ALTERNATE STRATEGIES FOR SAFETY IMPROVEMENT INVESTMENTS

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Disclaimer

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In Memoriam: Dr. Tom Maze
During the preparation of this White Paper, Tom Maze passed away at far too young an age. He had a large presence and a giant intellect. He was a dedicated teacher, a valued colleague, a dear friend and an accomplished sailor. May the wind always be at his back.
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Chapter 1 Introduction

A Change in Emphasis: Fatal and Serious-Injury Crashes
For many years, the approach to improving highway safety in the U.S. focused on reducing the overall number of crashes, regardless of severity. This was in recognition of the fact that the National safety performance measure was all crashes (fatal + injury + property damage). It appears that the selection of this performance measure was based on the thinking that was prevalent at the time that there were really no differences in the factors contributing to fatal, injury or property damage crashes. This thought process lead to an expectation that if the total number of crashes at a given location was reduced due to some mitigative action, some fraction of fatal crashes would also be reduced. In support of this approach to safety planning, safety programs were focused on identifying and addressing locations with large numbers of crashes and a great deal of effort went towards developing techniques and models to assist analysts more accurately identify those locations where the large number of crashes was also greater than what would be expected. Even though the performance measure was all crashes, there always was a desire to reduce the number of fatal crashes but it seems as if this was expected to occur as a logical consequence of the efforts to reduce all crashes.

After sharp declines in highway deaths in the 1970s, and continued declines through the 1980’s, the downward trend in severe crashes stalled (Figure 1-1). Safety advocates sought a new approach with a change in emphasis: preventing and reducing the number of crashes that result in death or life-changing injuries. The American Association of State Highway Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) provided national leadership on this change in emphasis.

![Figure 1-1: National fatality total and fatality rate trends. 1965–2008.](image-url)
AASHTO’s Strategic Highway Safety Plan, first published in 1997, raised two important issues. First, if the national objective truly is a reduction in the number of highway deaths and serious injuries, then the safety performance measure needs to change. Instead of attempting to reduce fatal crashes as a byproduct of programs meant to address all crashes, the focus of the safety programs should be on severe crashes, because the factors that contribute to them are different than crashes as a whole. Current safety research indicates that most crashes, viewed collectively, involve multiple vehicles and occur at lower speeds in urban areas. Severe crashes, however, more often involve a single vehicle and occur at higher speeds in rural areas.

Second, AASHTO acknowledged that focusing safety investments only on state highways systems has not been the most effective way to address safety. National crash statistics overwhelmingly support a conclusion that in order to improve the effectiveness of safety programs, states need new partners in a more comprehensive approach to safety. State safety programs need to address all road systems and more actively engage local road authorities in the statewide safety planning process – state systems may carry the bulk of the vehicle miles travelled, but local systems account for as much as 90% of total road miles and 60% of fatal crashes. Ignoring the fraction of fatal crashes on the local system would make achieving statewide fatal crash reduction goals that much more difficult in many states.

In 2005, Congress enacted SAFETEA-LU, the current federal transportation bill. This legislation doubled the size of the federal Highway Safety Improvement Program (HSIP) to approximately $1.3 billion per year. FHWA published its guidelines for the states—Strategic Highway Safety Plans: A Champion’s Guide to Saving Lives. This document provides states with guidance for complying with the safety provisions of the legislation. A key requirement of the new law is that each state must prepare a Strategic Highway Safety Plan that documents its process for reducing the number of fatal and serious injury crashes across the entire roadway system, regardless of jurisdiction (management by state or local agency).

FHWA also implemented a policy change to HSIP that revised the objective of the program from reducing highway crashes in general, to specifically emphasizing the prevention of fatal and serious-injury crashes. This change in emphasis—from all crashes to severe crashes—presents a new challenge to the professionals implementing safety programs within the states. Because of the random, widely-distributed nature of severe crashes, it is difficult to identify specific at-risk locations. For example, in Minnesota approximately 33% of fatal crashes (190 per year) involve a single vehicle running off the road, 75% of these (145 per year) are in rural areas and 62% of these (90 per year) are on the local system. However, this system is made up of over 45,000 miles of two-lane highways, which results in a density of 0.002 fatal road departure crashes per mile per year. This statistic begs two questions: are all of these miles equally at-risk and if not, how can the most at-risk locations (for severe) crashes be identified as candidates for safety investment. To address these questions and truly focus on reducing the most severe crashes, new approaches and analytical techniques are required.
Current Methods for Allocating Safety Resources

There are currently two methods available to the states for allocating safety resources. The terminology commonly used to describe these methods is 1) “black spot” analysis and 2) the “systematic” method.

**Black Spot Analysis** has been the most common method used by transportation agencies in the U.S for identifying candidate locations for safety investment. The objective of black spot analysis is to find locations that exhibit unusually high crash frequencies or crash rates. The crash data is then analyzed and problem locations are prioritized and ranked. Infrastructure based countermeasures, such as improving intersection geometry, or traffic control devices are then applied to address safety deficiencies at these specific locations.

The technical analysis normally considers all crashes, because severe crashes are too rare (fatal plus A injury crashes generally account for fewer than 2% of all crashes) random and widely distributed geographically to efficiently identify specific problem locations. However, the use of all crashes as the safety performance measure generally points analysts towards locations with high traffic volumes in urban areas. As a result, common black spot locations are intersections, particularly signalized intersections along multi-lane urban arterial roadways (Figure 1-2).

![Figure 1-2: Black spot analysis identifies specific locations with high crash frequencies or crash rates. Urban intersections, with high traffic volumes and a high number of conflict points, are common black spots.](image)

Black spot analysis is clearly a necessary component of a comprehensive program to improve the safety of the nation’s highways. In urban areas, where traffic volumes and crash frequencies are high, it will likely continue to be the most common method utilized for allocating safety resources. Intuitively, it seems to make sense to target limited safety
funds at locations that have documented safety deficiencies. However, black spot analysis has not proven effective at reducing the fatal and serious-injury crashes that are widely distributed across the roadway system—crashes that are not concentrated enough to identify candidates for improvement by a process that focuses on the total number of crashes.

The Systematic Method is being added by a number of states to their safety planning efforts to better address the very low density of severe crashes in rural areas and to complement the black-spot component of their program. The objective is to identify candidates for a wide deployment of lower-cost safety measures over many miles of roadway segments, corridors, or even over the entire roadway system.

Road-departure crashes are a good example of where the systematic approach is beneficial. Road-departure crashes account for 53% of fatal crashes in the U.S. \(^1\), but are most common on rural, high-speed roadways, normally involve a single vehicle, and are widely distributed geographically. (As was previously mentioned, the density of fatal road departure crashes in Minnesota is 0.002/mile.) Lower-cost countermeasures, such as shoulder rumble strips (Figure 1-3) and improved roadway delineation can be implemented on a more system-wide basis. A number of states have indicated that they expect this approach to be a more effective approach for reducing these types of widely-distributed severe crashes.

Figure 1-3: Partially-paved shoulders with rumble strips were added to this rural two-lane highway. The systematic method focuses on implementing safety measures over longer roadway segments, rather than at spot locations.

Where do Severe Crashes Occur? Rural vs. Urban and State vs. Local

A closer look at where severe crashes occur provides further support for including systematic approaches in highway safety programs. Figure 1-4 illustrates the high percentage of fatalities that occur on rural roads. In 29 states, 50% or more of highway fatalities occur on

\(^1\) 2007 data from the Fatal Analysis Reporting System (FARS).
deaths are occurring on rural highways. In 20 of those states, 70% or more of highway deaths are on rural roads. Nationwide, 56% of highway fatalities occur on rural roads.

Traffic volumes are much lower on rural roads; as a result, crash frequencies at rural locations are usually too low to trigger a black-spot based safety improvement. For example, rural intersections in Minnesota average around 0.5 crashes per year and 0.01 fatal crashes per year. Most black spots are in urban areas or other densely traveled corridors while the majority of fatalities are in rural areas with lower traffic volumes. It is clear that the states expect a systematic approach would be necessary to address the high number of severe crashes that are widely scattered across rural roadways.

