Infrastructure that Works

Elissa Goughnour and Kim Eccles, VHB

May 17, 2017
Overview of Presentation

- Infrastructure that Works
  - Intersections and Interchanges
  - Roadway Departure
  - Non-motorized Strategies
- Applying CMFs in Virginia
  - VDOT Smart Scale
  - HSM Application
CMFs and Better Decision-Making

- **CMFs – Crash Modification Factors**
  - Estimates of the impact of strategies on crashes
  - CMFs under 1.0 represent a reduction in crashes from applying strategy
  - CMFs over 1.0 represent an increase in crashes
  - Provide method to calculate comparisons between alternatives or projects

“So last week estimating was fine, but this week we need to get the answer exactly?! Make up your mind!”
CMFs: How do we know?

• Before/After Studies
  • Compare safety performance before and after infrastructure change
  • Numerous study designs often with some form of reference group

• Cross-sectional Studies
  • Compares locations “with” to those “without” strategy
  • Locations have to be very similar in all other regards
  • New study design introduce techniques for this “matching”
CMFs: How do we know?
CMF Clearinghouse

- FHWA Resource
- Quantifiable estimates of crash impact of strategies
- Up to date resource
- VA installations contribute to this clearinghouse!

www.cmfclearinghouse.org
Intersection and Interchanges
Virginia Adaptive Signal Control

• **Background**
  • Traffic signal timing plans that change by time of day using data from the recent past.

• **Problem:**
  • Can become outdated
    • Traffic changes over time
    • Seasonal traffic changes (tourism, shopping, special events, etc.)
Virginia Adaptive Signal Control

- **Solution? Adaptive Signal Control**
- **Benefits:**
  - Real-time signal timing changes
  - Reduced congestion
  - Reduced costs
  - Improved safety

Typical steps in adaptive control system technology processing:

1. Detect
2. Optimize
3. Control
4. Respond
Virginia Adaptive Signal Control

- **Study**
  - Virginia Transportation Research Council (VTRC)
  - Evaluated safety and traffic flow impacts
  - 13 roadways
Virginia Adaptive Signal Control

<table>
<thead>
<tr>
<th>Benefits of Adaptive Signal Control Technology From the Pilot Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel times improved</td>
</tr>
<tr>
<td>Speed increase at roadways where travel time improved</td>
</tr>
<tr>
<td>Average decrease in 95th percentile travel times</td>
</tr>
<tr>
<td>Improvement in p.m. peak travel-time reliability</td>
</tr>
<tr>
<td>Average reduction in number of stops</td>
</tr>
<tr>
<td>Reduction in total intersection crashes</td>
</tr>
<tr>
<td>Benefits accrued in one year outweighed cost of installation</td>
</tr>
<tr>
<td>Benefit-Cost ratio (average annual)</td>
</tr>
</tbody>
</table>
Virginia Adaptive Signal Control

- For more information about the study, contact:

  Michael D. Fontaine, Ph.D., P.E.
  Michael.Fontaine@vdot.virginia.gov
Intersection Multi-Strategy Applications

- SCDOT statewide intersection improvement program
  - Initiated in 2009
  - 8,300 intersections screened
  - 2,200+ intersections selected
    - 2% of all State-maintained intersections
    - 50% of intersection crashes and fatalities
- Focused on low-cost improvements
  - Signals, signs, and markings
  - Signalized Intersections (158 intersections)
  - Stop-controlled intersections (918)
Multi-Strategy: Signalized Intersections

Signal improvements

• Replace signal heads (some intersections but not all)
• Replace pedestrian signal heads, pushbuttons, and signs
• Install backplates with retroreflective borders
• Restripe stop bars and crosswalks
• Install overhead signs
  • R10-12
  • R3-5L
  • R3-5R
## Aggregate Results

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>EB</th>
<th>CMF</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.96</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Fatal + Injury</td>
<td>0.89</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Rear-end</td>
<td>0.97</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>0.88</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.97</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>
Disaggregate Results by Area Type

Appear to be more effective at:

