</td>
<td>$1,050,782.31</td>
</tr>
<tr>
<td>I-70</td>
<td>$1,823,782.31</td>
</tr>
</tbody>
</table>

Daily Tolls

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Toll Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Toll Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Total Weekly Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Total Monthly Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Total Yearly Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Total Lifetime Revenue:

- Week 6/1/2014: $2,076,358.84
- Week 6/8/2014: $1,702,355.84
- Week 6/15/2014: $1,050,782.31
- Week 6/22/2014: $1,823,782.31

Work Zone Performance Monitoring
<table>
<thead>
<tr>
<th>Date</th>
<th>I-95</th>
<th>I-695</th>
<th>US-50</th>
<th>I-70</th>
<th>Daily Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wed 4/9/2014</td>
<td>$2,678,358.64</td>
<td>$626,606.88</td>
<td>$229,861.28</td>
<td>$48,652.15</td>
<td>$3,583,478.94</td>
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<tr>
<td>Thu 4/10/2014</td>
<td>$1,239,852.54</td>
<td>$1,050,702.81</td>
<td>$301,406.33</td>
<td>$77,104.65</td>
<td>$2,669,066.33</td>
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<tr>
<td>Fri 4/11/2014</td>
<td>$1,806,342.05</td>
<td>$1,105,801.53</td>
<td>$474,634.47</td>
<td>$107,010.25</td>
<td>$3,493,788.29</td>
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<tr>
<td>Sat 4/12/2014</td>
<td>$3,367,462.23</td>
<td>$210,767.02</td>
<td>$6,721.70</td>
<td>$107,765.02</td>
<td>$3,660,917.46</td>
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<tr>
<td>Sun 4/13/2014</td>
<td>$2,548,281.70</td>
<td>$639,927.57</td>
<td>$8,015.17</td>
<td>$83,570.24</td>
<td>$2,677,692.82</td>
</tr>
<tr>
<td>Mon 4/14/2014</td>
<td>$2,661,674.55</td>
<td>$198,868.28</td>
<td>$184,730.13</td>
<td>$198,868.28</td>
<td>$3,369,250.33</td>
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<tr>
<td>Tue 4/15/2014</td>
<td>$2,838,798.60</td>
<td>$905,736.49</td>
<td>$258,710.91</td>
<td>$125,311.87</td>
<td>$4,128,557.87</td>
</tr>
<tr>
<td>Wed 4/16/2014</td>
<td>$2,937,018.16</td>
<td>$500,186.92</td>
<td>$212,687.02</td>
<td>$83,203.90</td>
<td>$3,733,096.00</td>
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<tr>
<td>Corridor Totals</td>
<td>$20,077,788.75</td>
<td>$4,729,538.59</td>
<td>$1,867,770.87</td>
<td>$640,749.82</td>
<td>$27,315,848.03</td>
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</table>
## UDC Options and Corridor Selection

### USER DELAY COST BY CORRIDOR AND DAY OF WEEK

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Cost Per User</th>
<th>Total Delay</th>
<th>Delay Per User</th>
<th>Total User Delay Cost</th>
<th>Cost Per User</th>
<th>Total Delay</th>
<th>Delay Per User</th>
<th>Total User Delay Cost</th>
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</thead>
<tbody>
<tr>
<td>I-95</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Wed 4/9/2014</td>
<td>$2,678,358.64</td>
<td>$48,981.08</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Thu 4/10/2014</td>
<td>$1,239,852.54</td>
<td>$77,618.02</td>
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<td></td>
</tr>
<tr>
<td>Fri 4/11/2014</td>
<td>$1,806,342.05</td>
<td>$109,861.43</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sat 4/12/2014</td>
<td>$3,367,462.75</td>
<td>$179,057.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sun 4/13/2014</td>
<td>$2,548,281.10</td>
<td>$37,468.98</td>
<td></td>
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<tr>
<td>Mon 4/14/2014</td>
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<td>$323,977.01</td>
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<tr>
<td>Tue 4/15/2014</td>
<td>$2,838,798.60</td>
<td>$905,736.49</td>
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<tr>
<td>Wed 4/16/2014</td>
<td>$2,937,018.16</td>
<td>$500,186.92</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Corridor Totals**

- I-95: $20,077,788.75
- Total User Delay Cost: $1,867,770.87
- Grand Total: $27,315,848.03

