Horizontal Curves Virtual Peer Exchange

Introduction and Background

This report provides a summary of a peer-to-peer videoconference sponsored by the Federal Highway Administration (FHWA) Office of Safety. The videoconference, which piloted a virtual event format, is part of a series of roadway departure-focused peer exchanges sponsored by the Office of Safety as a follow-up to face-to-face peer exchanges held with roadway departure Focus States in 2008 and 2009.

The Office of Safety selected seven States — Arkansas, Georgia, Kentucky, North Carolina, Pennsylvania, Virginia, and Washington — to participate in this pilot virtual peer exchange. The selected States are among the top ten for percentage of fatal crashes on horizontal curves, and share mountainous topography.

The peer exchange provided opportunities for participants to share:

- Practices for systematic implementation of roadway departure countermeasures on horizontal curves,
- Methods for addressing crash problems on local roads; and
- Challenges encountered in implementing safety programs and countermeasures.

The event also allowed stakeholders to learn from peers who demonstrated innovative approaches to safety on horizontal curves and strategies for funding safety projects and programs. Peer presentations were made by the Kentucky Transportation Cabinet (KYTC), Minnesota Department of Transportation (MnDOT), and the Virginia Department of Transportation (VDOT).

Forty-one participants representing Departments of Transportation (DOTs), Governor Highway Safety offices, Local Transportation Assistance Programs (LTAPs), and FHWA Division Offices attended the virtual peer exchange (see Appendix A for the complete list of event participants and presenters).

The peer exchange discussions and presentations focused on the following topics (see Appendix B for the full agenda):

- Crash reduction on curves, including selecting treatments and projects;
- Strategies and roadblocks to fund local safety projects; and
- Benefits and challenges to systematic implementation and treating local roads.

Facilitated roundtable discussions on each of the topics were a significant

ABOUT THE PEER EXCHANGE

FHWA's RSPCB Peer-to-Peer Program (P2P) supports and sponsors peer exchanges and workshops hosted by agencies.

Date

May 24, 2012

Hosts

FHWA Office of Safety

Key Participants

Arkansas Department of Transportation
FHWA Arkansas Division Office

Georgia Department of Transportation
FHWA Georgia Division Office

Kentucky Transportation Cabinet
FHWA Kentucky Division Office

North Carolina Department of Transportation
FHWA North Carolina Division Office

Pennsylvania Department of Transportation
FHWA Pennsylvania Division Office

Virginia Department of Transportation
FHWA Virginia Division Office

Washington State Department of Transportation
FHWA Washington Division Office

Minnesota Department of Transportation

FHWA Resource Center

U.S. DOT Volpe Center

FHWA's Office of Safety sponsors P2P events.
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component of the event. During the discussion, each State shared its experiences in addressing safety on horizontal curves, including innovative practices, challenges, and use of Intelligent Transportation Systems (ITS) solutions.

Peer Exchange Proceedings

Welcoming Remarks

An FHWA Office of Safety representative welcomed participants to the peer exchange. Attendees then introduced themselves and briefly described their role in roadway safety.

Peer Presentations

Peer presentations covered a wide range of issues, including strategies to address safety on horizontal curves, management of local safety programs, and employment of systematic approaches to target roadway departure crashes. The following section provides an overview.

Crash Reductions with Friction

Tracy Allen Lovell, P.E., Kentucky Transportation Cabinet, Division of Traffic Operations

KYTC's Transportation Engineer described the State's approaches to addressing safety on horizontal curves, particularly its application of high-friction surfaces. As a Focus State for roadway departure crashes, Kentucky developed a roadway departure implementation plan with FHWA's assistance that included high-friction surface countermeasures. Prior to developing the plan, Kentucky had identified its 30 worst interchange ramps for wet-weather crashes. The implementation plan refined Kentucky's focus on two-lane rural roads and included development of a curve inventory.

Kentucky completed the first phase of its high-friction countermeasure project last year. Use of calcined bauxite and a two-part epoxy binder improved safety at 26 sections, some with multiple curves. Installation of these materials at the sites cost approximately $1 million. Kentucky is currently completing the second phase of the high-friction countermeasures project, during which it will investigate 21 curve sections and 7 ramps. Kentucky plans to complete phase three of the project by fall 2012. In general, application of high-friction materials was the only countermeasure deployed in phases one and two, but some sites received updated signage as well. The following results demonstrate the success of the countermeasures project:

- One location near Louisville had experienced an average of four wet-weather crashes per year— crashes declined to 2.8 per year following application of high-friction surface material.
- An Oldham County location experienced approximately 20 wet-weather crashes per year — these dropped to less than two per year after installation of the countermeasure.
- A Fayette County location has not experienced any wet-weather crashes since the installation of high-friction material; previously the section of roadway experienced an average of seven wet-weather crashes per year.