**Urban intersections**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td># intersections</td>
<td>58</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>0.95</td>
<td>0.98</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>0.85</td>
<td>1.05</td>
</tr>
<tr>
<td>Rear-End</td>
<td>0.96</td>
<td>1.06</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.97</td>
<td>0.94</td>
</tr>
</tbody>
</table>
### Disaggregate Results by Approaches

**Appear to be more effective at:**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>3-Legged</th>
<th>4-Legged</th>
</tr>
</thead>
<tbody>
<tr>
<td># intersections</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>0.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>0.81</td>
<td>0.91</td>
</tr>
<tr>
<td>Rear-End</td>
<td>0.82</td>
<td>1.00</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>0.90</td>
<td>0.88</td>
</tr>
<tr>
<td>Nighttime</td>
<td>1.04</td>
<td>0.96</td>
</tr>
</tbody>
</table>
## Disaggregate Results by Approaches & Lanes

<table>
<thead>
<tr>
<th>Statistic</th>
<th>3-legged 2x2</th>
<th>3-legged 4x2</th>
<th>4-legged 2x2</th>
<th>4-legged 4x2</th>
</tr>
</thead>
<tbody>
<tr>
<td># ints.</td>
<td>5</td>
<td>9</td>
<td>15</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>0.90</td>
<td><strong>0.85</strong></td>
<td>0.73</td>
<td>1.00</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>0.77</td>
<td>0.82</td>
<td><strong>0.75</strong></td>
<td>0.93</td>
</tr>
<tr>
<td>Rear-End</td>
<td>0.79</td>
<td><strong>0.83</strong></td>
<td>0.90</td>
<td>1.01</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>1.10</td>
<td>0.83</td>
<td><strong>0.51</strong></td>
<td>0.93</td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.81</td>
<td>1.13</td>
<td>0.91</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Multi-Strategy: Stop Controlled

• Sign improvements
  • Double 48” x 48” STOP and YIELD signs
  • Double 36” x 36” intersection warning signs
  • Double 48” x 48” advanced traffic control signs
  • Fluorescent yellow sheeting where appropriate
  • Retroreflective sign posts
  • Advance street names
Multi-Strategy: Stop Controlled

• Marking improvements
  • Stop bars (placed within 4 – 10 ft of edge of through lane)
    • Yield bars for yield conditions
  • Dashed white edgeline through intersection (major road)
  • Marked turn lanes
    • Lane arrows
    • Word “ONLY”
  * As needed, remark:
    • Stop bars
    • Crosswalks
    • Arrows
    • Words
# Multi-Strategy: Stop Controlled Aggregate Results

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>EB</th>
<th>CMF</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.92</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Fatal + Injury</td>
<td>0.90</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Rear-end</td>
<td>0.93</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>0.94</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.85</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>
## Multi-Strategy: Stop Controlled Disaggregate Results by Area Type

### Rural intersections

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td># intersections</td>
<td>188</td>
<td>245</td>
</tr>
<tr>
<td>Total</td>
<td>1.07 (0.03)</td>
<td>0.75 (0.02)</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>1.10 (0.05)</td>
<td>0.73 (0.03)</td>
</tr>
<tr>
<td>Rear-End</td>
<td>1.01 (0.04)</td>
<td>0.81 (0.04)</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>1.03 (0.04)</td>
<td>0.83 (0.04)</td>
</tr>
<tr>
<td>Nighttime</td>
<td>1.01 (0.05)</td>
<td>0.72 (0.04)</td>
</tr>
</tbody>
</table>
Multi-Strategy: Stop Controlled Disaggregate Results by Approaches

**Appear to be more effective at:**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>3-Legged</th>
<th>4-Legged</th>
</tr>
</thead>
<tbody>
<tr>
<td># intersections</td>
<td>242</td>
<td>191</td>
</tr>
<tr>
<td>Total</td>
<td>0.96 (0.02)</td>
<td>0.85 (0.03)</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>0.95 (0.04)</td>
<td>0.84 (0.04)</td>
</tr>
<tr>
<td>Rear-End</td>
<td>0.96 (0.04)</td>
<td>0.86 (0.05)</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>0.98 (0.04)</td>
<td>0.90 (0.04)</td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.90 (0.04)</td>
<td>0.78 (0.05)</td>
</tr>
</tbody>
</table>
Multi-Strategy: Stop Controlled
Disaggregate Results Approaches & Lanes