As states shift a portion of safety resources to lower-cost, systematic safety improvements on rural highways, another important question is raised. That is, how should resources be shared with local agencies which have jurisdiction over a large percentage of the nation’s rural highway system? Most local agencies do not have any staff trained in safety planning, have historically devoted their entire capital improvement programs to construction and maintenance of their systems and have no experience competing for funds specifically directed at improving highway safety.

*Figure 1-5* documents the estimated distribution of fatalities between highways managed by the State Transportation Agency vs. those managed by county, city, or other local units of government (Note – the FARS data does not specify the roadway jurisdiction. As a result, the state vs. local split was inferred from the route signing field. For example, interstate highways were assigned to the states list and county roads were assigned to the local agency list. A complete description of the assignment process is in Appendix A). Most states have a significant percentage of severe crashes occurring on local highways. In 30 states, 40% or more of highway deaths are occurring on the local system. It is clear that providing local highway agencies with technical and financial resources is an important component of a comprehensive statewide highway safety plan.

*Figure 1-4:* Rural vs. Urban highway fatalities.

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Source: 2007 data from the Fatal Analysis Reporting System (FARS).
**Figure 1-5:** Fatal crashes by jurisdiction (highways managed by the State Transportation Agency vs. highways managed by Local Agencies).

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<tr>
<td>Texas</td>
<td>1,654</td>
<td>48%</td>
</tr>
<tr>
<td>Utah</td>
<td>205</td>
<td>69%</td>
</tr>
<tr>
<td>Vermont</td>
<td>38</td>
<td>58%</td>
</tr>
<tr>
<td>Virginia</td>
<td>630</td>
<td>61%</td>
</tr>
<tr>
<td>Washington</td>
<td>275</td>
<td>48%</td>
</tr>
<tr>
<td>West Virginia</td>
<td>302</td>
<td>70%</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>354</td>
<td>47%</td>
</tr>
<tr>
<td>Wyoming</td>
<td>118</td>
<td>79%</td>
</tr>
<tr>
<td>U.S. Total</td>
<td>23,514</td>
<td>57%</td>
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</table>

Source: 2007 data from the Fatal Analysis Reporting System (FARS).

Description of Study

The focus of this study is to provide answers to key questions by providing a synthesis of current practice of how safety resources are being allocated in the U.S. A survey of practice was distributed to all 50 states to gain a better understanding of the extent to which states are using black-spot and systematic methods. Because the systematic approach is a relatively new concept in the U.S., agencies are in the early stages of applying it. There are questions regarding how much of safety budgets should be devoted to each approach. What balance would achieve the greatest safety improvement with the limited resources that every state faces? A good first step in answering these questions is to look at the current state of practice across the country.

In addition, information was requested related to how safety resources are allocated based on jurisdiction—state highways under the jurisdiction of the State Transportation Agency vs. local highways under the jurisdiction of county, city or other local agencies.

Follow-up case studies were conducted with four of the responding states—Iowa, Minnesota, Missouri, and North Carolina—to gain a more in-depth understanding of how these states are striving to balance the two approaches.

On January 27, 2009, a survey of practice was mailed out to all State Traffic Safety Engineers. A total of 25 states responded (Figure 2-1) and the results are summarized in this section. The full, written responses from each state are included in Appendix B.
Chapter 2 State of the Current Practice

Figure 2-1: Responding states (shaded dark blue).

The survey consisted of the following questions:

1. Approximately how large is your state’s safety improvement budget? We recognize that your agency’s safety improvement may not all come from safety improvement programs but instead safety improvements are incorporated into design guidance or policy. However, only provide the discretionary improvement budget. Please add explanation if necessary.

2. Are there established method(s) that your state uses to determine where safety dollars will be spent? This may include severity or rate ranking methods of high crash locations. It may also include system wide improvements such as edge line or centerline rumble strips for the whole system regardless of whether a crash has occurred. Please add explanation if necessary.

3. How are your state’s districts/regions/etc. involved in choosing safety projects? Is your state’s safety funding administered at a centralized location, or are funds distributed to the districts/regions by formula?

4. What portion of your state’s safety improvement budget is used to fund safety improvements at high crash locations (black spot analysis)?

5. What portion of your state’s safety improvement budget is used to fund system wide improvements (rumble strips, median cable barrier, signing, pavement marking improvements, delineation, etc.) throughout the whole system whether or not a crash has occurred at a specific location (systematic improvements)?

6. Has the level of safety improvement funding in your state allocated through black spot analysis and through systematic improvements changed in recent years? Please explain.

7. Do you share or grant federal safety funds with local (cities and counties) or regional jurisdictions to make roadway safety improvements?
Safety Improvement Budgets

Discretionary safety improvement budgets vary greatly across the United States. Budgets reported from the 25 state respondents are illustrated in Figure 2-2.

- Seven states, which are generally geographically smaller or less populous, have budgets in the $5–15 million range.
- Ten states have budgets ranging from $15–30 million.
- Eight states have budgets ranging from $30–55 million.
- California has, by far, the largest safety budget with an annual reserve of $200 million. The amount of California’s budget actually spent each year varies based on the number of projects that meet qualifying criteria.
- The average budget for the 25 states that responded to the survey is $33.1 million.

![Discretionary Safety Improvement Budget](image)

**Figure 2-2:** Safety improvement budgets of the 25 responding states.

Methods for Determining where Safety Dollars are Spent

Most of the states reported an analytical method based on crash data that also includes a ranking/prioritization component. Ranking based on benefit/cost analysis is a common method. Some interesting trends include:

- Most states reported that money is being allocated for both improvements at spot locations based on crash history as well as more proactive system-wide improvements.
- Increased focus is being given to fatal and serious-injury crashes, which influences how safety funds are allocated.
- Strategic Highway Safety Plans are another influence. For example, Michigan reported that “each submitted project must address serious injuries and fatalities and fit into one of the focus areas of the SHSP”. South Dakota noted that road departure crashes were identified as the leading cause of fatalities in their SHSP and they are focusing investments that target that particular crash type.

**Involvement of Districts/Regions**

Nearly all of the respondents reported that safety programs are administered centrally, but with significant input from districts/regions. In many cases, the districts submit candidate locations or projects for safety funding which are then reviewed, prioritized, and approved by safety staff or committees at the agency’s headquarters. Seven states indicated a distribution of funds to districts by formula.

**Funding at High Crash Locations vs. System-Wide Improvements**

As illustrated in *Figure 2-3*, most states target their safety funds at high crash locations. Some interpretation of the responses was required as some states provided a numerical percentage, while others provided a more explanatory response. For this reason, the states are grouped into the three ranges shown in Figure 6.

Keep in mind that the survey asked about budgets specifically intended for safety improvements. Several states indicated that some system-wide safety improvements are accomplished through other funding sources, such as 3R and regular construction budgets.

**Figure 2-3:** most states focus safety funding on high crash locations.

There is a clear trend towards increasing the proportion of safety funding to system-wide improvements. Fifteen of the 25 respondents indicated that the percentage of money allocated to system-wide improvements either had already increased or would be increasing, based on in-progress policy reviews. Reasons for the shift include:

- Changes in priorities and strategies that resulted from the Strategic Highway Safety Planning process.
• The effectiveness of certain system-wide strategies for reducing severe road departure crashes such as shoulder rumble strips and cable median barrier.
• Increased weighting of fatal and serious-injury crashes which have lowered the priority of some intersection “black-spots”.
• A large number of serious crashes occurring on rural and local roads that are widely and randomly dispersed across the system.