Given these results, Kentucky is satisfied with the high-friction countermeasure project and is exploring other opportunities for deployment.

Lessons learned from Kentucky's experience include:

- Work with maintenance crews to answer questions before the project begins.
- Convince leadership that the project has value and will deliver results. Conducting pilot or trial tests can help provide an early indication of positive results that can be shared with leadership and other stakeholders.
- Provide guidelines to installation crews for determining how far in advance of and beyond a curve to apply the high-friction material, but rely on crews' professional judgment as well.
- Use high-build epoxy or thermo tape to facilitate application of pavement markings on the high-friction material.

Overcoming Traditional Funding Barriers
Julie Whitcher, P.E., PTOE, Minnesota Department of Transportation

MnDOT's Assistant State Traffic Safety Engineer described Minnesota's local safety programs. In recent years, Minnesota has changed the way it funds local projects. Prior to 2004, MnDOT spent all of its Federal safety funding on the State highway system although over half of all fatalities occurred on local roads. Focusing funding on local issues, however, was challenging because fatalities on local roads did not tend to occur in clusters. When MnDOT began to share Federal safety funding with local agencies in 2004, it emphasized making systematic safety improvements to help address these fatalities. MnDOT distributed funding to local agencies based on the number of fatalities and serious injury crashes in each District. Within each District, funding is allocated to the local and State system based on the division of serious crashes.

To help local agencies use their Federal safety funding more effectively, MnDOT is developing a County Road Safety Plan (CRSP) for each of the State's 87 counties and eight Districts. CRSPs include roadway and crash data, ranking criteria, a short list of strategies considered, basic cost estimates, and location photos. The first local CRSP was completed in November 2009 and all of the plans will be completed by January 2013. Previously, local agencies experienced difficulty in identifying projects that fit within the State's Strategic Highway Safety Plan (SHSP) and had a justification for funding. CRSPs are designed so that a county engineer can submit a project to MnDOT directly from the plan with minimal additional documentation, which makes it easier for counties to identify projects and apply for funding.

Roadway Departure Crashes: Using Crash and Alignment Data to Target Resources
Stephen Read, P.E., Highway Safety Improvement Programs Planning

VDOT's Highway Safety Improvement Program (HSIP) manager provided an overview of Virginia's safety programs. While Virginia has an excellent systematic safety improvement process, implementation has been slow. In its last SHSP, Virginia emphasized intersection safety and deployed many spot improvements as part of that effort. Virginia updated its SHSP in winter 2012 and established roadway departure crashes as the highest priority emphasis area.

VDOT has analyzed routes in all counties and prioritized them based on roadway departure risks. The highest priority routes were identified as those that experienced more than five percent of roadway departure fatalities and injuries by county. VDOT also assessed local roads, identifying routes with more than ten severe crashes over a five-year period.

VDOT has targeted routes for road safety audits (RSA) that cut across multiple jurisdictions. VDOT examined data and associated crash reports to identify contributing crash factors and recommend countermeasures. Recurring factors included inappropriate speed given conditions, basic visibility issues, and poor understanding of the roadway alignment.

To address safety issues and facilitate crash analysis more systematically, Virginia anticipates procuring updated roadway alignment data. In 2011, VDOT purchased alignment data for its interstate and primary systems. Annually, the vendor drives 15 percent of the secondary system; by 2013, VDOT will have data available for the entire secondary system if they decide to capture the alignment data. Data provided by the vendor will include points of curvature and associated mile points, as well as curve attributes including radius and deflection. VDOT has explored obtaining super-elevation data but found that the information was only accurate for curves with a 2,000-foot or larger radius.

VDOT wants to use these new data to analyze its routes based on three criteria:

- Number of horizontal curves per mile;
- Number of "impacting" curves per mile (curves with radius of less than 2,000 feet); and
- Radius of 15-percentile for each curve segment (curves with radius less than 2000 feet).

Based on these criteria, VDOT can categorize segments according to curvature (e.g., straight, smooth, small curvature, medium curvature, and high curvature). These new data will also help VDOT assess curves based on heat maps of crashes per mile. VDOT's engineers will use the results of this analysis to design lower-cost treatments.

