



## SCAN TEAM REPORT

NCHRP Project 20-68A, Scan 09-03

# Best Practices In Lane-Departure Avoidance And Traffic Calming

*Supported by the*  
National Cooperative Highway Research Program

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# Executive Summary

## Scan Overview

This domestic scan was developed from proposals of state highway engineers concerned about the unacceptable levels of run-off-road crashes, injuries, and fatalities on the nation's highways. The scan team's mission was to identify transportation agencies with successful solutions to lane departures, to be educated on those solutions, and to disseminate information from these promising programs to other transportation agencies.

The scan tour's scope was further restricted to low-cost measures on high-speed rural roadways. The scan team also chose to focus primarily on engineering solutions through standard engineering practices instead of on education, enforcement or emergency-response strategies.

The team's members were:

- Mark Nelson, North Dakota DOT, AASHTO chair
- John P. Miller, Missouri DOT
- Ina Zisman, Colorado DOT
- Cassandra Isackson, Minnesota DOT
- Daniel Helms, Mississippi DOT
- Richard B. Albin, FHWA
- Dean Focke, subject matter expert

The team chose to focus on the following program categories as topics of interest; specifically, transportation agencies:

- That have advanced highway safety programs
- That employ systematic countermeasures (i.e., proactive measures)
- With proven successes in mitigating lane departures
- That have implemented low-cost programs

The scan travel schedule was as follows:

- Week 1, November 14–20, 2010
  - The team traveled to Detroit for a Monday meeting with Michigan DOT (MDOT), followed by a Tuesday meeting with Pennsylvania DOT (PennDOT), and a Wednesday meeting with South Carolina DOT (SCDOT).

- On Thursday, the scan team traveled to Georgia for a field visit with Georgia DOT (GDOT) personnel in Carroll and Douglas Counties. The Team ended the week at GDOT, and concluded with a strategy session late Friday afternoon.
- Week 2, November 28–December 5, 2010
  - The team met in Minnesota DOT (MnDOT) in Minneapolis on Monday morning, followed by an afternoon field visit to Wright County, Minnesota, hosted by the Wright County engineer. MnDOT finished its presentation to the scan team Tuesday morning. Iowa DOT followed with a presentation of its own at the Minneapolis location.
  - On Wednesday, Colorado DOT (CDOT) hosted the team, including site visits in Clear Creek and Summit Counties. CDOT finished its discussion on Thursday morning. In the afternoon, the Mendocino County, California, engineer made a presentation to the team.
  - The team had an all-day meeting with Washington State DOT (WSDOT) on Friday
  - On Saturday, the team held a final meeting to summarize the scan tour and develop an implementation plan.

## Summary of State and County Discussions

The following highlights are a brief summary of the topics the scan team discussed at each venue. They are listed in the order in which the hosting agency presented them.

### Michigan

- **Cable median barrier** – MDOT has installed 180 miles of high-tension cable and plans to install 100 more miles in freeway medians. Using Highway Safety Improvement Program (HSIP) funding, 75% of the cable projects are standalone projects.
- **Rumble strips** – MDOT has installed 5,400 miles of centerline rumble strips (CLRS) and 2,700 shoulder miles of non-freeway shoulder rumble strips on existing pavements. The strips are used on pavement in all conditions, even chip-seal and crack-sealed pavement.
- **Delineation** – MDOT has a test program in place that is using proprietary products for continuous line delineation on guardrail and barriers.
- **Local safety** – Michigan Local Technical Assistance Program (LTAP)<sup>1</sup>, in cooperation with MDOT, enhanced the RoadSoft Safety Module<sup>2</sup> to assist local agencies in identifying targeted safety locations. The module provides detailed safety analyses and integrates crash data into reporting features and collision diagrams. Through

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<sup>1</sup> National Local Technical Assistance Program/Tribal Technical Assistance Program (LTAP/TTAP), <http://www.ltap.org/>

<sup>2</sup> RoadSoft GIS, <http://www.roadsoft.org/>

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MDOT's Local Safety Initiative<sup>3</sup>, safety engineers provide traffic-engineering services to local agencies, advising them on road safety issues and providing funding application assistance.

- **High-friction pavement** – Five spot locations are using high-friction pavements as part of an FHWA program. MDOT is also evaluating this treatment in various other locations beyond the FHWA program.
- **Road diets** – Michigan is in the initial stages of researching road diets. One of the deliverables, guidance on when to convert a roadway, will be applicable to local agencies. MDOT has converted 44 corridors, having a combined length of 46 miles, as a means of addressing crashes.
- **Traffic signing** – The state has an aggressive 15-year replacement program for signs, using the latest standards, including the Clearview font<sup>4</sup>. For improved emergency response times, the state is installing enhanced reference location signs at one-mile spacing on rural freeways and 0.2-mile spacing on urban freeways. Upon the request of local emergency services, Michigan is considering placing these signs at 0.2-mile spacing on rural freeways.
- **Public outreach** – MDOT developed “Median Man” public service announcements as part of public education on cable median barrier. MDOT developed a first responder flyer and video, which are educational tools on the correct procedure for approaching a crash site involving cable barrier.

