HOW EFFECTIVE ARE SAFETY IMPROVEMENT PROJECTS IN COLORADO?

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FHU
Colorado Safety Knowledge Base Was Extensively Used First to Select Projects and then Conduct Observational Before After Studies
Rural Flat and Rolling 2-Lane Undivided Highways

Accidents/Mile/Year vs. AADT

Lower Limit (20%)  Total  Upper Limit (80%)
Rural Flat and Rolling 2-Lane Undivided Highways

Lower Limit (20%)  INJ + FAT  Upper Limit (80%)

Accidents/Mile/Year

AADT

INJ + FAT
### Rural Flat and Rolling 2-Lane Undivided Highways

#### Colorado Department of Transportation
DiExSys™ Roadway Safety Systems
Diagnostics Comparison Percentages Baselines

**Highway Class:** CO - Rural Flat and Rolling 2-Lane Undivided Highways - AADT 0 - 3,000 (2002)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th># ACC’s</th>
<th>%</th>
<th>CATEGORY</th>
<th># ACC’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Damage Only (PDO)</td>
<td>2,787</td>
<td>63.18%</td>
<td>Tree</td>
<td>38</td>
</tr>
<tr>
<td>Injury (INJ)</td>
<td>1,483</td>
<td>33.62%</td>
<td>Large Boulders or Rocks</td>
<td>28</td>
</tr>
<tr>
<td>Fatal (FAT)</td>
<td>141</td>
<td>3.20%</td>
<td>Rocks in Roadway</td>
<td>5</td>
</tr>
<tr>
<td>Persons Injured</td>
<td>2,253</td>
<td>0.00%</td>
<td>Barricade</td>
<td>1</td>
</tr>
<tr>
<td>Persons Killed</td>
<td>171</td>
<td>0.00%</td>
<td>Wall or Building</td>
<td>0</td>
</tr>
<tr>
<td>Single Vehicle Accidents</td>
<td>3,937</td>
<td>89.25%</td>
<td>Crash Cushion</td>
<td>0</td>
</tr>
<tr>
<td>Two Vehicle Accidents</td>
<td>428</td>
<td>9.70%</td>
<td>Mailbox</td>
<td>4</td>
</tr>
<tr>
<td>Three or More Vehicle Accidents</td>
<td>39</td>
<td>0.88%</td>
<td>Other Fixed Cushion</td>
<td>25</td>
</tr>
<tr>
<td>Unknown Number of Vehicles</td>
<td>7</td>
<td>0.16%</td>
<td>Involved Other Object</td>
<td>75</td>
</tr>
<tr>
<td>On Road</td>
<td>1,812</td>
<td>41.08%</td>
<td>Road Maintenance Equipment</td>
<td>13</td>
</tr>
<tr>
<td>Off Road</td>
<td>2,598</td>
<td>58.90%</td>
<td>Total Fixed Objects</td>
<td>1,334</td>
</tr>
<tr>
<td>Off Road Left</td>
<td>1,172</td>
<td>26.57%</td>
<td>Total Other Objects</td>
<td>93</td>
</tr>
<tr>
<td>Off Road Right</td>
<td>1,425</td>
<td>32.31%</td>
<td>Daylight</td>
<td>2,267</td>
</tr>
<tr>
<td>Off Road at Tee</td>
<td>1</td>
<td>0.02%</td>
<td>Dawn or Dusk</td>
<td>301</td>
</tr>
<tr>
<td>Off Road in Median</td>
<td>0</td>
<td>0.00%</td>
<td>Dark - Lighted</td>
<td>15</td>
</tr>
<tr>
<td>Unknown Road Location</td>
<td>1</td>
<td>0.02%</td>
<td>Dark - Unlighted</td>
<td>1,749</td>
</tr>
<tr>
<td>Overturning</td>
<td>1,266</td>
<td>28.70%</td>
<td>Unknown Lighting</td>
<td>79</td>
</tr>
<tr>
<td>Other Non Collision</td>
<td>189</td>
<td>4.28%</td>
<td>No Adverse Weather</td>
<td>3,251</td>
</tr>
<tr>
<td>Vehicle Cargo or Debris</td>
<td>0</td>
<td>0.00%</td>
<td>Rain</td>
<td>143</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>5</td>
<td>0.11%</td>
<td>Snow or Sleet or Hail</td>
<td>666</td>
</tr>
<tr>
<td>Broadside</td>
<td>3</td>
<td>0.07%</td>
<td>Fog</td>
<td>53</td>
</tr>
<tr>
<td>Head On</td>
<td>70</td>
<td>1.59%</td>
<td>Dust</td>
<td>2</td>
</tr>
<tr>
<td>Rear End</td>
<td>186</td>
<td>3.5%</td>
<td>Dirt</td>
<td>3</td>
</tr>
</tbody>
</table>