Roundtable Discussion

A summary of key questions from the roundtable discussions follows below:

Q: What unique or innovative practices or treatments have you recently tried to address safety on horizontal curves?

- Pennsylvania
  Pennsylvania has experimented with curve warning pavement markings that are not included in the *Manual on Uniform Traffic Control Devices* (MUTCD). Pennsylvania has also installed turn arrows along with the word "SLOW" on pavement in advance of curves (see photo below).

  After assessing the trial implementation of these countermeasures, Pennsylvania found that they led to some initial crash reductions. Eventually, Pennsylvania would like to have this countermeasure approved as part of the MUTCD. As part of a low-cost pooled-fund study, Iowa has also pursued the experimental use of painted arrows and text as curve warnings.

- Kentucky
  Kentucky implemented a systematic process for installing and upgrading curve warning signs, which developed from the State's roadway departure implementation plan. The plan identified curves that should be evaluated for signage and pavement markings. KYTC also asked its consultant to evaluate all other curves on routes that appeared in the implementation plan to determine what signs and markings need to be installed based on the 2009 MUTCD.

Q: What challenges or hurdles related to horizontal curve safety have States faced?

- North Carolina
  An older edition of MUTCD was in place when North Carolina started its systematic roadway departure process. The 2009 edition is more prescriptive and requires more engineering to determine advisory speeds for curves. The change in engineering requirements for signing and marking curves will significantly reduce (by up to two-thirds) the number of curves that North Carolina can treat with low-cost solutions.

  North Carolina is testing six-inch pavement markings on two-lane rural roads, following a study in Utah that found significant crash reductions associated with these markings. NCDOT plans to treat up to four 100-mile segments of two-lane rural roads with different treatment combinations to determine whether to revise pavement markings on all two-lane rural roads. The four treatment combinations include:
  - Four-inch lines with standard elements;
  - Four-inch lines with highly reflectorized elements;
  - Six-inch lines standard elements; and

- Six-inch lines with highly-reflective elements.

North Carolina is deciding whether to follow a similar approach as Kentucky in signing and marking curves. North Carolina is concerned about the cost of this treatment and does not want to over-sign or over-delineate curves that do not have a safety issue.

Q: Are any States using Intelligent Transportation Systems (ITS) technology to address curve safety?

- Washington has a pilot project that uses a dynamic message warning system, which detects vehicle speeds as they approach a curve.
- Kentucky has not used speed sensors at curves but has deployed them at intersections. In preliminary evaluations, Kentucky found that speeds actually increased slightly after installation of speed sensors.
- PennDOT deployed an ITS device on a four-lane divided road where there was a crash problem. The device detects vehicle speeds and flashes a warning for vehicles traveling above the advisory speed for the curve. Preliminary data demonstrated a decrease in crashes, but long-term results are not yet available.
- Virginia is about to begin a research effort that explores adding active Light Emitting Diode (LED) lights to chevrons and in-lane delineation.
- North Carolina deployed active speed detection devices and warnings for a few years in several locations. North Carolina has experienced success with "your speed" signs on loop ramps leading onto freeways near Charlotte and Raleigh. These installations have demonstrated success in reducing truck rollover crashes.
- Georgia has one speed warning installation on an interchange ramp near Atlanta. The installation is on a heavily traveled, high-speed exit ramp and is designed to slow as well as guide traffic. Lights are installed just outside the edgeline on both sides of the ramp and illuminate sequentially as a vehicle approaches (as a vehicle triggers the mechanism, lights turn on in 50-foot intervals).

Q: Are any States looking at horizontal curves in combination with other features, such as vertical curvature or intersections?

- Kentucky has some vertical grade information that is used to identify vertical alignments. While this information is not as accurate as horizontal alignment information, it captures locations in greater detail. Kentucky plans to explore its vertical grade information more in the future, especially as photolog data become more available.

Key Areas of Interest and Next Steps

One of the primary purposes of this virtual peer exchange was to connect states with their peers so that they might observe and pursue innovative ways of improving safety on horizontal curves. Opportunities were offered for either formal interaction through FHWA's Roadway Safety P2P Program or informal interaction using contacts made during the peer exchange.