Cost Sharing with Local Agencies
The amount of safety funds shared with local agencies varies greatly and is summarized in Figure 2-4.
• Seven states indicated that no federal funds are shared with local agencies (one has a state-funded program that allows local applications). One reason for this that was cited by two states was that the federal aid process is cumbersome for the relatively small amount of funding that is available.
• Eight states indicated that local jurisdictions can submit candidate projects or locations that compete or are ranked against the candidates from the state highway system. The amount allocated to local agencies varies from year-to-year and no typical or average amounts were indicated.
• Four states indicated specific allocations to local jurisdictions. California and Minnesota have the highest local share with a 50-50 split of federal funds.
• Three states indicated that the entire public road system is analyzed and that safety funds are distributed accordingly. Louisiana stated that approximately 25% of fatal and serious injury crashes occur on local roads and, because of that, 25% of the state’s safety budget is allocated to local roads. South Dakota stated, “our crash search is done on all public roads. The money is used where the problems are located.”
• The High Risk Rural Roads (HRRR) program is a popular means of cost sharing for several states. Three indicated that 100% of these funds are allocated to local agencies. Another indicated an allocation of $3.1 million.

<table>
<thead>
<tr>
<th>lower cost share with locals</th>
<th>moderate cost share or locals allowed to compete</th>
<th>higher cost share with locals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>Colorado</td>
<td>California</td>
</tr>
<tr>
<td>Iowa</td>
<td>Hawaii</td>
<td>Kansas</td>
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<td>Kentucky</td>
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<td>Virginia</td>
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</tbody>
</table>

Figure 2-4: relative levels of cost sharing with local jurisdictions.
Chapter 3 Case Studies

To gain a better understanding of how states are striving to find the proper balance between black spot and systematic methods, four states were contacted for more detailed information. The following case study summaries from Iowa, Minnesota, Missouri and North Carolina illustrate a range of practices for how HSIP and other funds are being allocated to improve highway safety in each of the states. The full case study write-ups for each state are included in Appendix C.

Iowa Case Study

Black Spot vs. Systematic Methods

Iowa reported an approach that combines systematic and black spot methods in terms of allocating HSIP funds. The high priority strategies, which are rural road edges and cable median barrier, were selected through a system-wide analysis. When specific projects are selected and prioritized for implementation of these strategies, crash data is used to identify roadway segments that have historically had the greatest problems.

Rural vs. Urban Funding

Approximately 90% of HSIP funds are spent on rural roads. In addition, Iowa makes significant systematic improvements through the use of non-safety funding. With funding from the 3R program, paved shoulders and shoulder rumble strips are being added to rural state highways with an ADT greater than 3,000 vpd. This work is done in conjunction with resurfacing or other pavement rehabilitation projects.

State vs. Local Funding

HSIP funds are available for projects developed by local agencies for implementation on local systems. However, few local agencies avail themselves of this opportunity due to a dislike for federal reporting requirements and the fact that Iowa has a separate state-funded safety program with less paper work. This program is funded through 0.5% of the State Road Use Tax Fund and 70% of this amount is directed to safety projects developed by local agencies for implementation on local roads. When looking at the overall safety budget, both federal and state-funded, Iowa directs approximately 18% of safety funds towards projects on local roads.

SHSP Considerations

Iowa’s SHSP identifies lane departure, rural expressway (4-lane divided) intersections, and safety corridors as the infrastructure-based emphasis areas. These selections influenced the current focus on systematic improvements on rural roads.

The driver-behavior strategies identified in the SHSP are seat belt enforcement (including nighttime and rural gravel roads) and targeted DUI and speed enforcement (in safety corridors identified in the 5% process).
Organizational Structure, Funding Mechanisms, and Evaluation

In terms of allocating HSIP funds, Iowa has a centralized organization. The Central Office’s Traffic and Safety staff is responsible for both program and project development. The safety program and proposed projects are reviewed with District staff, but final decisions relative to implementation rest with the Central Office.

Iowa DOT prepares a safety program evaluation as required by FHWA. Individual projects are evaluated as part of this evaluation. In addition, the DOT is working with Iowa State University on evaluation several systematic strategies—shoulder paving and enhanced curve delineation and warning.

The distribution of funds is not based on formula. The actual allocation is subjective based on need, the specific strategy selected, and the 5% process. Projects are prioritized by benefit-cost analysis consistent with requirements for reporting project evaluations to FHWA.

Figure 3-1: Guardrail improvements at a local (county) bridge in Iowa.
**HSIP Approach: Strengths, Weaknesses, and Potential Improvements**

The following strengths of the current HSIP approach were identified:

- Multi-disciplinary approach.
- Consideration of driver behavior issues.
- Good return on safety investments, as a result of the data driven effort to map from crash causation to safety emphasis areas to priority strategies to specific projects.
- Good data. Reasonably accurate crash data is available for all roads. This allows strategic safety investments on the local system.

The following weaknesses of the current HSIP approach were identified:

- Concerns about statistical reliability due to the small number of severe crashes. Iowa DOT is using 8 to 10 years of data in an effort to address sample size.
- Lack of a consistent, systematic method for identifying potential sites for safety improvement.
- Underfunding of safety investment on the local system. Between HSIP and state-funded safety programs, about 82% of available funds are spent on the state system, but almost 50% of the fatal crashes occur on the local system.

The following improvements to the current HSIP approach are being considered:

- Working on developing a process for identifying sites with potential for safety investment, continuing to work towards a more systematic deployment of safety strategies.
Minnesota Case Study

Black Spot vs. Systematic Methods
Minnesota reported an approach with HSIP funds that is predominantly black-spot based in the Minneapolis/St. Paul metropolitan area where crash densities are higher and predominantly systematic in the rest of the state, where crash densities are lower. Ninety percent of fatal crashes occur on rural roads, which supports the strong systematic component of Minnesota’s program.

In addition to the $20 million per year in HSIP funds, Minnesota has two other safety programs. The Central Safety Fund (incentive dollars from NHTSA) has previously invested between $5 and $10 million per year in projects including cable median barrier, shoulder rumble strips, and targeted speed enforcement. Several Mn/DOT Districts have also invested between $1 and $5 million per year in non-safety construction funds to add safety features to larger construction projects.

Rural vs. Urban Funding
Forty percent of safety funds go to the Metro District where 90% are spent on urban highways. Sixty percent of safety funds go to the seven Districts that make up the rest of the state. Of these funds, 80–90% are spent on rural roads.

Figure 3-2: Chevrons enhance curve delineation on a rural Minnesota highway.
State vs. Local Funding
Minnesota has one of the strongest programs in the nation, in terms of sharing safety funds with local units of government. Safety funds distributed to each District are split between the state and local systems based on the fraction of Fatal and A-injury crashes. Statewide, between 40 and 50% of the state’s safety funds support projects on the local system.

SHSP Considerations
Minnesota’s SHSP identified road departure crashes in rural Minnesota and intersection related crashes in the metro area as the top priorities. The road departure crashes tend to be widely dispersed across many miles of the rural system and are best addressed with systematic approaches. The intersection crashes in the metro area are concentrated at signalized intersections along urban arterials and are best addressed using a black spot approach.

Driver behavior based emphasis areas include seat belt usage, impaired driving, speeding, and young drivers. The Minnesota DOT is preparing to request permission from FHWA to flex a portion of their safety funds to pay for targeted speed enforcement.

Organizational Structure, Funding Mechanisms, and Evaluation
Mn/DOT is a decentralized organization and all project definition and development is the responsibility of the eight Districts. However, the safety program is more collaborative. The Central Office manages the program and selects projects submitted by the Districts for inclusion in the program. The Districts identify and develop the projects.

Mn/DOT prepares an annual program review, as required by FHWA. Specific projects are evaluated using simple before-after analysis. Mn/DOT is also preparing to conduct system wide analysis of systematic strategies.

The distribution of funds is based on a formula—each District receives funds based on their fraction of fatal and A-injury crashes. Within each District, funds are split again based on the fraction of fatal and A-injury crashes that occur on the state system vs. the local system. Benefit-cost analysis is used to rank black-spot based improvements (primarily in the metro District). B-C analysis is not used for the systematic-based improvements that are predominantly implemented on the rural system.