<table>
<thead>
<tr>
<th>Statistic</th>
<th>3-legged 2x2</th>
<th>3-legged 4x2</th>
<th>4-legged 2x2</th>
<th>4-legged 4x2</th>
</tr>
</thead>
<tbody>
<tr>
<td># ints.</td>
<td>126</td>
<td>116</td>
<td>131</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>0.90</td>
<td>1.00</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Fatal &amp; Injury</td>
<td>0.81</td>
<td>1.08</td>
<td>0.82</td>
<td>0.88</td>
</tr>
<tr>
<td>Rear-End</td>
<td>0.94</td>
<td>0.98</td>
<td>0.88</td>
<td>0.84</td>
</tr>
<tr>
<td>Right-Angle</td>
<td>0.99</td>
<td>0.97</td>
<td>0.89</td>
<td>0.92</td>
</tr>
<tr>
<td>Nighttime</td>
<td>0.83</td>
<td>0.98</td>
<td>0.78</td>
<td>0.78</td>
</tr>
</tbody>
</table>
Interchanges

• **Background**
  • 60,100 miles access-controlled highways
  • About 58% in rural areas – BUT about 1% increase per year in mileage in urban areas.
  • Interchange-related crashes represent 22 percent of all fatal crashes occurring on freeways.
Interchanges

Engineer's

Diamonds Are A Girl's Best Friend

Trinilla
Interchanges

- Diamond: 62%
- Partial Cloverleaf: 16%
- Full Cloverleaf: 8%
- Directional: 6%
- Trumpet: 4%
- SPU: 1%
- Other: 3%
Interchanges

- NCHRP 17-45: Safety Prediction Methodology and Analysis Tool for Freeways and Interchanges
  - Extending acceleration ramp length – 20-50% decrease in crashes
  - Extending deceleration ramp length – benefit up to 700 feet. After 700 feet there is no benefit.
  - Add lanes to entrance/exit ramps (1 to 2 lanes) – 60 to 65% increase in crashes
• Enhanced Interchange Safety Analysis Tool
  • NCHRP 17-45
  • HSM supplemental chapters 18 and 19
• Methodology covers freeway segments, ramps, ramp terminals
Crash Modification Factors Clearinghouse

The Crash Modification Factors Clearinghouse is a web-based database of CMFs along with supporting documentation to help transportation practitioners identify the most appropriate countermeasure for their safety needs. Click here for more information on the Clearinghouse.

Safety Analyst

Safety Analyst is a software tool used by state agencies for highway safety management. It incorporates state-of-the-art safety management approaches into computerized analytical tools for guiding the decision-making process to identify safety improvement needs and develop a systemwide program of site-specific improvement projects. Safety Analyst is applicable to Part B of the HSM. Click here for additional information on Safety Analyst.

Interactive Highway Safety Design Model (IHSDM)

The Interactive Highway Safety Design Model (IHSDM) is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways. The IHSDM performs the predictive method for the facilities in Part C of the first edition of the HSM (i.e., two-lane, two-way rural roads, rural multilane highways, and urban and suburban arterials). Click here for more information on IHSDM.

NCHRP HSM Data Needs Research Digest

This digest presents a summary of the data needed to use Part C of the HSM. This includes rural two-lane highways, rural multilane highways, and urban and suburban arterials. Click here for more information.