At the conclusion of the roundtable discussion, States discussed key areas of interest based on information that emerged from the peer exchange, as well as topics that they intend to explore in the future:

- Several States expressed interest in learning more about effective outreach mechanisms to reach other stakeholders, particularly county and local agencies; focusing on better coordination of safety programs; and making more comprehensive, systematic improvements.
- Participants from Washington noted that they do not have a horizontal curve program, but rather a safety program that explores hot spots. It might be useful to explore how States define their horizontal curve programs and what factors contribute to States' abilities to identify horizontal curve safety issues.
- Participants from Virginia noted they were interested in pursuing data-driven safety plans at the county level.
- Participants from Pennsylvania were interested in learning more about how to deploy countermeasures on a statewide, proactive basis, rather than reacting to crashes.

- North Carolina is interested in the approach described by Kentucky to address safety on horizontal curves and plans to follow up with them.
- Kentucky hopes to improve their interaction with local agencies.
- Georgia is in the final stages of developing their Roadway Departure Implementation Plan and is also interested in pursuing the use of high-friction surface treatments.
- Arkansas will be applying a systematic approach with a Roadway Departure Implementation Plan. They also have two research projects: one on horizontal curves and one on pavement surface treatments.
- Some States expressed interest in additional guidance on countermeasures such as design parameters for rumble strips. Many States mentioned an interest in exploring or experimenting with new engineering solutions to address horizontal curve safety issues, including wider lane markings, and high-friction surfacing treatments.

Feedback and Suggestions

The virtual peer event was considered a success. Although there were some technical challenges with the videoconference format, the group appreciated the opportunity to view the presentations via video and participate in the question and answer portion of the event. Participants also enjoyed the opportunity to network with peer States and facilitators. Highlights identified by the participants included:

- Examples of data analysis to guide program implementation;
- Positive outcomes of using skid resistant overlay on horizontal curves;
- Horizontal curve tracking and countermeasures;
- Resource availability for horizontal curves on FHWA websites;
- New and innovative devices and treatments for horizontal curves; and
- Crash modification factors for different treatments on curves.

Suggestions on how the event could have been improved included:

- Expand presentation/discussion with more detail about how locations were analyzed, including what crash information was evaluated, what driver behaviors were present, and how geometry affects crashes.
- Address the balance between reactive versus proactive safety spending.
- Share States' experience using the *Highway Safety Manual* (HSM) prediction module that includes horizontal curves.

A participant from WSDOT noted, "The concept of these peer exchanges has a lot of merit. Please keep working with this approach. The first one offered some learning moments, but also sparks the interest in additional efforts in the future."

Appendix A: Event Participants

FHWA	
Nick Artimovich FHWA Office Of Safety Phone Number: 202-366-1331 Email: nick.artimovich@dot.gov	Cathy Satterfield Safety Engineer FHWA Office of Safety Phone Number: 708-283-3552 Email: cathy.satterfield@dot.gov
Tamiko Burnell RSPCB Program Manager FHWA Office of Safety Phone Number: 202-366-1200 Email: tamiko.burnell@dot.gov	Will Longstreet Safety Engineer FHWA Office of Safety Phone Number: 202-366-0087 Email: will.longstreet@dot.gov
Joseph Cheung Civil Engineer FHWA Office Of Safety Phone Number: 202-366-6994 Email: joseph.cheung@dot.gov	
ARKANSAS	
Andrew Brewer Section Head, Traffic Safety AHTD Phone Number: 501-569-2642 Email: andrew.brewer@arkansashighways.com	Tymli Frierson Research Study Engineer AHTD Phone Number: 501-569-2071 Email: Tymli.Frierson@arkansashighways.com
Laura Carter Technology Transfer Program Manager LTAP Center, AHTD Phone Number: 501-569-2380 Email: Laura.carter@arkansashighways.com	Sherman Smith Director Pulaski County Public Works Phone Number: 501-912-2199 Email: Sdsmith@co.pulaski.ar.us
Brent Dather Area Engineer - FHWA AR Division Phone Number: 501-324-6424 Email: Brent.Dather@dot.gov	
GEORGIA	
Randy Clayton Operations Manager Governor's OHS Phone Number: 404-651-8503 Email: rclayton@gohs.ga.gov	Greg Morris Safety, ITS, Traffic Engineer FHWA GA Division Phone Number: 404-562-3619 Email: greg.morris@dot.gov
Norm Cressman Safety Program Manager Georgia DOT Phone Number: 404-635-8131 Email: ncressman@dot.ga.gov	Cody Wilbers Student Trainee, Civil Engineer FHWA GA Division Phone Number: 404-562-3444 Email: cody.wilbers@dot.gov