HSIP Approach: Strengths, Weaknesses, and Potential Improvements
The following strengths of the current HSIP approach were identified:

- Local system participation—dedicating safety funds for projects on the local system of highways. Local highways have almost as many fatal crashes as rural state highways and a 30% higher fatal crash rate.
- Good data and good crash analysis system for state highways. Minnesota DOT has the ability to merge crash data and system design features data sets.
- Good data and good crash analysis system for local highways. MnCMAT, a GIS-based crash analysis tool, has been distributed to all local highway agencies.
- Effective distribution of safety funds.
- The focus of the safety program in Minnesota is on deploying stand-alone projects on a system-wide basis and, when supported by crash data, cost effective spot safety
improvements. All projects selected for safety funding are the result of a data driven analysis.

The following weaknesses of the current HSIP approach were identified:

- Challenges in moving the safety program from 100% black spot to a more balanced approach.
- Lack of buy in by designers in some Districts that adding low-cost safety features (paved shoulders, shoulder rumble strips, etc.) to larger construction projects is worth the additional investment.
- Lack of safety expertise in local agencies has resulted in few “good” projects being submitted in response to the HSIP solicitation.

The following improvements to the current HSIP approach are being considered:

- Mn/DOT is in the process of initiating a safety planning effort in all 87 counties in Minnesota, to address county engineers’ lack of experience conducting system-wide safety analyses and safety project development.
- Mn/DOT is working on developing methods to identify sites with promise to support system-wide deployment efforts. Research is now underway on methods to prioritize rural highway segments, rural horizontal curves, and rural STOP controlled intersections based on crashes, geometric features, and traffic volume.
- Mn/DOT is working on developing a database to support project evaluations.
Missouri Case Study

Black Spot vs. Systematic Methods

Missouri reported that 75% of HSIP funds had historically been directed towards black spots—primarily intersections with a history of severe crashes. However, since 2007, the focus has shifted to a more systematic approach and almost two-thirds of HSIP funding has been directed towards system wide solutions including shoulder improvements and edge line rumble stripes on their major roads. Missouri’s total safety program is a combination of HSIP, HRRR, and other diversion dollars. Historically, HSIP has focused on black spot intersections, HRRR has focused on road departure crashes, and diversion dollars have paid for cable median barrier projects. Recently though, over 75% of the combined safety money has gone to systematic methods.

Missouri has made very strong progress with implementation of systematic improvements on the state roadway system by paying for them with non-safety funds. Specifically, Missouri has been a national leader in the installation of cable median barrier, with approximately 600 miles of barrier installed in the state by the end of 2009. Missouri has also invested heavily in reducing road departure crashes by adding paved shoulders and rumble strips to their system—approximately 5,600 miles on high-priority state routes. These have also been paid for with non-safety funds.

*Missouri has financed significant systematic improvements through the use of non-safety funding. 600 miles of cable median barrier and 5,600 miles of paved shoulders and rumble strips have been constructed with non-safety dollars.*
Rural vs. Urban Funding
The HSIP funding split is approximately 50/50 between urban and rural areas. This is influenced by the two large urban areas in the state—St. Louis and Kansas City. As mentioned previously, significant safety improvements, like cable median barrier and paved shoulders/rumble strips, have been financed with non-safety dollars. When factoring in total safety expenditures, the split shifts to a higher rural proportion.

State vs. Local Funding
HSIP funds are not currently shared with local units of government. Missouri would consider projects on the local system for HSIP funding, but does not expect that they would rank high enough to be funded based on current prioritization methods that are primarily black spot based and require meeting a benefit-cost threshold.

SHSP Considerations
Missouri’s updated SHSP (2008) identifies road departure and intersection crashes as their safety emphasis areas. The identification of road departure crashes in the 2004 SHSP drove the systematic improvements that were made with other funding sources. It is hoped that the success of these efforts will allow Missouri to continue to transition HSIP funding towards a more systematic approach.
In terms of the other E’s (Enforcement, Education, and Emergency Response), the primary driver-behavior strategy identified in the SHSP is targeted enforcement. This effort is funded with non-HSIP dollars. MoDOT has not requested authorization to flex HSIP dollars and currently has no plans to do so, as there are significant needs in engineering/infrastructure improvements.
Organizational Structure, Funding Mechanisms, and Evaluation

In terms of allocating HSIP funds, Missouri has a decentralized organization. The Central Office provides overall program management and sends crash data and a listing of high priority intersections and roadway segments to the Districts. The Districts are responsible for project development and selection. The Central Office has input on each District’s HSIP spending, but final decisions are made at the District level. Each District receives a specified percentage of HSIP funds. Within this amount, there are no caps on HSIP project costs.

There is an annual program evaluation carried out by the MoDOT Traffic Division and Highway Safety Division. In terms of individual projects, each District is required to conduct a before-after study for each HSIP funded project. Missouri uses a formula and a benefit-cost requirement for determining projects that are eligible for HSIP funding. The formula is primarily based on the number of crashes and also considers population and traffic volume. The benefit-cost ratio for a proposed project must be greater than 1.0. Missouri is reviewing this B-C requirement as it relates to potentially funding a greater proportion of systematic improvements through HSIP.

HSIP Approach: Strengths, Weaknesses, and Potential Improvements

The following strengths of the current HSIP approach were identified:

- A Safety Quality Circle has been established, which is developing safety champions in the Districts. The Safety Quality Circle is made up of Central Office and District staff. This group meets monthly to help transition the state’s safety focus to more systematic, proactive approaches.
- MoDOT leadership has been safety focused and willing to devote substantial resources to add safety features to larger projects.
- MoDOT has a very good relationship with FHWA.
- MoDOT has very good crash data, including the ability to analyze local systems.

The following weaknesses of the current HSIP approach were identified:

- Lack of involvement with local governments. About 25% of fatal crashes are on the local system, but no safety funds have been directed to local roads. (Note that a fraction of the state’s gas tax is dedicated to local roads, but this is used for construction and maintenance).
- MoDOT has yet to identify an approach or methodology for finding sites that are at-risk but that have few or no crashes.

The following improvements to the current HSIP approach are being considered:

- MoDOT is revising their safety program guidelines to provide the Central Office more oversight earlier in the project development process.
- MoDOT is working to establish a more direct link between the 2008 SHSP priorities and actual HSIP spending.
MoDOT expects the HSIP to continue to transition toward a more proactive, systematic approach as a result of the new focus on severe crashes and road departure crashes.
North Carolina Case Study

Black Spot vs. Systematic Methods
North Carolina reported an HSIP approach that is predominantly black spot focused—approximately 90% of the program. Several system wide improvements, primarily cable median barrier and shoulder rumble strips, are integrated into the overall effort. North Carolina’s HSIP has evolved over the years and continues to be improved with each update. The Traffic Engineering Accident Analysis System (TEAAS) and the capabilities of North Carolina’s headquarters and division safety professionals have helped guide the development of the current approach. This approach identifies locations meeting or exceeding specific criteria such as those with a high frequency of crashes or exceeding established severity thresholds. The HSIP distributes about $28 million per year for safety improvements along both state and local roads in North Carolina. In addition, there is a state-funded spot safety program that invests another $9.1 million per year.

Figure 3-4: North Carolina’s safety program has a black spot focus, such as improving geometry and adding turn lanes at intersections.

Approximately 90% of North Carolina’s $28 million HSIP budget is focused on black spot improvements. In addition, there is a $9.1 million state safety program that also focuses on high accident locations.
Rural vs. Urban Funding
North Carolina has a fairly even (50/50) distribution of safety funds between urban and rural areas. There are fewer, higher cost projects in urban areas and more, lower cost projects in rural areas.

