Module 4: Roadway Curve and Segment Safety Improvements

Low Cost Safety Improvements

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Learning Outcomes

• Define roadway curve and tangent safety in the U.S.

• Identify/describe some signing and marking safety improvements for curves and tangents

• Interpret and apply signing and marking safety improvement crash reduction factors (CRFs)
Roadway Crash Experience

• In 2015:
  • 59.9% (19,276) of total fatal crashes occurred on the roadway
  • 64.5% (12,436) not at an intersection
  • 45.5% are roadway departure

• Approximately 25% of fatalities on curves
Strategies

- Keep vehicles from encroaching into the opposite lane
- Keep vehicles from encroaching on the roadside
- Minimize the likelihood of crashing into an oncoming vehicle
- Improve the roadway and driving environment to better accommodate an aging population
- Reduce the severity of the crash
In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Signing Treatments

- Dynamic speed feedback sign
- Curve warning sign with/without advisory speed
- Doubling up curve warning signs
- Fluorescent sheeting
- Curve warning sign with flashing beacon
- Post mounted delineators
- Reflective barrier delineation
- Arrow signs at horizontal curves
- Traditional and sequential dynamic dynamic chevrons

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Marking Treatments

- Optical speed bars
- In lane pavement markings
- Edgelines
- Centerlines
- Wider lines
- Wet reflective markings
- Raised pavement markings
- Centerline rumblestrips
Miscellaneous Treatments

- Improve friction/skid resistance
- Lighting
Signing

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Dynamic Speed Feedback Signs

Flash or display message when driver is exceeding pre-set threshold

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install dynamic speed feedback sign**</td>
<td>5%</td>
<td>All</td>
<td>All</td>
<td>Rural Curve</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Use on tangents:

- Mean speed reduced 0.6 - 5.9 mph
- Saw significant decreases in those traveling $\geq 10$ & $15$ mph over speed limit
Curve Warning Signs

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance static curve warning signs***</td>
<td>30%</td>
<td>All</td>
<td>Serious Injury, Minor Injury</td>
<td>Not Specified</td>
<td>★☆☆☆☆☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, www.cmfclearinghouse.org

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
**Curve Warning Sign with Advisory Speed**

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install combination horizontal alignment/</td>
<td>13%</td>
<td>All</td>
<td>Serious Injury, Minor Injury</td>
<td>Not Specified</td>
<td>★★★☆☆☆</td>
</tr>
<tr>
<td>advisory speed signs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Doubling Up Curve Warning Signs

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Fluorescent Sheeting on Signs

Fluorescent Yellow Chevron

Standard Yellow Chevron

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install new fluorescent curve signs or upgrade existing curve signs to fluorescent sheeting***</td>
<td>18%</td>
<td>Head on, Non-intersection, Run off road, sideswipe</td>
<td>All</td>
<td>Rural</td>
<td>★★★★☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [ww.cmfclearinghouse.org](http://ww.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Curve Warning Sign with Flashing Beacons

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install flashing beacons as advance warning***</td>
<td>30%</td>
<td>All</td>
<td>All</td>
<td>Not Specified</td>
<td>Not rated</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Delineation Countermeasures

- Define the roadway operating area
- Define direction and sharpness of curves

- Types of crashes treatments address:
  - Run off road
  - Head on
  - Sideswipe
Post Delineators & Post Mounted Delineators

Mixed results on effectiveness

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Reflective Barrier Delineation

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Install Arrow Signs at Horizontal Curves

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Chevrons

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install chevron signs on horizontal</td>
<td>6%</td>
<td>Head on, Non-intersection, Run off road,</td>
<td>All</td>
<td>Rural</td>
<td>★★★★★☆</td>
</tr>
<tr>
<td>curves***</td>
<td></td>
<td>Sideswipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22%</td>
<td>Nighttime Head on, Non-intersection, Run</td>
<td>All</td>
<td>Rural</td>
<td>★★★★★☆</td>
</tr>
<tr>
<td></td>
<td></td>
<td>off road, Sideswipe</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Sequential Dynamic Chevrons System

- LED lights illuminate as the vehicle passes through curve
- 58% crash reduction in rural areas
Additional Signing Countermeasures

- Oversized signs
- Icy curve warning systems
- Full-post reflective treatment to chevron post
- Sign maintenance
Pavement Markings

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Use of Optical Speed Bars

- Mean, median and 85th percentile speed reductions have been seen (Katz, 2004)
In Lane Pavement Markings

Have been found to reduce speeds by 4 mph at rural curves (Chrysler and Schrock, 2005).