Spreadsheets and ISAT for Part C Calculations

There are spreadsheets and the Enhanced Interchange Safety Analysis Tool (ISAT) and Users Manual to help new users understand how to apply the predictive method included in Part C of the HSM. The spreadsheets demonstrate the crash prediction procedure for rural two-lane two-way roads (HSM Chapter 10), rural multilane highways (HSM Chapter 11), and urban and suburban arterials (HSM Chapter 12). The ISAT can be used to evaluate freeway and interchange safety. Click here for a direct link to spreadsheets.
ISATe Evaluation Process

1. Define Project Limits
2. Define Study Period
3. Acquire Traffic Volumes and Crash Data
4. Acquire Geometric and Traffic Control Data
5. Divide Project into Individual Sites (Segmentation)
6. Assign Observed Crashes
7. Initiate Calculations and Review Results
ISATe Potential applications

- As a tool to assess design options:
  - Interchange configuration alternatives
  - Ramp and ramp terminal alternatives
  - Evaluate effect of increasing or decreasing weaving distance
  - Evaluate proposed design exceptions
  - Evaluate impacts of proposed development
Roadway Departure

STRATEGIC APPROACH & PLAN

COUNTERMEASURES

Keep Vehicles on Roadway

Provide for Safe Recovery

Reduce Crash Severity

Includes Hardware Eligibility letters
Roadway Departure

• **Keep vehicles on the roadway**
  • **High friction surface treatments:**
    • 57 (wet road crashes) – 24 (all)% reduction in crashes
  • **Rumble strips and stripes:**
    • Centerline: 9% reduction in all rural crashes
    • Edgeline: 33% reduction in rural run-off-road crashes
  • **Horizontal curve safety:**
    • Chevrons on rural highways: 4-25% reduction
    • Fluorescent yellow sheeting: 18-35% reduction
• **Curve Realignment**
Roadway Departure – Horizontal Curves

- Curves – 33% of fatal, single vehicle crashes
- Most involve striking a fixed object or overturning
- Signing and striping are lower cost but have shorter lives

Source: FHWA
Curve Realignment

- Conducted a before-after empirical Bayes evaluation of horizontal curve realignments
  - California – 36 realigned curves
  - North Carolina – 11 realigned curves
  - Ohio – 15 realigned curves
- Reference curves identified from nearby curves on same route as treated curves
- Small but meaningful sample
Data Sources

- HSIS (Highway Safety Information System)
  - Road characteristics
  - Traffic volume
  - Crash data
- Project files
  - Project specifics
  - Location verification
- Map measurement
  - Before and after curve radius
  - Presence of nearby curves
## CMF Results

<table>
<thead>
<tr>
<th>Metric</th>
<th>Total</th>
<th>Injury and Fatal</th>
<th>Run-Off-Road plus Fixed Object</th>
<th>Dark</th>
<th>Wet-Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB estimate of crashes expected in after period without strategy</td>
<td>91.43</td>
<td>38.11</td>
<td>50.29</td>
<td>21.9</td>
<td>33.88</td>
</tr>
<tr>
<td>Count of crashes observed in after period</td>
<td>29</td>
<td>10</td>
<td>11</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Estimate of CMF</td>
<td>0.315</td>
<td>0.259</td>
<td>0.216</td>
<td>0.584</td>
<td>0.204</td>
</tr>
<tr>
<td>Standard error of estimate of CMF</td>
<td>0.064</td>
<td>0.086</td>
<td>0.068</td>
<td>0.176</td>
<td>0.079</td>
</tr>
</tbody>
</table>
Roadway Departure

• Provide for safe recovery
  • Wider shoulders and shoulder type - generally 5 to 20 percent, more shoulder, more reduction
  • Clear zones – most studies find approximately 25 percent reduction
  • Safety edge
Provide for Safety Recovery: SafetyEdge℠

• FHWA sponsored an evaluation of SafetyEdge℠ treatment
• Included treatment and reference sites in several States
  • Iowa
  • North Carolina
  • Ohio
  • Pennsylvania
  • Florida
*Statistically significant at the 95% confidence level.