State vs. Local Funding
Local government projects are eligible for consideration for HSIP funding. Local projects usually involve collaboration with DOT division staff and are not independently submitted. Approximately 95% of HSIP funds go towards safety projects on the state system, which consists of 80,000 miles. There are 20,000 miles under the jurisdiction of local agencies.

There is no single mechanism or methodology when local agencies submit a project for HSIP funding. It is evaluated based on a B-C analysis just like the other candidate projects on the state system. The final determination regarding the selection of a local project for HSIP funding would be case dependent and negotiated.

SHSP Considerations
North Carolina’s SHSP identified road departure, intersections, pedestrians/bicyclists, and bridges as emphasis areas. These emphasis areas have influenced both systematic and black spot efforts. North Carolina has an established black spot (corrective) program that has some flexible components to it. It is mature and successful. Most of the systematic efforts are countermeasure specific such as median barrier, rumble strips on freeways, safety edges, clearance intervals, removal of late night flash for signals, etc.

In terms of driver behavior, the North Carolina Governor’s Highway Safety Program has developed and manages grant based behavioral safety programs including seat belt and child safety seat usage, alcohol programs, and speed enforcement. North Carolina also continues to keep a motorcycle helmet law in place despite strong opposition from user groups.

Organizational Structure, Funding Mechanisms, and Evaluation
North Carolina reported a partnership between their central office and regional offices located throughout the state. The Central Office administers the safety program and provides technical support to the regions in the form of crash data and identification of hazardous locations. The regions are responsible for conducting investigations, recommending countermeasures/treatments, project development, and coordination through the construction phase. The Central Office determines which projects are selected for funding.

NCDOT prepares an annual program review, as required by FHWA. There is also a Safety Evaluation Group that performs system, project, and treatment specific evaluations and system studies. This group conducts a before-after analysis for each project and when enough projects of one type are available, an empirical Bayes analysis is conducted of the group.

Programmed HSIP safety projects are filtered through an equity formula, which is used to distribute the funds to the regions for North Carolina’s TIP. Due to the lower cost of most safety projects, the equity formula is typically not a factor beyond the balancing of division specific projects.
North Carolina’s FHWA approved HSIP project programming process requires benefit-cost analysis of all safety projects. Projects are selected for programming based on the B-C ratios.

**HSIP Approach: Strengths, Weaknesses, and Potential Improvements**

The following strengths of the current HSIP approach were identified:

- The black spot component of the HSIP is refined yearly as additional data, research, and program evaluation feedback is implemented. This component is actively managed to ensure that at-risk sites are identified as well as work process tweaks and field staff feedback mechanisms. This black spot component of the HSIP is also flexible. Each year the black spot program identifies pattern locations that focus on lane departure (including specific lane departure wet and night warrants), intersection locations (with specific warrants to identify patterns of severe, frontal impact, night crashes), bridge locations, and bike/ped crash pattern locations. The program also identifies additional focus areas—topics such as larger trucks, motorcycles, speed, alcohol, and others can be added to core focus areas.

- The systematic component of the HSIP is less formalized. However, as countermeasures are proven to be effective, policies and guidance will be developed that will encourage system wide deployment. Examples include the median barrier program, rumble strips for freeways, removal of late night flash from most signals, and adjustment of clearance intervals for all signals. The median crossover limited movement (J-turns) initiative is very successful and is entrenched in design and operational policies. Safety edge requirements are being pursued now.

The following weaknesses of the current HSIP approach were identified:

- The systematic approach is less formal and not as aggressive as the mature black spot program. The length of time to implement a new system wide initiative can be long due to the large size of North Carolina’s state-maintained highway system (80,000 miles), many stakeholders, and cost considerations. Most system wide initiatives are funded with TIP money and are not limited to HSIP funding. However, this is a time consuming (lengthy) and highly competitive process.

The following improvements to the current HSIP approach are being considered:

- NCDOT acknowledges that continued implementation of black spot improvements at current investment levels probably won’t drive the number of fatal crashes down substantially. As a result, there is an effort underway to investigate ways of transitioning and adopting NCDOT’s HSIP toward a more systematic deployment of strategies.

- Begin deployment of new programs to direct safety funds for low cost rural intersection improvements, to improve bicycle and pedestrian modules, and to further refine specialized query capabilities to support safety investigations.
Chapter 4 Lessons Learned

The states that provided information through the survey of practice and the subsequent interviews made it clear that their highway safety programs are evolving and the primary agent of change is the passage of SAFETEA-LU and the adoption of severe crashes as the new national safety performance measure. SAFETEA-LU required the preparation of Strategic Highway Safety Plans (SHSP) and all of the states had complied by the October, 2007 deadline. The states indicated that the SHSP data driven development process has helped focus their programs through the identification of their individual Safety Emphasis Areas, which has influenced the type of projects selected for Highway Safety Improvement Program (HSIP) funding. However, the participating states acknowledged that the adoption of severe crashes as the safety performance measure has had the most profound effect on their safety program.

Finding a Balance—Black Spot vs. Systematic Methods

The participating states indicated that prior to SAFETEA-LU their safety programs had been almost exclusively focused on finding and then addressing black spots—locations with large numbers of crashes—on the their system of highways. However, this process tended to direct safety investments towards signalized intersections along high volume, urban, multi-lane arterials. This historic type of safety investment was based on the notion that if the process found locations with high frequencies of crashes and were able to mitigate some of them, some fatal crashes would be eliminated along with the injury and property damage crashes. The problem with this approach that became apparent over time is that fatal crashes were not going down, primarily because severe crashes are under represented in urban areas in general and particularly at signalized intersections along high volume arterials on the state’s highway system. In support of this Minnesota offered the following example:

- Mn/DOT has annually published a Top 200 list of high crash cost intersections along their 12,000 mile state highway system. These intersections are overwhelmingly signalized (70%) and in urban areas (69%).
- Mn/DOT made it a practice to direct some of their HSIP funds every year towards the highest priority intersections on this list. However, they determined that this approach did not reduce the number of fatal crashes. The Top 200 intersections accounted for fewer than 10% of fatal crashes and the annual number of fatal intersection related crashes remained at approximately 200 per year over the eight year period between 1998 and 2005.

The national statistics are very clear: well over one-half of fatal crashes are in rural areas and approximately one-half of these are on the local system—locations with little or no history of safety investments because for all practical purposes there are no black spots. The states recognize that the historic approach of reacting to black spots cannot be entirely effective given the new safety performance measure because most severe crashes are randomly distributed across thousands of miles of rural roads and at tens of thousands of rural intersections, where there is no history of previous severe crashes. As a result, the
participating states reported that they are attempting to transition their HSIP from a focus primarily on reacting to black spots in urban areas to a program that includes:

- a rural/urban split that reflects their distribution of severe crashes, and
- a yet to be defined balance between reactively investing at a few black spot locations plus adding a proactive approach that widely deploys low cost improvements across their rural system of highways.

However, most of the participating states reported that their HSIP still had a black spot focus. Iowa and North Carolina indicated that 50% and 90%, respectively, of their safety funding was directed towards locations with high frequencies of crashes. These states suggested that the reason for this continued focus on black spots was due to the fact that the supporting analytical process was more mature and better understood by their technical staff. The states also indicated that they expected to transition to a more proactive approach as new analytical tools and techniques become available and the number of black spots is reduced.

One of the participating states (Minnesota) has adopted a unique approach in an attempt to find a balance between a reactive and proactive focus for their HSIP. They have adopted twin goals; directing 70% of the safety funding to reactively addressing black spots in the Metropolitan District (where 70% of their Top 200 intersections are located) and 70% of the safety funding towards the proactive deployment of low cost strategies in their rural Districts with their large system of rural highways and where only a few safety investments have been previously implemented (due to the lack of identified black spots). Minnesota provided the following data in support of their twin goals:

- In Minnesota, 70% of all crashes are in urban areas but 70% of fatal crashes are in rural areas.
- Rural crashes are more severe than urban crashes—the fatality rate on rural roadways in Minnesota is more than 2.5 times the rate in urban areas.
- Fatal crashes in Minnesota are different than less severe crashes. The most common type of crash is a rear end (28%)—but the most common types of fatal crashes are run off road (34%), right angle (23%) and head-on (17%). Rear end crashes account for only 4% of fatal crashes.

