What Engineering Can Do for You!

Low Cost Countermeasures for Transportation Safety

Adam Larsen
Safety Engineer
Federal Highway Administration
360-619-7751
Adam.Larsen@DOT.GOV
Adam Larsen
TTP Safety Engineer & Tribal Coordinator
Federal Highway Administration
360-619-7751, Adam.Larsen@DOT.GOV
In several states, Native Americans are two times over represented in motor vehicle fatality rates

Motor vehicle-related death rates per 100,000 population—American Indian/Alaskan Natives aged 1-44 years, United States, 2003-2007.
Safety History

According to the NHTSA Fatality Analysis Reporting System (FARS):

![Bar chart showing Native American Fatalities from 2004 to 2011]

Five year total of 2,752 fatalities reported.
Motor Vehicle Crashes are the leading cause of death for Native Americans and Alaska Natives ages 1 to 44.
Define Safety

- **Road User** – Do I *feel* safe?

- **Engineer** – meets design standards or crash frequency below threshold

- **Legislation** – Crash Experience - No fatal or injury incidents
Engineering Countermeasures

Countermeasure—An action expected to result in a reduction of crashes
1. **Data-Driven Problem ID**

<table>
<thead>
<tr>
<th></th>
<th>Roadway Departure</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="10" alt="Image" /></td>
<td>Night / Low Light Crashes</td>
</tr>
<tr>
<td><img src="5" alt="Image" /></td>
<td>Young Drivers (&lt;20 years old)</td>
</tr>
<tr>
<td><img src="5" alt="Image" /></td>
<td>Speed Management</td>
</tr>
<tr>
<td><img src="5" alt="Image" /></td>
<td>Restraint Usage</td>
</tr>
<tr>
<td><img src="10" alt="Image" /></td>
<td>Impaired Driving</td>
</tr>
<tr>
<td><img src="10" alt="Image" /></td>
<td>Pedestrians and Bicycles (17% of reservation fatal crashes compared to 9% statewide rural)</td>
</tr>
<tr>
<td><img src="10" alt="Image" /></td>
<td>Intersection related crashes</td>
</tr>
</tbody>
</table>

*Image: 10 deaths in 5 years*
1. Data-Driven Problem ID

2. Multi-disciplinary strategies to address problems

* Enforcement
* EMS
* Education
* Engineering
  * Spot Locations
  * Systematic Improvement
Contributing Factors

Human Factors (95%)

Road Environment Factors (28%)

Vehicle Factors (8%)

TYPICAL REPORTED CRASH CAUSES
Before applying countermeasures, answer these questions:

1. What type of crash does it address?
2. Where should it be used?
3. Why will it work?
4. What is the estimated time and cost to deploy?
5. How effective will it be?
Countermeasure Selection Resources

- Manual for Selecting Safety Improvements on High Risk Rural Roads
  - NCHRP 500 Series
  - http://CMFClearingHouse.org/
- http://Safety.FHWA.DOT.GOV
- AASHTO Roadside Design Guide
- Highway Safety Manual
- State Strategic Highway Safety Plans
- IRR Safety Management System Implementation Plan
- Strategic Highway Safety Plan for Indian Country

http://safety.fhwa.dot.gov/hsip/hrrr/manual

- Assists State, local, and Tribal agencies in finding and comparing cost-effective treatments on high risk rural roads
- Developed by conducting a survey and study of State, local, and Tribal agencies’ current practices
HRRR Manual – Features

- Organized in color-coded categories by roadway feature
  - Describes where treatments may be most effectively used
  - Allows a user to quickly narrow potential treatments

<table>
<thead>
<tr>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Curves</td>
</tr>
<tr>
<td>Intersections (Signalized)</td>
</tr>
<tr>
<td>Intersections (Unsignalized)</td>
</tr>
<tr>
<td>Non-Motorized User</td>
</tr>
<tr>
<td>Pavement and Shoulder Resurfacing</td>
</tr>
<tr>
<td>Pavement Marking</td>
</tr>
<tr>
<td>Roadside</td>
</tr>
<tr>
<td>Signing</td>
</tr>
<tr>
<td>Vertical Curves</td>
</tr>
<tr>
<td>Other Treatments</td>
</tr>
</tbody>
</table>
A matrix in each category section helps users narrow the possibilities based on criteria specific to an agency's needs and available resources, such as:

- Initial cost
- Ongoing maintenance cost
- Safety benefit
- Benefit-cost ratio

The manual also contains:

- Safety program management
- Potential funding sources
- Decision-making tools

<table>
<thead>
<tr>
<th>SAFETY TREATMENT</th>
<th>COST</th>
<th>SAFETY BENEFIT</th>
<th>BENEFIT-COST RATIO&lt;sup&gt;19&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install Curve Warning Signs</td>
<td>11</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Install/Upgrade Curve Warning Signs with Fluorescent Yellow Sheeting</td>
<td>12</td>
<td>$</td>
<td>–</td>
</tr>
</tbody>
</table>

**Cost:**
- $ = $0 to $5,000
- $ = $5,001 to $20,000
- $ = $20,001 to $50,000
- $ = $50,001 to $100,000
- $ = $100,001 and up

**NCHRP 500 Performance Rating<sup>20</sup>**
- P – Proven
- T – Tried
- E – Experimental
- U – Unknown

*Lower Volume ≤1000 vpd
**Higher Volume = Between 1,001 and 8000 vpd
***Optimal Conditions = 12-foot lanes, 6-foot paved shoulders
****Narrower Conditions = 10-foot lanes and no shoulders
Proven Countermeasures
Safety.FHWA.DOT.GOV

- Roundabouts
- Corridor Access Management
- Backplates with Retroreflective Borders
- Longitudinal Rumble Strips and Stripes on Two-Lane Roads
- Enhanced Delineation and Friction for Horizontal Curves
- Safety Edges™
- Medians and Pedestrian Crossing Islands in Urban and Suburban Areas
- Pedestrian Hybrid Beacon
- Road Diet
Fatal Crash Types

- Lane Departure: 53%
- Intersections: 20%
- Pedestrians: 12%

% of Total Fatal Crashes
Roadway Departure Engineering Countermeasures

• Keep on Road

• Lessen Severity After Departure
Enhanced Delineation and Friction for Horizontal Curves

Longitudinal Rumble Strips and Stripes on Two-Lane Roads

Safety EdgesSM
Enhanced Delineation and Friction for Horizontal Curves

http://MUTCD.FHWA.DOT.GOV
2009 MUTCD on Curves

- Install Advanced Warning – 30% crash reduction
- Install Chevrons – 4% to 25% crash reduction
- Install post mounted delineators – 15% crash reduction
2009 MUTCD on Curves

- MUTCD.FHWA.DOT.GOV
- 2009 MUTCD Table 2C-5
- Not required for roads with <400 ADT
- Adding Chevrons CRF: 20 – 50
- December 2019 Compliance Date

Table 2C-5. Horizontal Alignment Sign Selection

<table>
<thead>
<tr>
<th>Type of Horizontal Alignment Sign</th>
<th>Difference Between Speed Limit and Advisory Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 mph  10 mph  15 mph  20 mph  25 mph or more</td>
</tr>
<tr>
<td>Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), and Combination Horizontal Alignment/Intersection (W10-1) (see Section 2C.07 to determine which sign to use)</td>
<td>Recommended Required Required Required Required</td>
</tr>
<tr>
<td>Advisory Speed Plaque (W13-1P)</td>
<td>Recommended Required Required Required Required</td>
</tr>
<tr>
<td>Chevrons (W1-8) and/or One Direction Large Arrow (W1-6)</td>
<td>Optional Recommended Required Required Required</td>
</tr>
<tr>
<td>Exit Speed (W13-2) and Ramp Speed (W13-3) on exit ramp</td>
<td>Optional Optional Recommended Required Required</td>
</tr>
</tbody>
</table>

Note: Required means that the sign and/or plaque shall be used, recommended means that the sign and/or plaque should be used, and optional means that the sign and/or plaque may be used.

See Section 2C.06 for roadways with less than 1,000 ADT.
Option for fluorescent colors

- Florescent Yellow Chevrons on high risk curves
- 34% crash reduction

Standard yellow

Fluorescent yellow
Roadway Departure Friction Treatments

Enhanced Delineation and Friction for Horizontal Curves

25-60% Crash Reduction
Roadway Departure Rumble Strips

- Injury crash reduction
  - 18% on rural two-lane highways.
  - 17% on rural multi-lane divided highways.