NOTE: Drop-off-related CMFs were only able to be developed for IA, NC and OH data.
### SafetyEdge℠

<table>
<thead>
<tr>
<th></th>
<th>Drop-off*</th>
<th>ROR*</th>
<th>Head-on*</th>
<th>F+I*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMF</strong></td>
<td>0.655</td>
<td>0.790</td>
<td>0.813</td>
<td>0.892</td>
<td>0.989</td>
</tr>
<tr>
<td><strong>Std Error</strong></td>
<td>0.064</td>
<td>0.042</td>
<td>0.076</td>
<td>0.034</td>
<td>0.025</td>
</tr>
</tbody>
</table>

*Statistically significant at the 95% confidence level.

NOTE: Drop-off-related CMFs were only able to be developed for IA, NC and OH data.
Roadway Departure

• Reduce crash severity
  • Clear zone
  • Crash cushions
  • Barriers
    • Cable median barrier
Roadway Departure: Cable Median Barriers with Shoulder Rumble Strips
Roadway Departure: Cable Median Barriers with Shoulder Rumble Strips

- Conducted an EB before/after analysis
  - Illinois
  - Kentucky
  - Missouri
- States differed in before conditions
- Over 400 miles of installed strategy, several years of data
## Roadway Departure: Cable Median Barriers with Shoulder Rumble Strips

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>CMF</th>
<th>SE of CMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1.247</td>
<td>0.034</td>
</tr>
<tr>
<td>Injury and fatal (KABC)</td>
<td>0.745</td>
<td>0.040</td>
</tr>
<tr>
<td>Injury and fatal (KAB)</td>
<td>0.783</td>
<td>0.073</td>
</tr>
<tr>
<td>Cross-median</td>
<td>0.119</td>
<td>0.053</td>
</tr>
</tbody>
</table>
Non-motorized Strategies
LOOK AT THAT POOR WOMAN WALKING! HER CAR MUST HAVE BROKEN DOWN. MAYBE WE SHOULD OFFER HER A RIDE.
Uncontrolled pedestrian crossing treatments

- NCHRP Report 841: Development of CMFs for Uncontrolled Pedestrian Crossing Treatments
  - Led by UNC Highway Safety Research Center
  - 14 cities studied including Arlington and Alexandria
  - Four strategies studied
    - Rectangular rapid flashing beacons (RRFBs)
    - Pedestrian hybrid beacons (PHBs)
    - Pedestrian refuge islands
    - Advance YIELD or STOP markings and signs
### Uncontrolled pedestrian crossing treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crash Type</th>
<th>CMF Estimate</th>
<th>Standard Error</th>
<th>Study Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Refuge Island</strong></td>
<td>Pedestrian</td>
<td>0.685</td>
<td>0.183</td>
<td>Median from two studies</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.742</td>
<td>0.071</td>
<td>Cross-section</td>
</tr>
<tr>
<td></td>
<td>All Injury</td>
<td>0.714</td>
<td>0.082</td>
<td>Cross-section</td>
</tr>
<tr>
<td></td>
<td>Rear-End/Sideswipe Total</td>
<td>0.741</td>
<td>0.093</td>
<td>Cross-section</td>
</tr>
<tr>
<td></td>
<td>Rear-End/Sideswipe Injury</td>
<td>0.722</td>
<td>0.106</td>
<td>Cross-section</td>
</tr>
<tr>
<td><strong>Advanced YIELD or STOP Markings and Signs</strong></td>
<td>Pedestrian</td>
<td>0.750</td>
<td>0.230</td>
<td>Median from two studies</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.886</td>
<td>0.065</td>
<td>Before-after</td>
</tr>
<tr>
<td></td>
<td>Rear-End/Sideswipe Total</td>
<td>0.800</td>
<td>0.076</td>
<td>Before-after</td>
</tr>
</tbody>
</table>
### Uncontrolled pedestrian crossing treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crash Type</th>
<th>Recommended CMF</th>
<th>Study Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHB</td>
<td>Pedestrian</td>
<td>0.453</td>
<td>Median from two studies</td>
</tr>
<tr>
<td>PHB + Advanced YIELD or STOP Markings and Signs</td>
<td>Pedestrian</td>
<td>0.432</td>
<td>Median from two studies</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.820</td>
<td>Before-after</td>
</tr>
<tr>
<td></td>
<td>Rear-End/Sideswipe Total</td>
<td>0.876</td>
<td>Before-after</td>
</tr>
<tr>
<td>RRFB</td>
<td>Pedestrian</td>
<td>0.526</td>
<td>Cross-section</td>
</tr>
</tbody>
</table>
Pedestrian Countermeasure Crash Modification Factor Study