**Statewide Average**

- Property Damage Only (PDO): 2,787
- Injury (INJ): 1,483
- Fatal (FAT): 141
- Persons Injured: 2,253
- Persons Killed: 171
- Single Vehicle Accidents: 3,937
- Two Vehicle Accidents: 428
- Three or More Vehicle Accidents: 39
- Unknown Number of Vehicles: 7
- On Road: 1,812
- Off Road: 2,598
- Off Road Left: 1,172
- Off Road Right: 1,425
- Off Road at Tee: 1
- Off Road in Median: 0
- Unknown Road Location: 1
- Overturning: 1,266
- Other Non Collision: 189
- Vehicle Cargo or Debris: 0
- Pedestrian: 5
- Broadside: 3
- Head On: 70
- Rear End: 186

**Statewide Average Percentages**

- Property Damage Only (PDO): 63.18%
- Injury (INJ): 33.62%
- Fatal (FAT): 3.20%
- Persons Injured: 0.00%
- Persons Killed: 0.00%
- Single Vehicle Accidents: 89.25%
- Two Vehicle Accidents: 9.70%
- Three or More Vehicle Accidents: 0.88%
- Unknown Number of Vehicles: 0.16%
- On Road: 41.08%
- Off Road: 58.90%
- Off Road Left: 26.57%
- Off Road Right: 32.31%
- Off Road at Tee: 0.02%
- Off Road in Median: 0.00%
- Unknown Road Location: 0.02%
- Overturning: 28.70%
- Other Non Collision: 4.28%
- Vehicle Cargo or Debris: 0.00%
- Pedestrian: 0.11%
- Broadside: 0.07%
- Head On: 1.59%
- Rear End: 2.45%
Rural Mountainous 2-Lane Undivided Highways

![Graph showing accident rates vs. AADT for Rural Mountainous 2-Lane Undivided Highways. The graph includes lines for Lower Limit (20%), INJ + FAT, and Upper Limit (80%) for accidents per mile per year.]
## Rural Mountainous 2-Lane Undivided Highways