**Legend**

- Weekend
- Lowest
- Highest
- No Data
### Work Zone Dashboard

#### Current Workzones in Maryland

<table>
<thead>
<tr>
<th>Location</th>
<th># of Workzones</th>
<th>Lane Status</th>
<th>Queue Lengths (ft)</th>
<th>Average Queue Delay (sec)</th>
<th>User Delay Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maryland (11)</td>
<td>10</td>
<td>294</td>
<td>$4,542,030</td>
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<td>$416,082</td>
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<tr>
<td>Allentown (3)</td>
<td>3</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Harrisburg (3)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pittsburgh (3)</td>
<td>3</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Cleveland (2)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Buffalo (1)</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Boston (4)</td>
<td>4</td>
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<td>0</td>
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<tr>
<td>New York (3)</td>
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<tr>
<td>Philadelphia (5)</td>
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<td>0</td>
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<tr>
<td>Baltimore (2)</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Washington, DC (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Richmond (1)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Charlotte (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Atlanta (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Miami (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Houston (1)</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>Dallas (1)</td>
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<tr>
<td>San Antonio (1)</td>
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<tr>
<td>Phoenix (1)</td>
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<td>0</td>
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<tr>
<td>Los Angeles (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>San Francisco (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Seattle (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Portland (1)</td>
<td>1</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minneapolis (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Denver (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Salt Lake City (1)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Las Vegas (1)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Honolulu (1)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Top Critical Workzones

<table>
<thead>
<tr>
<th>Severity/Event</th>
<th>Lane Status</th>
<th>Queue Lengths (ft)</th>
<th>Average Queue Delay (sec)</th>
<th>User Delay Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major #5</td>
<td>3.9</td>
<td>20</td>
<td>10</td>
<td>$1,512,082</td>
</tr>
<tr>
<td>Major #4</td>
<td>3.8</td>
<td>15</td>
<td>9</td>
<td>$1,056,056</td>
</tr>
<tr>
<td>Major #3</td>
<td>3.7</td>
<td>10</td>
<td>7</td>
<td>$744,042</td>
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<td>Major #2</td>
<td>3.6</td>
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<td>5</td>
<td>$456,024</td>
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<tr>
<td>Major #1</td>
<td>3.5</td>
<td>5</td>
<td>4</td>
<td>$304,016</td>
</tr>
</tbody>
</table>

### Workzone Locations

- **Map Layers:**
  - Workzones
  - Dynamic Message Signs
  - Probe Speed Data

### User Delay Cost by Corridor and Day of Week

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Daily Tota</th>
<th>Total User Delay Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-95</td>
<td>$2,670,358.64</td>
<td>$5,372,745.18</td>
</tr>
<tr>
<td>295</td>
<td>$5,624,680.88</td>
<td>$11,249,361.76</td>
</tr>
<tr>
<td>66-55</td>
<td>$12,103,678.90</td>
<td>$24,207,357.80</td>
</tr>
<tr>
<td>I-95</td>
<td>$12,145,680.90</td>
<td>$24,291,361.80</td>
</tr>
<tr>
<td>I-70</td>
<td>$12,195,680.90</td>
<td>$24,391,361.80</td>
</tr>
<tr>
<td>I-70</td>
<td>$12,245,680.90</td>
<td>$24,491,361.80</td>
</tr>
</tbody>
</table>

### Additional Data

- **Total Workzone Delay:**
  - $20,377,358.75
  - $4,729,328.59
  - $1,867,770.87
  - $540,748.32

### Workzone Performance Monitoring
Map Layers and Options

WORKZONE LOCATIONS

MAP LAYERS

- Workzones
- Dynamic Message Signs
- Probe Speed Data

Speed
Comparative
Average Congestion
- Congestion
Settings and Map

Planned Closure @ US 29 SOUTH AT INDUSTRIAL PKW

Data Type...
- Measured Speeds
- Comparison to Historical Average

Show...
- Work Zone Bounds
- Posted Speeds
- Associated DMS
- Nearby Cameras
- Nearby Incidents
- Lane Status
- Bottlenecks (when available)
  - 5 miles upstream
  - 5 miles downstream

Permit Information
- Project Information
- Site Details

Configure Alerts
Lane Profile

Segment Speeds

Live CCTV & DMS

Bottlenecks & Nearby Events
Individual Work Zone Profile

Planned Closure @ US 29 SOUTH AT INDUSTRIAL PKWY

- Current Conditions
- Travel Time Through Workzone Only
- Filter Results

Data Type:
- Average Speed
- Comparison to Historical Average

Show:
- Work Zone Boundaries
- Incident Times
- Status Messages
- Nearby Incidents
- Lane Status
- Bottlenecks (if available)

 Permit Information
- Project Information
- Site Details
- Configure Alerts

User Delay Cost
- Total User Delay Cost
- 12AM - 4AM
- 4AM - 8AM
- 8AM - 12PM
- 12PM - 4PM
- 4PM - 8PM
- 8PM - 12AM
- Daily Totals