• 2002 grants to install pedestrian countermeasures (Las Vegas, San Francisco, and Miami)
  • Increase the visibility and awareness of pedestrian crossings.
  • Evaluations were conducted but were based on behavioral observations (yielding, speed, violations, etc.)
  • These countermeasures served as the basis for this study.
Pedestrian Countermeasure Crash Modification Factor Study

- Research Plans:
  - High visibility crosswalks
  - In-street pedestrian signs
  - No Turn On Red signs
  - Exclusive right turn lane design and control
  - Prohibition of permissive left turns
  - Leading Pedestrian Intervals
Pedestrian Countermeasure Crash Modification Factor Study

- Study locations:
  - Chicago
  - New York
  - Toronto
  - Charlotte
Putting CMFs to Use in Virginia
VDOT Smart Scale
What is SMART SCALE?

Method for picking the best transportation projects and making use of limited tax dollars.

*The responsible agency for each process step is identified in italics in the figure above.*
### SMART SCALE Safety Factors Evaluation

<table>
<thead>
<tr>
<th>Factor Areas</th>
<th>Measure ID</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>S.1</td>
<td>Number of Fatal and Injury Crashes (50%)</td>
</tr>
<tr>
<td></td>
<td>S.2</td>
<td>Rate of Fatal and Injury Crashes (50%)</td>
</tr>
<tr>
<td>Congestion Mitigation</td>
<td>C.1</td>
<td>Person Throughput (50%)</td>
</tr>
<tr>
<td></td>
<td>C.2</td>
<td>Person Hours of Delay (50%)</td>
</tr>
<tr>
<td>Accessibility</td>
<td>A.1</td>
<td>Access to Jobs (60%)</td>
</tr>
<tr>
<td></td>
<td>A.2</td>
<td>Access to Jobs for Disadvantaged Persons (20%)</td>
</tr>
<tr>
<td></td>
<td>A.3</td>
<td>Access to Multimodal Choices (20%)</td>
</tr>
<tr>
<td>Environmental Quality</td>
<td>E.1</td>
<td>Air Quality and Environmental Effect (50%)</td>
</tr>
<tr>
<td></td>
<td>E.2</td>
<td>Impact to Natural and Cultural Resources (50%)</td>
</tr>
<tr>
<td>Economic Development</td>
<td>ED.1</td>
<td>Project Support for Economic Development (60%)</td>
</tr>
<tr>
<td></td>
<td>ED.2</td>
<td>Intermodal Access and Efficiency (20%)</td>
</tr>
<tr>
<td></td>
<td>ED.3</td>
<td>Travel Time Reliability (20%)</td>
</tr>
<tr>
<td>* Land Use</td>
<td>L.1</td>
<td>Transportation-Efficient Land Use (100%)</td>
</tr>
</tbody>
</table>

* For areas over 200,000 in population
Each project extent has several improvement categories -

**Project Extents:**
1. Intersection
2. Interchange
3. Segments
4. Bicycle and Pedestrian
5. Bridges

**1. Intersection: Improvement Features**
- Signal: New
- Roundabout: New
- New Turn Lane
- Add Turn Lane
- Remove minor approach left-turns (use right-turn and downstream u-turn)
- Improve skew angle
Developing Planning Level CMFs

Compile improvement category values from the CMF Clearinghouse

1. Intersection
   ➢ Signal: New

<table>
<thead>
<tr>
<th>Countermeasure: Install a traffic signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMF</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>0.56</td>
</tr>
<tr>
<td>0.23</td>
</tr>
<tr>
<td>0.33</td>
</tr>
</tbody>
</table>
Select appropriate CMFs for SMART SCALE application

For all crash types

Want to use CMFs with higher quality rating

And fatal and injury crashes
Define range of CMFs for various conditions to select applicable planning level value.