**Addressing ALL Roads**

The participating states also indicated that the provision of SAFETEA-LU that requires the statewide safety program and the underlying crash data system to address ALL public roads has caused them to re-evaluate their program and in some cases to fundamentally alter their approach to involving local road authorities. Virtually all of these states indicated that historically, their safety program was open to participation by local authorities and some even noted that their data systems were capable of identifying crash locations on the local systems. However, the most common response from the states was that they had never allocated their safety funds for a project on the local system because there were not enough crashes to be considered a priority in their evaluation process. Subsequent to the passage of SAFETEA-LU, and often with the encouragement of

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2 For example, statistical techniques that account for regression to the mean that would likely improve the accuracy of estimates of expected numbers of crashes for a given location.
FHWA safety engineers, several of the states reported that they revised their safety programs in order to increase the level of involvement with local road authorities (both from the perspective of providing technical assistance and directing safety funds towards projects on the local system). The responses, relative to the importance assigned to increasing the involvement of local road authorities, varied from state to state. North Carolina assigned a lower level of importance due to the fact that 80% of their roads are on the state system where as Iowa and Minnesota assigned a high level of importance because only 10% of their roads are on the state system. The states responses also noted several significant achievements and some challenges that will have to be addressed before including local road authorities in the safety planning process becomes routine.

Notable achievements include:

- California (57% of fatal crashes on the local system) is in the process of having the University of California (Berkeley) geo-code all fatal and severe injury crashes and to provide an interface with GIS in order to identify locations with concentrations of crashes. California also dedicates one-half of their HSIP funds for safety projects on local systems and provides technical assistance relative to the preparation of applications for the competitive project selection process.\(^3\)

- Illinois (39% of fatal crashes on the local system) has added the ability to the State’s crash data base to locate all crashes on the local system, including output in a GIS format to identify crash locations. Illinois DOT also provides safety training to local agencies and dedicates approximately 20% of their HSIP funds and all of their HRRR funds for safety projects on local systems.\(^4\)

- Iowa (53% of fatal crashes on the local system) has a mature map based crash records system (the Crash Mapping Analysis Tool, CMAT, which is available to all local highway agencies, law enforcement and private engineers) that covers all roads; individual crashes are spatially located by reference point along all roadways in each county in Iowa. The Iowa DOT also provides training for local engineers through an annual safety workshop and they direct about 70% of a separate state funded safety program to projects developed by local agencies for implementation on local roads. The 70% of the state safety funds directed to local projects amounts to approximately 18% of all safety expenditures.

- Louisiana (19% of fatal crashes on the local system) is implementing the Local Road Safety Program (LSRP), which is a partnership between the Department of Transportation and Development and the LTAP/Technology Transfer Center. Key components of the LSRP include; adding two part time traffic safety engineers to provide technical assistance to local agencies – crash analysis, safety training and help with the application process for safety funds. Approximately 25% of the HSIP is directed towards projects on the local system.\(^5\)

- Michigan (60% of fatal crashes on the local system) created a Local Safety Initiative (LSI) in their Department of Transportation and has dedicated 2.5 engineering full-

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\(^3\) Support by State Departments of Transportation for Local Agency Safety Initiatives, Thomas McDonald, Institute for Transportation, Iowa State University, July 2009

\(^4\) Support by State Departments of Transportation for Local Agency Safety Initiatives.

\(^5\) Support by State Departments of Transportation for Local Agency Safety Initiatives.
time equivalents to provide technical assistance to local agencies. LSI maintains and provides the RoadSoft Safety Module to local agencies, which includes ten years of crash data and output in a GIS format. MDOT has partnered with the Local Technical Assistance Program at Michigan Technical University to develop and provide safety training for local agencies and dedicates about one-third of their HSIP funds and all of their HRRR funds for safety projects on local systems.

- Minnesota (48% of fatal crashes on the local system) has provided a local version of CMAT to all cities and counties. MnCMAT contains 10 years of data and up to 73 data items are provided for each crash, including, route, location, date/day/time, severity, vehicle actions, crash causation, weather, road characteristics and driver condition. Mn/DOT has also provided technical assistance through a series of safety workshops around the state and has revised their approach to the HSIP. The safety fund is disaggregated by District based on the distribution of fatal crashes around the state and within each District the funds are split based on the distribution of fatal crashes between the state and local systems. This new approach has directed more than 60% of HSIP funds to Mn/DOT’s rural Districts and almost 50% of the safety funds are reserved for projects developed by local agencies for implementation on local roads.

Key Challenges

**Challenge 1: Methodologies and Tools to Support Safety Planning Efforts**

One of the key challenges identified by the participating states relates to the fact that analytical processes for identifying candidates for safety investments in rural areas—rural intersections and rural highway segments on both the state and local systems—are neither well developed nor are the basic processes understood by safety engineers and analysts. Most previous efforts to refine analytical processes have focused on improving the statistical methods for identifying high crash locations. However, most of the rural locations where most of the severe crashes occur have had few or no crashes during a typical three to five year study period. For example, in Minnesota:

- The average rural intersection averages 0.5 crashes per year, 0.01 fatal crashes per year and no intersection in the state averages one fatal crash per year.
- The average two-lane rural state highway averages 1.5 crashes per mile per year and 0.01 fatal crashes per mile per year.
- The average county highway averages 0.5 crashes per mile per year and 0.003 fatal crashes per mile per year.

The point is that the mature analytical systems that safety professionals are familiar with are primarily focused on finding locations with unusually high numbers of crashes, which most often are not the locations where the majority of the severe crashes are actually occurring. In response to this challenge, agencies at both the national and state levels have been working on developing tools to assist safety analysts with identifying at-risk rural locations that in addition to crashes, are based on identifying features, such as design characteristics and traffic volumes. Examples of these tools include:

**SafetyAnalyst.** This is a new suite of analytical tools for use in the decision making process to identify and manage a system wide program of site-specific improvements to enhance highway safety by cost-effective means. The package was developed by FHWA
and partner state and local agencies. The software can be used to identify the frequency and percentage of specific crash types system wide, for particular segments of a road network or at individual high crash locations (black spots). The program can also be used to characterize the need for system wide engineering improvements, such as edge treatments and cable median barriers. A key expected benefit of SafetyAnalyst is the automation of manual safety analyses being conducted by some road authorities.

The SafetyAnalyst package consists of six tools:

- network screening
- diagnosis
- countermeasure selection
- economic appraisal
- priority ranking
- countermeasure evaluation

The Network Screening tool is used to identify sites that have the potential for safety improvement based on higher than expected crash frequencies. The Diagnosis tool generates collision diagrams and helps the user understand the nature of collision patterns which may exist at screened sites. The tool includes a diagnostic expert system that asks the user questions of specific sites and specific crash scenarios in order to suggest specific countermeasures and the tool considers both engineering and human factors criteria. The Countermeasures Selection tool is integrated with the Diagnosis tool and presents users with a suggested set of countermeasures for their further consideration. The Economic Appraisal tool is used to assess the economic viability of each of the countermeasures, using four economic appraisal methods. The Economic Appraisal tool also includes an optimization algorithm that can consider multiple sites, multiple candidate countermeasures at each site and then suggest a set of sites and countermeasures that provides the maximum safety benefit within a user specified budget. The Priority Ranking tool is integrated with the Economic Appraisal tool and ranks the candidate treatment sites and countermeasures using a range of economic, safety and project cost measures.

The SafetyAnalyst software tools require access to a database that includes roadway/intersection characteristics, traffic volumes and crash data for the road network to be evaluated. Many of the data elements required for SafetyAnalyst should be readily available within highway agencies, but some effort may be required to complete data assembly. SafetyAnalyst includes a data management tool to help import and manage the necessary data inputs.