### Colorado Department of Transportation

**DiExSys™ Roadway Safety Systems**

**Diagnostics Comparison Percentages Baselines**

Highway Class: CO - Rural Mountainous 2-Lane Undivided Highways - AADT 0 - 6,000 (2002)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th># ACC's</th>
<th>%</th>
<th>CATEGORY</th>
<th># ACC's</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Damage Only (PDO)</td>
<td>6,458</td>
<td>60.67%</td>
<td>Tree</td>
<td>685</td>
<td>6.43%</td>
</tr>
<tr>
<td>Injury (INJ)</td>
<td>3,969</td>
<td>37.29%</td>
<td>Large Boulders or Rocks</td>
<td>625</td>
<td>5.87%</td>
</tr>
<tr>
<td>Fatal (FAT)</td>
<td>218</td>
<td>2.05%</td>
<td>Rocks in Roadway</td>
<td>137</td>
<td>1.29%</td>
</tr>
<tr>
<td>Persons Injured</td>
<td>5,732</td>
<td></td>
<td>Barricade</td>
<td>11</td>
<td>0.10%</td>
</tr>
<tr>
<td>Persons Killed</td>
<td>241</td>
<td></td>
<td>Wall or Building</td>
<td>22</td>
<td>0.21%</td>
</tr>
<tr>
<td>Single Vehicle Accidents</td>
<td>9,017</td>
<td>84.71%</td>
<td>Crash Cushion</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Two Vehicle Accidents</td>
<td>1,485</td>
<td>13.95%</td>
<td>Mailbox</td>
<td>16</td>
<td>0.15%</td>
</tr>
<tr>
<td>Three or More Vehicle Accidents</td>
<td>138</td>
<td>1.30%</td>
<td>Other Fixed Object</td>
<td>63</td>
<td>0.59%</td>
</tr>
<tr>
<td>Unknown Number of Vehicles</td>
<td>5</td>
<td>0.05%</td>
<td>Involving Other Object</td>
<td>147</td>
<td>1.38%</td>
</tr>
<tr>
<td>On Road</td>
<td>3,815</td>
<td>35.84%</td>
<td>Road Maintenance Equipment</td>
<td>52</td>
<td>0.49%</td>
</tr>
<tr>
<td>Off Road</td>
<td>6,825</td>
<td>64.11%</td>
<td>Unknown Accident Type</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Off Road Left</td>
<td>2,797</td>
<td>26.28%</td>
<td>Total Fixed Objects</td>
<td>4,341</td>
<td>40.78%</td>
</tr>
<tr>
<td>Off Road Right</td>
<td>4,025</td>
<td>37.81%</td>
<td>Total Other Objects</td>
<td>336</td>
<td>3.16%</td>
</tr>
<tr>
<td>Off Road at Tee</td>
<td>0</td>
<td>0.00%</td>
<td>Daylight</td>
<td>6,052</td>
<td>56.85%</td>
</tr>
<tr>
<td>Off Road in Median</td>
<td>3</td>
<td>0.03%</td>
<td>Dawn or Dusk</td>
<td>664</td>
<td>6.24%</td>
</tr>
<tr>
<td>Unknown Road Location</td>
<td>5</td>
<td>0.05%</td>
<td>Dark - Lighted</td>
<td>44</td>
<td>0.41%</td>
</tr>
<tr>
<td>Overturning</td>
<td>2,561</td>
<td>24.06%</td>
<td>Dark - Unlighted</td>
<td>3,709</td>
<td>34.84%</td>
</tr>
<tr>
<td>Other Non Collision</td>
<td>251</td>
<td>2.36%</td>
<td>Unknown Lighting</td>
<td>176</td>
<td>1.65%</td>
</tr>
<tr>
<td>Vehicle Cargo or Debris</td>
<td>0</td>
<td>0.00%</td>
<td>No Adverse Weather</td>
<td>7,835</td>
<td>73.60%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>8</td>
<td>0.08%</td>
<td>Rain</td>
<td>409</td>
<td>3.84%</td>
</tr>
<tr>
<td>Broadside</td>
<td>10</td>
<td>0.09%</td>
<td>Snow or Sleet or Hail</td>
<td>2,074</td>
<td>19.48%</td>
</tr>
<tr>
<td>Head On</td>
<td>387</td>
<td>3.64%</td>
<td>Fog</td>
<td>25</td>
<td>0.23%</td>
</tr>
<tr>
<td>Rear End</td>
<td>312</td>
<td>2.93%</td>
<td>Dust</td>
<td>1</td>
<td>0.01%</td>
</tr>
</tbody>
</table>

*Note: job #: 20150430134300*
Urban 4-Lane Divided Signalized 4-Leg Intersections

INJ+FAT Accidents per Year

40,000 AADT_Minor
36,000 AADT_Minor
32,000 AADT_Minor
28,000 AADT_Minor
24,000 AADT_Minor
20,000 AADT_Minor
16,000 AADT_Minor
12,000 AADT_Minor
8,000 AADT_Minor
4,000 AADT_Minor
Urban 4-Lane Divided Signalized 4-Leg Intersections

Total Accidents per Year

- 0.0
- 5.0
- 10.0
- 15.0
- 20.0
- 25.0
- 30.0
- 35.0
- 40.0

- 10,000
- 20,000
- 30,000
- 40,000
- 50,000
- 60,000
- 70,000

- 4,000 AADT
- 8,000 AADT
- 12,000 AADT
- 16,000 AADT
- 20,000 AADT
- 24,000 AADT
- 28,000 AADT
- 32,000 AADT
- 36,000 AADT
- 40,000 AADT

WESTERN ITE KEYSTONE 2018
Urban 4-Lane Divided Signalized 4-Leg Intersections

Colorado Model

HSM Model

Total Accidents per Year

0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0

- 10,000 20,000 30,000 40,000 50,000 60,000 70,000

4,000 AADT Minor
8,000 AADT Minor
12,000 AADT Minor
16,000 AADT Minor
20,000 AADT Minor
24,000 AADT Minor
28,000 AADT Minor
32,000 AADT Minor
36,000 AADT Minor
40,000 AADT Minor

