Road Safety Audits for Locals: Low Cost Safety Improvements
Mitigate Safety Issues

For each safety issue, the audit team may provide suggestions or possible solutions to reduce collision frequency and/or severity.

Suggestions should be:
- appropriate for stage of audit
- appropriate for all road users
- address the safety issue
- may be short term and/or long term
Roadway Issues

Horizontal Curves
Lane Departure
Roadside Hazards
Intersections
Low-Cost Countermeasures

Crash Reduction Factor (CRF):

Represent the quantitative results from research studies, indicating the percentage reduction in crashes that can be expected after implementation of the treatment

The following slides show low cost countermeasures with CRFs
HORIZONTAL CURVES

CRF 18% Curve Warning Sign Only (All Crashes)

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
HORIZONTAL CURVES

CRF 22% CW Sign w/ Advisory Speed Plaque (All Crashes)

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
HORIZONTAL CURVES

Sharp Curve Warning Sign
CRF 43% (Fixed Object Crashes)
CRF 44% (Head-On Crashes)
CRF 43% (Wet Surface Crashes)

NYSDOT Study of 41 Locations
HORIZONTAL CURVES

CRF  4-25% Chevron Signs

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
## CMF Clearinghouse – Installing Chevrons on a Horizontal Curve

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Roadway Type</th>
<th>Area Type</th>
<th>Reference</th>
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<tr>
<td>0.96</td>
<td>4</td>
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<td>Non-intersection</td>
<td>All</td>
<td>All</td>
<td>Rural</td>
<td>Srinivasan et al., 2009</td>
</tr>
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<td>0.94</td>
<td>6</td>
<td>★★★★★☆☆</td>
<td>Head on, Non-intersection, Run off road, Sideswipe</td>
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<td>Srinivasan et al., 2009</td>
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<td>Srinivasan et al., 2009</td>
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<td>All</td>
<td>All</td>
<td>Rural</td>
<td>Srinivasan et al., 2009</td>
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<tr>
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<td>All</td>
<td>All</td>
<td>Rural</td>
<td>Srinivasan et al., 2009</td>
</tr>
</tbody>
</table>
Provide Lighting at Rural Curves

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”
HORIZONTAL CURVES

Enhanced Curve Warning Sign Designs

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
HORIZONTAL CURVES

Enhanced Curve Warning Sign Designs

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
HORIZONTAL CURVES

Widened/Stabilized Lane or Shoulder on Inside of Curve

NCHRP 500 Volume 7 “Guide for Collisions on Horizontal Curves”
High Friction Surfaces
LANE DEPARTURE

Roadside Delineators
CRF 20% to 30% (All Crashes)
CRF 6% to 15% (Injury/Fatal Crashes)
LANE DEPARTURE

CRF 20% to 49% Edge Rumble Strips on 2-Lane Rural Road

NCHRP 500 Volume 6 “Guide for Addressing Run-Off-Road Collisions”
Centerline Rumble Strips on Two-Lane Rural Roads:
CRF 15% (All Injury/Fatal Crashes)
CRF 25% (Head-On & Sideswipe Injury/Fatal Crashes)

1. “Crash Reduction Following Installation of Centerline Rumble Strips on Rural Two-Lane Roads”, Persaud, et al
LANE DEPARTURE

Edge Rumble Stripes

NCHRP 500 Volume 6 “Guide for Addressing Run-Off-Road Collisions”
LANE DEPARTURE

Edge Rumble Stripes

Night + Rain Conditions

NCHRP 500 Volume 6 “Guide for Addressing Run-Off-Road Collisions”
LANE DEPARTURE

Edge Vertical Drop-Off

NCHRP 500 Volume 6 “Guide for Addressing Run-Off-Road Collisions”
LANE DEPARTURE

The “Safety Edge”

NCHRP 500 Volume 6 “Guide for Addressing Run-Off-Road Collisions”
Common Roadside Hazards

- Trees
- Utility Poles
- Luminaire Poles
- Sign Posts
- Mailboxes
- Ditches
Roadside Hazards Mitigation Hierarchy

Remove
Redesign
Relocate
Reduce (severity)
Shield
Delineate
SLOPES, EMBANKMENTS AND DITCHES

- Vertical Drop-Off
- Utility Pole In Ditch
- Non-TRaversable Foreslope
INTERSECTIONS

Provide Lighting at Rural Intersections:
CRF 25% to 50% (All Crashes)

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”
INTERSECTIONS

Provide Stop Bars: CRF 10% to 25% (All Crashes)

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”
INTERSECTIONS

Stagger Stop Bars for Turning Movements

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”
INTERSECTIONS

Enhanced TCDs: Auxiliary Plaques
INTERSECTIONS

Enhanced TCDs: Auxiliary Plaques
INTERSECTIONS

Enhanced TCDs - Oversized Signs: CRF 15% (All Crashes)

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”
Enhanced TCDs - Doubled-Up Signs: CRF 31% (All Crashes)

Winston, NC Study of Supplementary Signage
INTERSECTIONS

Special Emphasis Treatments - Section 2A.15 of 2009 MUTCD
INTERSECTIONS

Delineation w/ Traffic Pylons for Access Control
Part 3B.04 MUTCD2009
A lane drop marking shall be used
“...An auxiliary lane 1 mile or less in length between two adjacent intersections.”.