Information provided by the participating states indicates that only a few have decided to incorporate the use of SafetyAnalyst into their safety planning efforts and fewer yet plan to make the software an integral part of the efforts. In general, the comments provided by the states suggest that the very limited use of the software is due to the large data requirements. Minnesota staff indicated that even thought the SafetyAnalyst data requirements were based on their data base; it took them more than a month to load and get the model running. Minnesota also indicated that they intend to use SafetyAnalyst for improving the identification of black spots, but that the software was not capable of assisting them with identification of candidates for systematic improvements. Missouri
indicated that they intend to incorporate SafetyAnalyst into their statewide safety planning efforts, are in the process of purchasing the license and are working on making their intersection and segment characteristics databases compatible with the software requirements. Iowa and North Carolina indicated that they do not intend to use SafetyAnalyst to support their safety planning efforts and instead will continue to use and develop their own techniques and tools. The final comment reflected a nearly universal concern that SafetyAnalyst would not be used any time soon to assist with safety planning on local systems because local agencies would not have the necessary databases documenting roadway and intersection features.

**United States Road Assessment Program (usRAP).** This is a new methodology being developed by the AAA Foundation for Traffic Safety (AAAFTS) to evaluate safety improvement opportunities on a road network selected by a highway agency and to identify cost-effective safety improvements.

The road network to be considered is selected by a participating highway agency in consultation with usRAP. usRAP includes three protocols; risk mapping, star ratings and countermeasures selection. Risk maps only require information about severe crash locations and a limited amount of roadway features and traffic volume characteristics. While more reactive in nature, risk mapping provides a system wide view of crash density, motorist risk, road performance and potential for improvement.
Star ratings do not require crash data, and are based solely on road and traffic characteristics. Star ratings requires as input, approximately 40 key data elements related to safety. A unique aspect of the protocol is that it does not require detailed, site specific crash data, but relies on an inspection of roadway design features that can be done from a videolog.

usRAP also provides countermeasures selection software which can be calibrated for application to the road network of any highway agency. The methodology requires assembling required data inputs (roadway and traffic characteristics) from new or existing video records and some elements may be obtained from existing roadway inventories. usRAP software then provides an evaluation of each location on the network. Crash countermeasures are identified, crash reduction benefits are computed and a benefit to cost ratio is calculated to help prioritize the countermeasures. Nearly 70 common crash countermeasures are considered by the software including roadway improvements, median treatments, shoulder paving and widening, roadside improvements and pedestrian and bicycle facilities.

The software analysis tool provides a list of potential safety improvement projects, suggested countermeasures, project location, estimated project cost, estimated project benefits (in terms of fatal and serious injury crashes reduced and in monetary terms) and benefit-cost ratio.

The usRAP risk mapping protocol has been pilot tested in eight states and the star rating protocol has been tested and validated against crash data in two states. These pilot studies have demonstrated the technical feasibility of the usRAP risk mapping and performance tracking protocols for states with good quality crash data. A third pilot study is nearing completion which is evaluating the application of the software and analytical processes in a state with more challenging data issues. Given the very limited testing to date, it is too early to forecast how widely this new methodology will be deployed after the initial pilot tests.
State Initiatives. A search of the safety literature combined with conversations with state DOT staff and university researchers revealed a number of initiatives that are intended to fill the gap in the analytical process associated with identifying candidates for safety investments in rural areas. New methodologies and tools to are being developed including; statistical models and describing surrogates to crashes to assist with the efforts to find and prioritize at-risk locations on the rural systems where more than one-half of severe crashes occur, but where crash densities are very low. Examples of these initiatives include:

**Iowa.** Iowa State University is in the process of conducting a safety analysis of low volume rural roads. The primary objective of the project is to develop a safety performance function for low volume rural county highways and a new statistical model. The new model would then be incorporated into the Iowa Traffic Safety Data Service, which provides technical assistance to county highway agencies, including; preparation of maps and lists of at-risk locations and recommendations of potential safety improvement projects.\(^6\)

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\(^6\) Safety Analysis of Low Volume Rural Roads in Iowa, In Progress, Principal Investigator: Reginald Souleyrette, Iowa State University, Sponsor: Iowa Department of Transportation.
**Texas.** The Texas Transportation Institute at Texas A&M University studied horizontal curves along that State’s Farm-to-Market road system.\(^7\) These curves were selected based on being identified as at-risk locations that don’t regularly show up using traditional “hot-spot” techniques. In support of a system approach for finding and prioritizing the most at-risk curves, a relationship was developed between crash rate and curve radius (*Figure 4-1*).

![Figure 4-1: Curve crash rates as a function of radius.](image)

**Minnesota.** The Minnesota Department of Transportation has recently published research that analyzed three components of the state’s rural highway system—horizontal curves, STOP controlled rural intersections and two-lane highway segments. These features were selected for analysis because the data driven process associated with Minnesota’s Strategic Highway Safety Plan identified rural curves, intersections and segments as priorities based on the distribution of severe crashes. The research resulted in the identification of analytical processes for identifying and prioritizing at-risk locations that would be candidates for the proactive deployment of low cost safety improvements.

The research projects identified the characteristics of the locations with crashes and then developed a process for prioritizing these types of locations across almost 53,000 miles of the rural state and local highway systems based on the number of similarities with the features associated with locations with crashes. An example of this work, dealing with horizontal curves found:

- There are literally thousands of curves scattered across the state and county highway systems—it’s estimated that there are over 3,000 curves along the state’s 8,000 miles of two-lane rural highways and over 26,000 curves along the 45,000 miles of rural county highways.

- Curves average about 0.1 crashes per year and slightly more than one-half of the curves have no crashes during a five year study period.

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\(^7\) FHWA/TX-07/0-5439-1, Development of Guidelines for Establishing Effective Curve Advisory Speeds, James Bonneson, Texas Transportation Institute, Texas Department of Transportation, October 2007.
• Approximately 40% of the road departure crashes occur in curves even though curves make up only about 10% of the system mileage.

• All curves are not equally at-risk.

Consistent with previous work completed by the Texas Transportation Institute (FHWA/TX/07/0-5439-1), Mn/DOT found that radius could be used to find and prioritize at-risk curves. The crash rate in curves with radii greater than 2,000 feet approximates the average rate on two-lane rural roads, but as curve radius decreases the crash rate increases—the crash rate at 1,500 foot radius is three times the system average, at 1,000 foot radius the crash rate is four times the system average and at 500 foot radius the crash rate is eleven times the system average (Figure 4-2). This research also found that 90% of fatal crashes and 75% of injury crashes occurred on curves with radii less than 1,500 feet.

![Figure 4-2: Mn/DOT District 7 curve crashes disaggregated by radius (source: Mn/DOT District 7 Highway Safety Plan)](image)

A methodology based on this curve radius-crash rate relationship was applied and refined as part of the preparation of a Countywide Safety Plan for Olmsted County, Minnesota. One of the key results from a data driven analysis process found that road departure crashes in horizontal curves were over represented—40% of severe road departure crashes occurred in curves even though curves only made up only 15% of rural county highway mileage. The methodology was used to evaluate all 241 curves that are located along the County’s 324 miles of two-lane rural highway. The objective of the analysis was to identify a subset of curves that are most at-risk and then to develop a low cost safety project involving a system wide deployment. Curves were ranked based on two primary factors; radius (it was determined that curves with radii between 500 and 1,500 feet had the highest fraction of severe road departure crashes) and serious crashes and three secondary factors; traffic volume (volumes between 500 and 2,500 vehicles per day had the highest fraction of curve related crashes), presence of an
intersection and visual trap (Figure 4-3). The exercise resulted in the ranking of 23 high priority curves along the County’s rural highway system—about 10% of all rural curves in the County. Olmsted County subsequently used the results from this exercise to secure funding from Minnesota’s Highway Safety Improvement Program to proactively add chevrons at the 23 high priority curves. (Figure 4-4).