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Install Edgeline Markings

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install edgelines (tangent)***</td>
<td>6.1%</td>
<td>All</td>
<td>All</td>
<td>Rural</td>
<td>★★★☆☆☆</td>
</tr>
<tr>
<td>Install edgelines (curves)***</td>
<td>25.9%</td>
<td>All</td>
<td>All</td>
<td>Rural</td>
<td>★★★☆☆☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Install Centerline Markings

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place centerline markings</td>
<td>1.0%</td>
<td>All</td>
<td>Serious injury, Minor injury</td>
<td>Rural</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Place edgeline and centerline markings</td>
<td>24.0%</td>
<td>All</td>
<td>Fatal, Serious injury, Minor injury</td>
<td>Rural</td>
<td>★★★★★★</td>
</tr>
</tbody>
</table>

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Install Wider Striping

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install wider edgelines (4 in to 6 in)***</td>
<td>36.5%</td>
<td>All</td>
<td>Fatal, Serious Injury, Minor Injury</td>
<td>Rural</td>
<td>★★★★★☆</td>
</tr>
<tr>
<td>Install wider edgelines (4 in to 5 in)***</td>
<td>37.7%</td>
<td>All</td>
<td>Fatal, Serious Injury, Minor Injury</td>
<td>Rural</td>
<td>★★★★☆☆</td>
</tr>
<tr>
<td>Place wide (8 inches) edgeline markings</td>
<td>-5%</td>
<td>All</td>
<td>Serious Injury, Minor Injury</td>
<td>Rural</td>
<td>★★★★☆☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Upgrade to Wet-reflective Pavement Markings

Wet-reflective markings

- May be applied as a paint, tape, or thermoplastic material
- Provide improved level of retroreflectivity during wet road surface conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade existing markings to wet-reflective markings***</td>
<td>31.5%</td>
<td>Wet Road</td>
<td>All</td>
<td>Not specified</td>
<td>★★★★☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Install Raised Pavement Markers

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install raised pavement markers***</td>
<td>19%</td>
<td>Nighttime</td>
<td>All</td>
<td>Rural</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, www.cmfclearinghouse.org

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Additional Marking Countermeasures

- Profiled thermoplastic markings
- Narrow painted median
- Smooth lane narrowing
- Install two-way left turn lane
- High visibility crosswalks

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Miscellaneous

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Improved Friction/ Skid Resistance

- Not necessarily high friction
- May be epoxy-based or chip seals

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve pavement friction (increase skid resistance)***</td>
<td>65.4</td>
<td>Wet road</td>
<td>All</td>
<td>Rural</td>
<td>★★★★★☆</td>
</tr>
<tr>
<td>Improve pavement friction (HFS - High Friction Surface)***</td>
<td>51.9</td>
<td>Wet road</td>
<td>All</td>
<td>All</td>
<td>★★★★★☆</td>
</tr>
</tbody>
</table>

CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
CRFs provided here are just an example of those available at the CMF Clearinghouse, [www.cmfcleaninghouse.org](http://www.cmfcleaninghouse.org)

<table>
<thead>
<tr>
<th>Description</th>
<th>CRF</th>
<th>Crash type</th>
<th>Crash severity</th>
<th>Area Type</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide highway lighting</td>
<td>28%</td>
<td>Nighttime</td>
<td>Serious/Minor Injury</td>
<td>All</td>
<td>★★★★★☆</td>
</tr>
<tr>
<td>Install lighting ***</td>
<td>49%</td>
<td>Nighttime</td>
<td>Fatal</td>
<td>All</td>
<td>★★★★★☆</td>
</tr>
</tbody>
</table>

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Review Learning Outcomes

- Define roadway curve and tangent safety in the U.S.
- Identify/describe some signing and marking safety improvements for curves and tangents
- Interpret and apply signing and marking safety improvement crash reduction factors (CRFs)
Review Question #1

Which of these crash types do delineation countermeasures target?

a) Run off road
b) Sideswipe
c) Head on
d) All of the above
Review Question #2

Name at least one countermeasure that can help improve safety during wet conditions.

- Improving friction/skid resistance
- Raised pavement markings
- Wet reflective pavement markings
Resources #1

- Manual of Uniform Traffic Control Devices (MUTCD)
- FHWA Office of Safety Website
- FHWA, Low Cost Treatments for Horizontal Curve Safety
- FHWA, Roadway Departure Safety - A Manual for Local Road Owners
- Toolbox of Countermeasures and their Potential Effectiveness for Roadway Departure Crashes

This is a draft update, these slides are not final. In the application of CRF/CMFs it is critical to select the one that is relevant to the context of your potential project.
Resources #2

- Toolbox of Countermeasure for Rural Two Lane Curves (CTRE)
- Speed Management Toolbox for Rural Communities (CTRE)
- FHWA, Good Practices: Incorporating Safety into Resurfacing and Restoration Projects
- ATTSA and NACE - Low Cost Local Road Safety Solutions