1. Intersection
   - Signal: New

<table>
<thead>
<tr>
<th>Project Extent</th>
<th>Improvement Type</th>
<th>MIN</th>
<th>MAX</th>
<th>AVE</th>
<th>MEDIAN</th>
<th>STDEV</th>
<th>Planning Level CMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection</td>
<td>Signal: New</td>
<td>0.33</td>
<td>0.86</td>
<td>0.65</td>
<td>0.67</td>
<td>0.18</td>
<td>0.65</td>
</tr>
</tbody>
</table>
Some improvement categories required review of countermeasures combinations:

- For project types with multiple improvement choices, countermeasures were grouped and combined into broader categories with the CMF chosen from the range.

<table>
<thead>
<tr>
<th>Project Extent</th>
<th>Improvement Type</th>
<th>MIN</th>
<th>MAX</th>
<th>AVE</th>
<th>MEDIAN</th>
<th>STDEV</th>
<th>Planning Level CMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segments</td>
<td>Non-Freeway: Access Control/Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Install median</td>
<td>0.24</td>
<td>1.70</td>
<td>0.71</td>
<td>0.71</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Install directional median</td>
<td>0.76</td>
<td>0.82</td>
<td>0.79</td>
<td>0.80</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Install RCUT</td>
<td>0.38</td>
<td>0.73</td>
<td>0.61</td>
<td>0.67</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close/relocate driveways</td>
<td>0.69</td>
<td>0.75</td>
<td>0.72</td>
<td>0.71</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>
For more information go to http://vasmartscale.org/

To learn more about how the SMART SCALE process was developed, and to see previous process documentation, click here.

2016 SMART SCALE Guidance Documents

- 2016 SMART SCALE Policy Guide (Formerly the HB2 Quick Guide)
- 2016 SMART SCALE Technical Guide (Formerly the HB2 Implementation Policy Guide)
  - 2016 SMART SCALE Technical Guide Errata - Sept. 9, 2016 (Clarifications and Corrections)
- 2016 SMART SCALE Application Guide
  - 2016 SMART SCALE Pre-Application Coordination Form
  - 2016 SMART SCALE Pre-Application Coordination Form Help Guide

July 28th, 2016 CTB Resolution to adopt the 2016 SMART SCALE Policy and Technical Guides.

Training and Applications Resources


2016 WebEx Training – What’s up with SMART SCALE? – 6/20/16
Applying CMFs in the Highway Safety Manual (HSM)
Highway Safety Manual

System Planning
Identify needs and program projects

HSM Application - Part B
- Identify sites most likely to benefit from safety improvement
- Identify targeted crash patterns for the network
- Prioritize expenditures for efficiency

Operations and Maintenance
Modify existing conditions to maintain and improve safe and efficient operation

HSM Application - Part B and C
- Identify crash patterns at existing locations
- Evaluate safety effectiveness of potential countermeasures
- Modify policies and design criteria for future planning and design

Project Planning & Preliminary Engineering
Identify alternatives and choose the preferred solution

HSM Application - Part B
- Identify targeted crash patterns for the project
- Evaluate countermeasures' costs and effectiveness
- Compare change in crash frequency to predict safety effect of alternatives

Design and Construction
Develop design plans and build projects

HSM Application - Part C
- Evaluate how performance measures are impacted by design changes and construction
- Assess potential change in crash frequency during design exception evaluation
Highway Safety Manual

• VDOT Extended HSM Spreadsheets
  • Requires Microsoft Excel
  • Joint effort between VDOT and the Alabama Department of Transportation (ALDOT)
  • HSM supplemental chapters 18 and 19

• Purpose:
  • Simplify the use of the HSM Part C: Predictive Methods Spreadsheets
  • To predict crashes on two-lane rural highways, multilane (presently four-lane) rural highways, and urban and suburban arterials.
How can you contribute?

1. Respond to requests from VDOT Central Office for locations and data.
2. Collect data:
   - Installation locations, dates, and details
   - Crash data
   - Exposure data