- Hourly Totals

Started: Thu, Apr 17, 2014 at 09:16:31 AM
Performance Charts

SPEED THROUGH WORKZONE

Through the Work Zone

[Graph showing speed through a work zone with data for different dates from Thu 04/10/2014 to Wed 04/16/2014]
Adjusting Parameters
Filtering Results
## Individual Work Zone UDC

<table>
<thead>
<tr>
<th>Day</th>
<th>12AM - 4AM</th>
<th>4AM - 8AM</th>
<th>8AM - 12PM</th>
<th>12PM - 4PM</th>
<th>4PM - 8PM</th>
<th>8PM - 12AM</th>
<th>Daily Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thu 4/17/2014</td>
<td>$11.52</td>
<td>$183.00</td>
<td>$9,306.97</td>
<td>$16,405.23</td>
<td>$2,958.90</td>
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<td>$28,933.20</td>
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<tr>
<td>Fri 4/18/2014</td>
<td>$6.17</td>
<td>$29.46</td>
<td>$82.00</td>
<td>$221.35</td>
<td>$127.06</td>
<td>$50.00</td>
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<tr>
<td>Sat 4/19/2014</td>
<td>$27.17</td>
<td>$7.65</td>
<td>$3.12</td>
<td>$22.42</td>
<td>$17.28</td>
<td>$46.01</td>
<td>$123.86</td>
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<td>Sun 4/20/2014</td>
<td>$39.81</td>
<td>$24.66</td>
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<td>$6.13</td>
<td>$26.78</td>
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<td>Mon 4/21/2014</td>
<td>$2.46</td>
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<tr>
<td>Tue 4/22/2014</td>
<td>$25.38</td>
<td>$264.46</td>
<td>$1,819.65</td>
<td>$5,771.39</td>
<td>$2,679.70</td>
<td>$189.00</td>
<td>$13,745.58</td>
</tr>
<tr>
<td>Wed 4/23/2014</td>
<td>$20.52</td>
<td>$477.24</td>
<td>$12,925.82</td>
<td>$13,993.07</td>
<td>$16,213.27</td>
<td>$80.23</td>
<td>$43,310.14</td>
</tr>
<tr>
<td>Hourly Totals</td>
<td>$133.04</td>
<td>$1,035.22</td>
<td>$24,523.89</td>
<td>$39,522.78</td>
<td>$22,918.33</td>
<td>$582.59</td>
<td>Grand Total: $38,518.66</td>
</tr>
</tbody>
</table>

Legend:
- **Weekend**: Blue
- **Lowest**: Green
- **Highest**: Red
- **No Data**: No color
### Create an Alert for This Work Zone

Fill out each section to set up an alert for this work zone.

1. **Alert me if...**
   - [ ] An accident happens near this work zone.
   - [ ] There is a bottleneck that's head or queue includes this work zone.
   - [ ] Speeds in the work zone fell below or exceed a certain range.

2. **Alert me by...**
   - [ ] Send me an email
   - [ ] Send me a text message

3. **Alert me when...**

   **Time zone**
   - US/Eastern

   **Time period**

   - **Select days of week**
     - Sun
     - Mon
     - Tue
     - Wed
     - Thu
     - Fri
     - Sat
   - **Select hours of day**
     - 12 AM
     - 6 AM
     - 12 PM
     - 6 PM
     - 12 AM
     - 5:00 AM - 5:00 PM

---

**Create alert**
Work Zone Alerts

CREATE AN ALERT FOR THIS WORK ZONE

Fill out each section to set up an alert for this work zone.

1. Alert me if...
   - An accident happens near this work zone.
     Within 1.5 mile(s) upstream or 0.5 mile(s) downstream
   - There is a bottleneck that's head or queue includes this work zone.
     Keep in mind the formula for determining bottleneck conditions.
     Alert me only when the queue upstream from the work zone exceeds 1.5 mile(s)
   - Speeds in the work zone fall below or exceed a certain range.
     When speeds fall below 35 mph
     When speeds rise above 65 mph
     Alert me when speed is out of range for longer than 5 minute(s)
     Alert me when speed returns within range for longer than 5 minute(s)

2. Alert me by...
   - Send me an email
     Alert will be sent to your account email: ivanovn@umd.edu
   - Send me a text message
     Enter your phone number: 3014093626
     Verizon Wireless
     Verify

3. Alert me when...
   - Time zone
     US/Eastern
   - Time period
     Hours of day: 6:00 AM to 5:00 PM
     Select days of week

Create alert
Next Steps

I-95 Corridor Coalition Expansion

- I-95 CC awarded $300,000 to deploy to as many agencies as possible.
- Backend re-architecture for scalability across 17 states.
- Data collection to support the application.

Improvements

- Increased spatial granularity of probe vehicle data.
- Multiple probe vehicle data providers.
Michael VanDaniker,
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