Frank Julian Safety Engineer FHWA Resource Center Phone Number: 404-562-3689 Email: frank.julian@dot.gov	
KENTUCKY	
Ken Agent Research Engineer University of Kentucky Phone Number: 859-257-4507 Email: kagent@engr.uky.edu	Jarrod Stanley Transportation Engineer KY Transportation Cabinet, Traffic Operations Phone Number: 502-564-9900 Ext. 3895 Email: jarrod.stanley@ky.gov
Tracy Lovell Transportation Engineer KY Transportation Cabinet Phone Number: 502-564-3020 Email: tracy.lovell@ky.gov	Ryan Tenges Safety Engineer FHWA KY Division Phone Number: 502-223-6750 Email: ryan.tenges@dot.gov
Jason Siwula Transportation Engineer Organization: KY Transportation Cabinet Email: Jason.Siwula@ky.gov	
NORTH CAROLINA	
Bradley Hibbs Operations Engineer FHWA-NC Division Phone Number: 919-747-7006 Email: bradley.hibbs@dot.gov	Kevin Lacy State Traffic Engineer NCDOT Phone Number: 919-707-2550 Email: jklacy1@ncdot.gov
Terry Hopkins State Traffic Safety Engineer NCDOT Phone Number: 919-773-2885 Email: thopkins@ncdot.gov	Tony Wyatt Central Regional Field Operations Engineer NCDOT Phone Number: 919-773-2887 Email: awyatt@ncdot.gov
MINNESOTA	
Julie Whitcher Senior Engineer MnDOT Phone Number: 651-234-7019 Email: julie.whitcher@state.mn.us	
PENNSYLVANIA	
Cory Greene Senior Engineer Organization: Pennoni Associates Phone Number: 717-620-5924 Email: cgreene@pennoni.com	Jeff Roecker Highway Safety Liaison PennDOT Phone Number: 717-525-5766 Email: jroecker@pa.gov
VIRGINIA	
Martha Kapitanov Highway Safety Engineer FHWA VA Division Phone Number: 804-775-3342 Email: martha.kapitanov@dot.gov	Tien Simmons VDOT Email: tien.simmons@vdot.virginia.gov

Theron Knouse VDOT Email: theron.knouse@vdot.virginia.gov	Tracy Turpin HSIP Program Manager VDOT Phone Number: 804-786-6610 Email: tracy.turpin@vdot.virginia.gov
Stephen Read VDOT Email: stephen.read@vdot.virginia.gov	
WASHINGTON	
Dick Albin Safety Engineer FHWA, Resource Center Phone Number: 360-753-9889 Email: dick.albin@dot.gov	Akmal Siddiqui Design Liaison Engineer WSDOT Phone Number: 360-705-7590 Email: siddiqa@wsdot.wa.gov
Matthew Enders Technical Services Manager Washington State DOT Phone Number: 360-705-6907 Email: matthew.enders@wsdot.wa.gov	Mark Sujka Safety Research Washington State DOT Phone Number: 360-705-7239 Email: sujkam@wsdot.wa.gov
Rick Mowlds Signing Engineer Washington State DOT Phone Number: 360-705-7988 Email: mowldsr@wsdot.wa.gov	John Tevis Trans. Engineer 4 WSDOT Phone Number: 360-705-7460 Email: TevisJ@WSDOT.WA.Gov
Dave Olson Design Policy, Standards, and Research Manager WSDOT Phone Number: 360-705-7952 Email: olsonda@wsdot.wa.gov	Chris Workman Geometrics Engineer WSDOT Phone Number: 360-705-7272 Email: workmac@wsdot.wa.gov

Appendix B: Agenda

Horizontal Curve Peer Exchange

Final Draft Agenda

Thursday, May 24, 2012

Eastern Time - 11:00am to 3:00 pm
Central Time - 10:00am to 2:00 pm
Pacific Time - 8:00am to 12:00 noon

- Introductions (20 minutes)
- Crash reductions with Friction on Curves (Tracy Lovell, KYTC) (15 minutes)
- Overcoming Traditional Funding Barriers (Julie Whitcher, MnDOT) (15 minutes)
- Discussion (55 minutes)
    - Selecting Treatments
    - Selecting Curve Projects
    - Challenges to Systemic Implementation and Treating Local Roads
- Break/Lunch (30 minutes)
- Wrap up previous discussion (15 minutes)
- Overlaying Crash and Curve Data (Stephen Read, VDOT) (15 minutes)
- Discussion (45 minutes)
    - Efficient means of gathering necessary info for implementation
    - Taking risks – why or why not?
- Take-Away Items (30 minutes)
    - Continuing concerns
    - Next steps
    - Future Peer-to-Peer