![Figure 4-3: Visual trap at a horizontal curve.](image)

The research dealing with STOP controlled intersections and two-lane highway segments came to a similar conclusion—all of these locations along rural systems are not equally at-risk. In addition, a methodology based on a combination of design features and traffic volume can effectively be used to develop a prioritized list of at-risk locations, which can then become candidates for safety investment.

Scott County, Minnesota also prepared a Highway Safety Plan and identified crashes at rural STOP controlled intersections as one of their safety emphasis areas—the crashes at these intersections account for approximately 16% of all severe crashes in the County. The challenge involved identifying the most at-risk intersections—six severe crashes occur annually across almost 100 rural intersections. To help identify candidates for safety improvement, the County conducted a prioritization exercise that considered intersection characteristics that...
were demonstrated to be associated with intersections with crashes—skewed approaches, proximity to a horizontal curve, traffic volume, distance from the last STOP sign (along the minor legs), presence of a rail crossing (on the minor leg), occurrence of intersection related crashes and commercial development. The exercise resulted in the ranking of 26 high priority intersections (Figure 4-5).

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**Challenge 2: Safety Experience at the Local Level**

The participating states identified an additional challenge that could be the most difficult to overcome—the lack of safety related experience among the staff at the local road authorities. Given the historic lack of involvement in statewide safety planning, county highway departments have been found to have little or no experience with safety analysis, the safety planning process, the competitive funding process or the development of safety projects. Mn/DOT found that even after opening their safety program to the counties and dedicating almost one-half of HSIP funds to local system projects, many county engineers were reluctant to participate and few of the projects submitted by the counties were consistent with the priorities established in the Strategic Highway Safety Plan (SHSP). In response to this challenge, Mn/DOT has just begun a statewide project that will develop a safety plan for each of Minnesota’s 87 counties, including a list of safety emphasis areas, a prioritized list of safety strategies and a unique list of safety projects (the application of the high priority strategies at the at-risk locations in each county) consistent with the state’s SHSP. However, after completion of the county safety plans it will still be the responsibility of the county engineer to respond to the HSIP solicitation, submit project descriptions and cost estimates to compete for HSIP funding and then if successful, prepare the construction documents necessary to get to implementation.

Iowa also identified a lack of safety related experience with their county engineers to be an issue. Their response included establishing both a county safety liaison position at the Institute for Transportation at Iowa State University (which is also the L/TAP Center for Iowa) and the Iowa Traffic Safety Data Service (ITSDS). The ITSDS provides local highway agencies with technical support for their safety planning efforts by filling the gap between what safety analysts can gather for themselves and what they could obtain from experts.
This last point leads to one final thought relative to states efforts to reach out to engage local road authorities. Even extraordinary levels of effort to involve local road authorities in the statewide safety planning process still requires a level of expertise and effort by staff at the local road authority in order to achieve the desire outcomes—high priority safety strategies implemented at identified at-risk locations. However, a number of states said that they face a challenge beyond deciding whether or not to provide local authorities with crash data, technical assistance related to safety planning or extending HSIP funds to projects on the local system. That is, the lack of technical staff at local agencies. In Missouri, for example, almost 90% of the counties have no county engineer. As a result, even if Missouri decided to change their approach to statewide safety planning by reaching out to local road authorities with technical assistance and funding, they could face a situation where the local authorities would not have professional staff familiar with the process for getting safety improvement projects from conception to completion. In order to provide additional insight relative to the issue of the presence of county engineers, the National Association of County Engineers (NACE) was contacted. NACE indicated that the majority of states do not have county engineers; besides Iowa, Minnesota and Washington most states are a mix of engineers and road superintendents with little formal education and no experience with safety planning.

Safety Investments Beyond HSIP

A final issue worth mentioning is the efforts several states are making to invest in safety features with more than just their HSIP funds. An overview of actions in Missouri, Iowa and Minnesota are summarized in the following paragraphs.

- Missouri determined that 75% of their highway fatalities occurred on their state maintained roads and that almost one-half of these occurred on the 5,600 miles that are designated “Major Roads” (these roads account for 16% of the state’s highway miles but carry 80% of the VMT). MoDOT’s Director concluded that a system-wide application is the solution because chasing fatal crashes around their system could not be an effective strategy. Over the past several years, MoDOT has undertaken extensive renovations of their high volume roads and have added safety features including: more than 500 miles of cable median barrier to the Interstate routes, six inch edge lines, paved shoulders and center and edge line rumble strips to two-lane rural roads. These safety features were added to many miles of major roads with out using HSIP funds.

- The Iowa DOT has almost never directed HSIP funds towards safety projects on the local system. This is partly based on historic precedent but mostly due to the fact that Iowa has a separate state funded safety program—the Traffic Safety Improvement Program (TSIP). TSIP funds are derived from 0.5% of the state’s Road Use Tax and approximately $5 million per year are available for three separate categories of projects: site specific improvements, traffic control devices and research, studies and public information initiatives. State, county and city jurisdictions are eligible to apply for the funding; with, about 70% of the program directed to projects developed by local agencies for implementation on local roads. Examples of projects selected for funding include various intersection improvements in metropolitan areas, adding street lighting at rural intersections, county wide deployment of chevrons at
horizontal curves on rural county highways and support for the Traffic and Safety Engineering Forum.

- Minnesota has established a Central Safety Fund to supplement their HSIP. Historically, Mn/DOT has been a decentralized organization where funding is allocated to the Districts by formula and the Districts are responsible for project definition, development and implementation. However, the Central Office of Traffic Safety was held responsible for the effectiveness of the Safety Program. In this context the Central Safety Fund was set up to provide the Central Office with a means of directing funds towards new (or new to Minnesota) strategies that the Districts were reluctant to support or towards strategies that were not eligible for HSIP. To date, the Central Safety Fund has invested between $5 and $10 million per year in projects including; cable median barrier, edge line rumble stripes and targeted speed enforcement. (Minnesota’s management of their safety program has recently been revised and is now more collaborative. The Central Office now manages the program and selects projects submitted by the Districts for inclusion in HSIP and the Districts still identify projects and do project development and implementation.)

Conclusions

The states that participated in this project clearly indicated that the combination of SAFETEA-LU and the adoption of a new national safety performance measure have influenced their approach to developing their Highway Safety Improvement Program. The characteristics associated with their severe crashes have caused their program to be more focused on rural areas, to include more projects that involve the proactive deployment of low-cost strategies widely across their system and to provide an increased level of engagement with local highway authorities – increased out reach, participation and funding of locally developed projects on the local systems.

In support of safety planning at the local level, a number of states reported adding technical staff devoted to assisting local authorities with analysis and project development. The states also reported developing or expanding crash data bases to identify crashes on local roads and then providing the soft ware (and training) free of charge. One state (Minnesota) has gone so far as to begin a project that involves the preparation of a data driven safety plan (including safety emphasis areas, high priority safety strategies and a unique set of safety projects consistent with the SHSP and eligible for HSIP funding) for every county in the State.

However, the states also identified two key challenges associated with the safety planning process. First, the analytical process for identifying candidates for safety investment in rural areas is not well developed. Severe crashes are scatted across tens of thousands of miles of rural highways and thousands of rural intersections, but techniques for identifying the most at-risk locations are not as mature as the techniques for finding black spots. Second, if states increase the level of engagement with local road authorities, there are concerns about the lack of safety planning experience, especially in counties that manage the rural secondary system where approximately one-half of the fatal crashes occur. Even if states choose to take the lead in preparing a safety plan for local road authorities, including conducting a data driven analysis that identifies a list of high priority safety projects, there is still a need for the local highway department to follow through with securing funding and completing the project development. It was
acknowledged that having a safety plan on a shelf won’t reduce crashes—that takes implementation.