## Pennsylvania

- **Administrative** – PennDOT is a decentralized department, having 44,000 miles of state roads and 78,000 miles of local roads. Local roads account for about 20% of the fatalities. A strong centralized safety group makes safety a component of every project. The Multi-Agency Safety Team (MAST) is made up of various stakeholders with a common interest in highway safety.
- **Safety programs** – PennDOT has established a low-cost safety improvement program to drive safety project selection. It uses measurable and accountable performance measures to instill a culture of safety statewide.
- **Lane-departure issues** – As with many of the states visited by the team, bicycling groups in Pennsylvania have concerns about the use of shoulder and edge line rumble strips (ELRS). The state has reached out to the cycling community to gather wider support. Pennsylvania has installed 3652 miles of shoulder/ELRS. Run-off-road fatalities in the state have fallen from an average of 703 annually over the last five years to 665 in 2010. The state has installed 4,405

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<sup>3</sup> MDOT Local Safety Initiative, [http://www.mi.gov/mdot/0,1607,7-151-9615\\_11261\\_45212---,00.html](http://www.mi.gov/mdot/0,1607,7-151-9615_11261_45212---,00.html)

<sup>4</sup> Clearview is a registered trademark of Terminal Design, Inc., <http://www.clearviewhwy.com/>

miles of CLRS. Head-on fatalities have dropped from an average of 180 per year over the last five years to 175 in 2010. CLRS are placed only in no-passing zones.

- **Data management** – The Crash Data Analysis and Retrieval Tool (CDART) is a Web-based query tool and reporting application with the ability to present crash data in several formats, including maps, spreadsheets, reports and data files. The application allows the user to write queries using Crash Reporting System<sup>5</sup> data from 1997 to the current time.
- **Countermeasures** – Pennsylvania is currently deploying a statewide process of systemic improvements, including rumble strips and curve-related improvements. The state is also performing a benefit-to-cost ratio study of cable median guiderail and horizontal curve treatments (advance curve-warning markings). Pennsylvania has an active tree removal/trimming and utility pole relocation program to reduce frequently hit fixed-object crashes.

### South Carolina

- **Administration** – SCDOT is a centralized department with responsibility for 40,000 miles of state highways. Approximately 95% of the fatalities occur on the state system versus 5% on 20,000 miles of local roads.
- **Safety program** – All projects must be prioritized and have a good benefit-to-cost ratio to be considered. SCDOT receives safety funding from the state government, in addition to federal HSIP funding.
- **Strategies** – South Carolina has finished a 10-year program installing cable median barrier on all of the warranted interstate highways (i.e., 400 miles). The state has added approximately 1,000 miles of two-foot-wide paved shoulders over the last five to six years.
- **Data analysis** – About 50% of all fatalities are lane-departure related. To address safety on its high mileage of rural roadways, the state developed the Crash Reduction by Improving Safety on Secondaries (CRISOS) program (now the State Rural Road Safety Program), allowing more resources to be used on lower volume roadways.
- **Countermeasures** – SCDOT uses a profiled edge stripe instead of the milled rumble strip. A two-foot width of paved shoulder widening is now the standard for roadways that previously did not have a paved shoulder. Dashed edge lines traversing through intersections are used as guidance lines for drivers.
- **Enforcement and education** – In a joint effort with Department of Public Safety for both enforcement and education, SCDOT uses radio ads, television ads, and press releases to educate the public about lane-departure issues. The state stringently enforces speeding, seatbelt, and DUI laws.
- **Challenges** – The two primary challenges SCDOT faces are the public's perception of noise

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<sup>5</sup> Crash Reporting System, <http://www.dot.state.pa.us/crash>

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generated by rumble strips and developing trust and a working relationship with bicycling groups.

## Georgia

- **Local agency off-system program** – In Georgia, 45% of fatalities are off-system. Because \$7 million is available for off-system safety improvements, the local agencies need no matching funds. Many counties do not have engineers, so GDOT provides road safety audits and other assistance to them so that they are able to apply for safety funds. As much as 95% of off-system projects are limited to low-cost signing, striping, and installing raised pavement markers.
- **Safety edge** – GDOT led the nation with the development of the safety edge. The safety edge is now policy, with standards and specifications established and used on all projects.
- **Horizontal curves** – GDOT is developing a program to address priority curves with high-friction pavement and/or warning signs and chevrons.
- **Rumble strips** – GDOT takes a systemic approach to rumble-strip installation as part of yearly resurfacing projects by using crash data to determine locations. It also installs CLRS, but avoids using shoulder and CLRS in the same location.
- **Crash data** – In 2005, GDOT took ownership of all crash data and is striving to improve its reliability and timeliness. About 34% of crash data is now entered into the electronic database. In return for modernizing the data collection, a private vendor has rights to sell the data (in the form of crash reports). This is done at no cost to GDOT.