Predicted Average Crash Frequency

0.0
5.0
10.0
15.0
20.0
25.0
30.0

0 5,000 10,000 15,000 20,000 25,000 30,000 35,000 40,000 45,000 50,000 55,000 60,000 65,000 70,000

AADT_{maj} = 1,000
AADT_{maj} = 3,000
AADT_{maj} = 5,000
AADT_{maj} = 7,000
AADT_{maj} = 15,000
AADT_{maj} = 20,000
AADT_{maj} = 25,000
AADT_{maj} = 30,000

Colorado Model

HSM Model
## Urban 4-Lane Divided Signalized 4-Leg Intersections

**Highway Class:** CO - Urban 4-Lane Divided Signalized 4-Leg Intersections (2002)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th># ACC's</th>
<th>%</th>
<th>CATEGORY</th>
<th># ACC's</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Damage Only (PDO)</td>
<td>35,506</td>
<td>68.78%</td>
<td>Tree</td>
<td>44</td>
<td>0.09%</td>
</tr>
<tr>
<td>Injury (INJ)</td>
<td>19,982</td>
<td>39.96%</td>
<td>Large Boulders or Rocks</td>
<td>5</td>
<td>0.01%</td>
</tr>
<tr>
<td>Fatal (FAT)</td>
<td>138</td>
<td>0.27%</td>
<td>Rocks in Roadway</td>
<td>4</td>
<td>0.01%</td>
</tr>
<tr>
<td>Persons Injured</td>
<td>24,351</td>
<td></td>
<td>Barricade</td>
<td>24</td>
<td>0.05%</td>
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<tr>
<td>Persons Killed</td>
<td>142</td>
<td></td>
<td>Wall or Building</td>
<td>44</td>
<td>0.09%</td>
</tr>
<tr>
<td>Single Vehicle Accidents</td>
<td>3,443</td>
<td>6.67%</td>
<td>Crash Cushion</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Two Vehicle Accidents</td>
<td>41,889</td>
<td>81.16%</td>
<td>Mailbox</td>
<td>7</td>
<td>0.01%</td>
</tr>
<tr>
<td>Three or More Vehicle Accidents</td>
<td>6,120</td>
<td>11.85%</td>
<td>Other Fixed Object</td>
<td>140</td>
<td>0.27%</td>
</tr>
<tr>
<td>Unknown Number of Vehicles</td>
<td>165</td>
<td>0.32%</td>
<td>Involving Other Object</td>
<td>110</td>
<td>0.21%</td>
</tr>
<tr>
<td>On Road</td>
<td>49,405</td>
<td>95.70%</td>
<td>Road Maintenance Equipment</td>
<td>16</td>
<td>0.03%</td>
</tr>
<tr>
<td>Off Road</td>
<td>2,096</td>
<td>4.06%</td>
<td>Unknown Accident Type</td>
<td>124</td>
<td>0.24%</td>
</tr>
<tr>
<td>Off Road Left</td>
<td>770</td>
<td>1.49%</td>
<td>Total Fixed Objects</td>
<td>1,989</td>
<td>3.85%</td>
</tr>
<tr>
<td>Off Road Right</td>
<td>1,294</td>
<td>2.51%</td>
<td>Total Other Objects</td>
<td>130</td>
<td>0.25%</td>
</tr>
<tr>
<td>Off Road at Tee</td>
<td>18</td>
<td>0.03%</td>
<td>Daylight</td>
<td>37,000</td>
<td>71.60%</td>
</tr>
<tr>
<td>Off Road in Median</td>
<td>14</td>
<td>0.03%</td>
<td>Dawn or Dusk</td>
<td>1,743</td>
<td>3.38%</td>
</tr>
<tr>
<td>Unknown Road Location</td>
<td>125</td>
<td>0.24%</td>
<td>Dark - Lighted</td>
<td>11,218</td>
<td>21.73%</td>
</tr>
<tr>
<td>Overturning</td>
<td>205</td>
<td>0.40%</td>
<td>Dark - Unlighted</td>
<td>702</td>
<td>1.36%</td>
</tr>
<tr>
<td>Other Non Collision</td>
<td>218</td>
<td>0.42%</td>
<td>Unknown Lighting</td>
<td>954</td>
<td>1.85%</td>
</tr>
<tr>
<td>Vehicle Cargo or Debris</td>
<td>0</td>
<td>0.00%</td>
<td>No Adverse Weather</td>
<td>45,689</td>
<td>88.50%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>909</td>
<td>1.76%</td>
<td>Rain</td>
<td>2,548</td>
<td>4.94%</td>
</tr>
<tr>
<td>Broadside</td>
<td>7,963</td>
<td>15.42%</td>
<td>Snow or Sleet or Hail</td>
<td>2,093</td>
<td>4.05%</td>
</tr>
<tr>
<td>Head On</td>
<td>289</td>
<td>0.58%</td>
<td>Fog</td>
<td>71</td>
<td>0.14%</td>
</tr>
<tr>
<td>Rear End</td>
<td>23,351</td>
<td>45.23%</td>
<td>Dust</td>
<td>5</td>
<td>0.01%</td>
</tr>
<tr>
<td>Sideswipe (Same Direction)</td>
<td>3,004</td>
<td>7.74%</td>
<td>Wind</td>
<td>185</td>
<td>0.36%</td>
</tr>
<tr>
<td>Sideswipe (Opposite Direction)</td>
<td>311</td>
<td>0.69%</td>
<td>Unknown Weather</td>
<td>1,035</td>
<td>2.00%</td>
</tr>
<tr>
<td>Approach Turn</td>
<td>10,014</td>
<td>19.40%</td>
<td>Dry Road</td>
<td>43,642</td>
<td>84.53%</td>
</tr>
<tr>
<td>Overtaking Turn</td>
<td>553</td>
<td>1.07%</td>
<td>Wet Road</td>
<td>4,454</td>
<td>8.63%</td>
</tr>
</tbody>
</table>
What will Happen if We Do Nothing?