- Reduction in run-off-road crashes of 38% on freeways.
Roadway Departure
Rumble Strips

Edge Rumble Stripes

Night + Rain Conditions
Roadway Departure Safety Edge
THE PROBLEM
Roadway Departure Safety Edge

- Improves Compaction
- Reduces Maintenance Expense
- Saves Lives (8 – 15% crash reduction)
- Adds Less than 1% to Pavement Resurfacing
“Safety Edge”

FHWA Loaner Shoe
After Departure

Strategy to minimize severity:

1. Remove / Redesign
2. Relocate Hazards
3. Protect / Reduce Severity
4. Delineate Hazards
Clear Zone

10 to 35 feet *minimum* depending on speed and slope.
(See AASHTO Roadside Design Guide)
Remove Hazards

**Fixed Objects**
- Trees / Vegetation
  - (>4” diam.)
- Non-breakaway posts
- Fences, especially with top rail
- Non-crashworthy barrier
- Drainage structures
- Boulders
- Monument Mailboxes

40% reduction in Fatal/Inj crashes
Protect / Shield

• Protect objects

• Grading to lessen severity

• Crashworthy
Dangerous Guardrail Ends

Blunt Ends
Turn Down Terminals
Delineate – Last Resort

- Objects
- Adverse / unexpected alignment
- Non-traversable slopes
Intersection Countermeasures Safety.FHWA.DOT.GOV

- Roundabouts
- Corridor Access Management
- Backplates with Retroreflective Borders
- Road Diet
Keys to Intersection Safety

- Manage conflict points
- Adequate sight distance
- Provide advance warning & navigation
- Increase intersection conspicuity
- Minimize road user delay
Intersection Conflict Points

- Eliminate conflict points
- Separate conflicts in space or time
- Control the type/severity of conflict
Install Traffic Signal

Magic Bullet?

Increase Rear end crashes by 50%

Decrease Angle crashes by 65%
Roundabout Conflict Points

Vehicular conflict points: Roundabout

Conflict Types

- Diverge: 4
- Merge: 4
- Crossing: 0

Total: 8
Intersection Conspicuity

Tree Blocks View of Intersection
Benefits color blind individuals at night

Improved safety during power outages
June 2014
Implement a sign maintenance program

Jan 2015
“regulatory” signs
“warning” signs
ground-mounted “guide” signs
(except street name signs)

Jan 2018
overhead guide signs
street name signs
Access Control

• Consolidate Conflict Points with Access Control.
• Improve safety, operations of road.
Road Diets

- 5-29% crash reduction
- Improved traffic flow
- Traffic Volume: 15k-20k or less
Reclaim street space for other uses

- On-street parking
- Median
- Bike Lanes
- Center Turn-Lane

Road diets
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 by going from 4 to 3 lanes: 3 – left turn/broadside
Reality: Before
Reality: After
Pedestrian Countermeasures

Safety.FHWA.DOT.GOV

Medians and Pedestrian Crossing Islands in Urban and Suburban Areas

Pedestrian Hybrid Beacon

Road Diet
Where do pedestrians get hit most often?
Before

Reclaiming road space creates room for ped islands
Reclaiming road space creates room for ped islands
Pedestrian Conflict Zones

Consolidate, Eliminate, and Separate
Where will pedestrians cross?

Provide Positive Guidance
Ped Activated Beacons

HAWK

Pedestrian Hybrid Beacon
Ped Activated Beacons

RRFB

Pedestrian Hybrid Beacon
Crosswalk Improvements

A curb extension at a mid-block crosswalk

A median island with a raised mid-block crosswalk

Medians and Pedestrian Crossing Islands in Urban and Suburban Areas
Avoid Pedestrian Obstacles
Eliminate Choke points or gaps
Eliminate Choke points or gaps
Pedestrian Facilities

Crash Reduction Factor (CRF):
- 6 ft Paved shoulders reduce pedestrian crashes 70%
- Sidewalks reduce pedestrian crashes 88%
Questions?

Adam Larsen  
TTP Safety Engineer  
(360) 619-7751  
adam.larsen@dot.gov

TTPSF@DOT.GOV
Your Safety Efforts

* Name

* Employer

* Safety Plan Status

* Applied to TTP Safety Fund? Plan to apply this year?

* Other Safety Initiatives by your Government?