## Minnesota

- **Toward Zero Deaths program** – Toward Zero Deaths is a partnership to create a culture in which traffic fatalities and serious injuries are no longer acceptable. MnDOT is doing this through the integrated application of education, engineering, enforcement, and emergency medical and trauma services. These efforts will be driven by data, best practices, and research. Minnesota has 141,000 miles of roads, with 11,000 miles of state trunk highway and 900 miles of interstate. Half of the severe crashes are on trunk highway, half on local roadway.
- **County roadway safety program** – One-half of all crashes happen on the 45,000 miles of Minnesota's county highways. County roadway safety plans are being completed and used to identify low-cost systemic safety projects to address the most severe types of crashes found on these roadways. MnDOT provides funding to use proven strategies, but will also consider tried and experimental strategies on occasion; both reactive and proactive strategies are used. The agency identifies surrogates to determine high-risk segments, curves, and intersections on rural roads to implement systemic countermeasures.
- **Horizontal curves** – Curves are over-represented on lane-departure crashes. In Minnesota, most curve crashes are on paved roads, with a radius between 500 and 1500 feet, and an average daily traffic (ADT) of between 500 and 1500 vehicles. Minnesota can identify curve radius inexpensively on the Web by using Google Earth<sup>6</sup>. MnDOT has found that the most

effective countermeasure is to install shoulder widening and shoulder rumble strips along with chevron signing.

### Iowa

- **Rural traffic calming** – A recent traffic calming study looked at a handful of sites in small rural communities, each town using a different set of devices (e.g., pavement markings, lane narrowing, optical speed bars, and speed tables). The results were mixed. The researchers found that sometimes the community did not accept the proposed or installed traffic-calming countermeasure.
- **Rumble stripes** – Four- to six-inch rumble stripes are used in locations where there is no paved shoulder or only a very narrow one. Locations where there is an offset between the stripes and the pavement edge yield better results.
- **Pavement edge drop-offs** – A study of over 230 sites in two states found that drop-offs became a problem for drivers at depths of two or more inches.
- **Safety edge** – Iowa specifies the use of a safety edge on highways with less than a four-foot paved shoulder. The DOT has found that contractors choose to use safety edge to mitigate maintenance of traffic control requirements (e.g., end-of-work-day shoulder buildup).
- **Safety plans** – Iowa DOT provides traffic engineering assistance (i.e., traffic-related studies) to small communities and counties.

### Colorado

- **Safety programs** – Colorado has 9,000 centerline miles of state-maintained system; the counties have 47,000 miles (only 12,000 miles are paved). Sixty percent of fatalities occur on the state system. The state's Funding Advancements for Surface Transportation and Economic Recovery (FASTER)<sup>7</sup> legislation uses state funds from licensing fees to fund safety projects.
- **Managing safety** – The Safety Assessment Program is centralized and institutionalized. Safety assessments are available for the entire system and are done on every project at scoping. CDOT has developed a level of service for safety and applies a pattern recognition algorithm to identify effective countermeasures.
- **Countermeasures** – CDOT has installed rumble strips on all rural interstate highways, and the agency has an ongoing cable median barrier program. Dynamic wildlife detection systems are being studied along 100 miles of wildlife corridors. An advance curve-warning system at one location with five curves has provided good results so far, but more data is needed.
- **Education** – CDOT funded a smart phone application that allows users to calculate their blood-alcohol level.

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<sup>6</sup> Google Earth, <http://www.google.com/earth/index.html>

<sup>7</sup> FASTER, <http://www.coloradodot.info/projects/faster>

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## Washington State

- **Target Zero** – The Washington Traffic Safety Commission administers the Target Zero program, for which impaired drivers, speeding, and run-off-road fatalities are the highest priority. Infrastructure improvements are not a solution for the majority of crashes – the other 4 E’s of highways safety (i.e., enforcement, education, and emergency medical services) are more effective.
- **Highway Safety Issues Group** – WSDOT does not have a designated safety engineer. Instead, the Highway Safety Issues Group (HSIG) is a coordinated and proactive roadway safety approach, which includes a team of safety experts, advocates, and executives that meets monthly to discuss safety issues. The group encourages buy-in from all agency regions and programs to allow implementation of safety policy. An executive team provides leadership direction, and the team membership consists of the state risk manager, design engineer, traffic engineer, program manager, highways and local programs director, and the maintenance engineer.
- **Local agency involvement** – The state has mapped all local roads and can provide detailed crash analysis for each of its 39 counties. With this information, Washington has determined that two-thirds of all crashes on the local system are run-off-road and has furthered identified prioritized sections for targeted safety projects.
- **Systemic countermeasures** – WSDOT spent 15 years getting all highway data into electronic format. The agency uses it to show the legislature that WSDOT is doing the right projects in a cost-effective manner. Systemic improvements include updating guardrail to standards and installing cable median barriers, rumble strips, and an inventory of roadside features.