\[ \alpha = 0.124 \]
What will Happen if We Do Nothing?

- Lower Limit (20%)
- INJ + FAT
- Upper Limit (80%)
- Observed (EB)
- 10% Reduction

Accidents/Mile/Year vs. AADT

Loss Levels:
- Loss I
- Loss II
- Loss III
- Loss IV

Mean and 20%, 80% confidence levels.

Western ITE Keystone 2018
Intersection Improvement Project
(SR AADT 30,000)

Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
Example 7

SH030A (Havana @ Mississippi)
CHOOSE SPF FROM LIBRARY
6-LANE URBAN
4-LEGS DIVIDED SIGNALIZED INTERSECTION
BEFORE FREQUENCY SPF
BEFORE
SEVERITY SPF

![Graph showing the relationship between Mainline AADT and Accidents/Year with data points and lines indicating the lower limit (20%), INJ + FAT, and upper limit (80%), along with observed and expected values. The graph illustrates the severity SPF before implementation.](image-url)
DISTRIBUTION OF CRASHES BY TYPE

- Approach Turn: 53 (48.2%)
- Sideswipe (Same): 8 (7.3%)
- Broadside: 14 (12.7%)
- Rear End: 30 (27.3%)
- Overtaking Turn: 2 (1.8%)
- Head On: 1 (0.9%)
- Sideswipe (Opposite): 1 (0.9%)
- Pedestrian: 1 (0.9%)
Crash Types

Approach
Turn
Crash
DIAGNOSTICS

\[ P(X \leq x) = B(x, n, p) = \sum_{i=0}^{x} \frac{n!}{(n-i)!i!} p^i (1-p)^{n-i} \]

\[ P(X \leq 53, n = 110, p = 18\%) \approx 100\% \]

Where:

- \( n \) – Total number of crashes (163)
- \( x \) – Number of observed approach turn crashes (45)
- \( p \) – Expected % approach turn crashes based on statewide statistics (18\%)
- \( P \) – Cumulative probability of observing \( x \), here 53, approach turn crashes or fewer out of 110
SH030A (Havana @ Mississippi)

Scope of Improvements

1. Signal Replacement
2. Re-phasing and Re-timing with Protected Left on All Approaches
3. Minor Widening to Accommodate Longer Storage
4. Repaving
BEFORE-AFTER FREQUENCY SPF

- **BEFORE**: 35.76 accidents/year
- **AFTER**: 20.43 accidents/year

Graph showing the frequency of accidents per year vs. Mainline AADT with confidence intervals and observed vs. expected values.
BEFORE-AFTER SEVERITY SPF