Enhanced Use of Pavement Markings
INTERSECTIONS

Widened Shoulders at Rural Intersections: CRF 2.8% per foot (All Crashes)
INTERSECTIONS

Mitigate poor ISD with Intersection Warning Signs
Advance Lane Assignment Signs OVH: CRF 15% (All Crashes)
INTERSECTIONS

Change Permissive LT Phase to Protected-Only LT Phase: CRF 97% (Left-Turning Crashes)
Enhance Traffic Signal Visibility:
Replace Post-mounted w/ Mast Arms:
CRF 25% to 32% (All Crashes)\(^1\)
Increase Head Diameter from 8” to 12”:
CRF 33% to 47% (Angle Crashes)\(^2\)

1. Winston-Salem NC Study
2. ITE RLR Handbook (Iowa, Kansas City MO study locations)
INTERSECTIONS

Enhance Traffic Signal Visibility - One Signal Head per Lane:
CRF 22% (All Crashes)  CRF 47% (Angle Crashes)

ICBC, Winston-Salem NC
INTERSECTIONS

Enhance Traffic Signal Visibility – Supplemental Heads
CRF 15% (AllCrashes)  CRF 47% (AngleCrashes)
INTERSECTIONS

Enhance Traffic Signal Visibility – Add Backplates:
CRF 2% to 24% (All Crashes)  CRF 32% (Angle Crashes)
50% Reduction in incidents of Red Light Running
INTERSECTIONS

Enhance Traffic Signal Visibility – Retroreflectorized Border:

CRF 24% (All Crashes)   CRF 16% (Injury/Fatal Crashes)
INTERSECTIONS

Enhance Traffic Signal Visibility – Retroreflective Border
Countdown Pedestrian Indications

CRF = 25%
One explanation of higher crash rate at marked crosswalks: multiple-threat crash

1st car stops too close, masks visibility for driver in 2nd lane

Solution: advance stop bar (comes later...)
Multiple threat crash solution

Advance stop/yield line

1\textsuperscript{st} car stops further back

1\textsuperscript{st} car no longer masks 2\textsuperscript{nd} car, which can be seen by pedestrian
“Classic Road Diet”
Road diets: reclaim street space for other uses

Not just for bike lanes
Road Diets
and Traffic Operations
3 crash types can be reduced by going from 4 to 3 lanes: which ones?
3 crash types can be reduced by going from 4 to 3 lanes: 1 – rear enders
3 crash types can be reduced by going from 4 to 3 lanes: 2 – side swipes
3 crash types can be reduced going from 4 to 3 lanes: 3 – left turn/broadside
Valencia Street (SF) - before road diet

Total width = 62’ 6”
Valencia Street (SF) - after road diet
Mission District, San Francisco
North-South ADTs

- Dolores
- Guerrero
- Valencia
- Mission
- S. Van Ness

1998 - before bike lanes
2000 - after bike lanes
Valencia Street Bicycle Volumes
PM peak hour counts

- Before bike lanes: 88 bikes/hr
- After bike lanes: 215 bikes/hr
Which road carries the most traffic?

Which road produces the highest speed?
- With a 4-lane road a fast driver can pass others
- With a 2-lane road the slower driver sets the speed

Which road produces the highest crash rate?

Which is better for bicyclists, pedestrians, businesses?

San Antonio TX

Designing for Pedestrian Safety – Road Diets
Road Diet CRF: Iowa DOT study results

25% reduction in total crashes/mile
19% reduction in crash rate

Based on 15 road diet projects with 15 control sites over 23 years
Reclaiming road space creates room for ped islands
Reclaiming road space creates room for ped islands
Reclaiming road space creates room for ped islands
This 5-lane Main Street was converted to...
Name 4 things that changed

- Fewer travel lanes
- Added bike lanes
- Parallel to back-in diagonal parking on one side
- New pavement
Kingston, New York
Traffic Circle ➔ Roundabout
Urban Double- and Multi-Lane Roundabout Examples

Coral Gables, FL

Avon, CO
Rural Single-Lane Roundabout Examples

Lisbon, MD

Leeds, MD
Rural Multi-Lane Roundabout Example
Essential roundabout characteristics

- Slow speed entry = yield
- Slow speed exit
- Truck apron
- Separated sidewalks
  - Direct peds to crosswalks
- Splitter island
- Crosswalk 1 car length back
- Lots of deflection = slow speeds throughout
- Slow speed entry = yield

Bend OR
Pedestrian movements at roundabout

- **Splitter Island**
- **Central Island (Do Not Use)**
- **Concrete Apron**
- **Yield Line**
- **Look To The Left**
- **Look Towards Entry Lane**
- **Stop For Pedestrians**
- **Look Towards Roundabout**

**Instructions:**
- Stop for pedestrians
- Look towards the roundabout
- Look to the left
- Yield line
- Central island (do not use)

**Caution:**
- Use caution at the roundabout.
Constrained entry slows drivers

Huntington NY
1. At entry lane

Well defined crossings & splitter islands
2. At exit lane

Well defined crossings & splitter islands
Truck apron keeps roadway narrower
Multi-lane roundabouts have less deflection, higher speed;
Lack of striping encourages drivers to “slip through”
Recommended striping for 2-lane roundabout

(Diagram from 2009 MUTCD)
Possible Mitigation For 2-lane Roundabout

- Ped signal at selected leg(s)

Signalized Pedestrian Crossing
Roundabouts can be used in residential neighborhoods if well-designed.
People figure out how to use roundabouts on their own
There’s potential on one-way streets too: Is this street operating at capacity?
Supplement textured crosswalks with white lines to increase visibility.
Brick street with asphalt crosswalks
Idea: imbed white crosswalk within contrasting color
Driver perspective: crosswalks show up well
Stage 1: ped stops traffic in one direction
Stage 1: ped crosses to median island
Stage 1 over: Traffic in one direction resumes
Stage 2: ped stops traffic in other direction
Stage 2 over: Traffic resumes
HAWK CROSSING

BY

CITY OF TUCSON
DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING
Road Safety Audits for Locals: Low Cost Safety Improvements

Highlights of Low Cost Safety Improvements

Questions?