## Wright County, Minnesota

- **Local issues** (typical of local transportation agencies nationwide) – Generally, much of the county road networks do not meet current engineering standards and it would be very costly to upgrade to current standards. Local government executives may make decisions that take into account factors other than highway safety concerns. Limited funds dictate many of the safety solutions available to local transportation agencies. Creative low-cost solutions can provide useful tools for the local highway engineer/supervisor.

## Mendocino County, California

- **Road system traffic reviews** – Data analysis is unrealistic because of low traffic counts and small statistical samples on county roads. These reviews were developed as a low-cost effort to identify and treat collision generators systemically and stretch resources to maximum limits.

## Preliminary Findings

### Lane-Departure Countermeasures

The team focused on these relatively low-cost initiatives taken by transportation agencies to mitigate the causes and effects of lane departures:

- Shoulder rumble strips (SRS)
- Centerline Rumble Strips (CLRS)
- Edge line rumble stripes (ELRS)
- Safety edge and pavement drop-offs (especially high-severity drop-offs)
- Paved shoulder widening
- Edge line pavement markings
- Pavement markings at curves
- Additional signing, especially at horizontal curves
- Dynamic signing (e.g. speed feedback and light-emitting diode [LED] illuminated signs)
- Cable median barriers
- Removal of frequently hit objects (e.g., trees and utility poles)

Successful agencies not only addressed “hot” or “black” spots in identifying crash locations (i.e., reactive), but they also realized that being proactive is an effective use of funding. Proactive countermeasures work well with systemic treatments for proven countermeasures. Some agencies were active in applying promising and innovative countermeasures at problematic spot locations.

### Accurate and Timely Crash Data and Data Analysis

Having appropriate and available crash data was another critical issue agencies face. Departments adept at processing crash data are better able to allocate scarce resources. These agencies had experienced a variety of problems with data, ranging from uncertainty about who “owns” the data, lack of confidence in the accuracy of the crash reports, the inability to input the data electronically (especially geographical coordinates), difficulties with data timeliness and ease of querying, and the inability to generate reports and maps of various formats.

### Performance Reviews

The scan team found another factor that is necessary to attain continuous safety improvements is the use of meaningful and relevant performance measures. Agencies that deliver constant program data seem better able to find and eliminate deficiencies.

### Funding Issues and Resources

Funding of countermeasures was an issue everywhere; however, successful agencies do manage

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to find safety money. Sources include SAFETEA-LU<sup>8</sup>, state set asides, and other methods, such as Section 154<sup>9</sup> or Section 164<sup>10</sup> funding.

### **Institutionalized Culture of Safety**

During its visits, the team noticed that a transportation agency's organizational culture had a direct and positive correlation with the success of various countermeasures for mitigating the effects of lane departures. The most basic of these correlations was the presence of an advocate within the agency who made it a personal mission to improve safety. Usually the advocate was directly involved in safety programs and in a position to effect changes in the agency's status quo.

A second correlation found in successful agencies was institutionalizing safety by taking successful strategies and codifying them into departmental policies (e.g., directives, standard operating procedures, standard plans, and design manuals). Not only does formalizing countermeasures result in wider acceptance, but it also has an added benefit of providing future continuity of the safety program within a department if the advocate retires or otherwise leaves the position.

Finally, top-performing transportation agencies strive to encompass safety in every aspect of the department. From planning and design to funding, construction, and beyond, these departments embrace safety from top-management staff down to hourly workers. The amount of resources that these agencies devote to safety is enormous. These organizations take highway safety from a lower-level program and advance it into a system-wide culture.

### **Partnerships**

This scan looked primarily at engineering solutions; however, the team found that agencies with successful safety programs were more likely to team up with other interested parties in an effort to utilize the 4 E's of highway safety: engineering, enforcement, education, and emergency medical services.

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<sup>8</sup> Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users, <http://www.fhwa.dot.gov/safetealu/>

<sup>9</sup> Section 154 Open Container Transfer Provision, <http://www.statehighwaysafety.org/html/stateinfo/programs/154.html>

<sup>10</sup> Section 164 Repeat Offender Transfer Provision, <http://www.statehighwaysafety.org/html/stateinfo/programs/164.html>