![Graph showing before and after severity SPF]
## RETROACTIVE BENEFIT/COST ANALYSIS

*Colorado Department of Transportation*

**DiExSys™ Roadway Safety Systems**

**Economic Analysis Report**

| Location: 30A | Begin: 5.79 | End: 5.79 | From: 01/01/2002 | To: 12/31/2004 |

### Benefit Cost Ratio Calculations

<table>
<thead>
<tr>
<th>Crashes</th>
<th>Projected Crashes and Reduction Factors</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDO: 66</td>
<td>Weighted PDO: 27.02</td>
<td>Cost of PDO: $10,400</td>
</tr>
<tr>
<td>INJ: 44</td>
<td>Weighted INJ: 24.16</td>
<td>Cost of INJ: $98,300</td>
</tr>
<tr>
<td>FAT: 0</td>
<td>Weighted FAT: 0.00</td>
<td>Cost of FAT: $1,724,300</td>
</tr>
</tbody>
</table>

B/C Weighted Year Factor: 3.00

- Interest Rate: 5%
- AADT Growth Factor: 2.0%
- Service Life: 20
- Capital Recovery Factor: 0.080
- Annual Maintenance/Delay Cost: $0

**Cost:** $1,100,000

From: 01/01/2002

To: 12/31/2004

Days: 1096

**Benefit Cost Ratio:** 17.73 (B/C Based on Injury Numbers: PDO/Injured/Killed)

**Type of Improvement:** SIGNAL REPLACING, PROTECTED LEFT ON ALL APPROACHES, MINOR GEOMETRIC

**Special Notes:**
LOCATIONS

- 48 Safety Projects Analyzed Across Colorado
  - More to be analyzed in 2018

- State Highway and Non-State Highway Locations

- Roadway and Intersection Safety Projects
PROJECT TYPES

• Roadway Projects
  ▪ Barriers
  ▪ ITS
  ▪ Wildlife Protection

• Intersection Projects
  ▪ Signals
  ▪ Roundabouts
  ▪ Geometric Improvements
  ▪ Signal Upgrades
BENEFIT/COST RESULTS
ROADWAY BARRIERS

• Median Barriers – B/C 6.07
  ▪ 7 Projects
  ▪ Highest B/C 20.55
  ▪ Lowest B/C 1.01

• Guard Rail – B/C 9.26
  ▪ 4 Projects
  ▪ Highest B/C 21.54
  ▪ Lowest B/C 0.71
BENEFIT/COST RESULTS
ROADWAY

• ITS – B/C 5.97
  ▪ 2 Projects

• Median Improvements – B/C 4.06
  ▪ Single Project

• Wildlife Protection – B/C 2.74
  ▪ 2 Projects
BENEFIT/COST RESULTS
INTERSECTIONS

- Install Signal – B/C 7.31
  - 8 Projects
  - Highest B/C 23.89
  - Lowest B/C 0.00

- Roundabout – B/C 5.94
  - 3 Projects
  - Highest B/C 15.36
  - Lowest B/C 0.67
BENEFIT/COST RESULTS
INTERSECTIONS

- Geometric Improvements – B/C 5.19
  - 10 Projects
  - Highest B/C 15.77
  - Lowest B/C 0.00

- Signal Upgrades – B/C 5.41
  - 11 Projects
  - Highest B/C 14.93
  - Lowest B/C 0.57
RESULTS
CONCLUSIONS

• 48 Safety Projects studied before and after Construction showed an Average Benefit/Cost Ratio of **6:1**

• When the nature of the safety problem was well understood prior to scoping the projects tended to be successful

• Our Estimates of Anticipated Crash Reduction Tended to be Conservative (We Under-predicted the Benefits) which May Possibly Mean that Reduction in One Crash Type May be Connected with Reduction in Other Crash Types Not Originally Considered

• When HSIP Application Was Primarily Motivated by the Need to Upgrade Hardware the Results Were Less than Desired
CONCLUSIONS

• Successful Project Types / Crash Types:
  - Barrier – Reduction in Off Road Crashes
  - Roundabouts – Reduction in Severe Crashes
  - Install Signal Only When Warranted – Reduction Severe Broadside Crashes
  - Left Turn Phasing – Reduction in Approach Turn Crashes