HSIP

U.S. Department of Transportation
Federal Highway Administration

HSIP Noteworthy Practice Series

HSIP Project Identification

About the HSIP Noteworthy Practice Series

The Highway Safety Improvement Program (HSIP) is a core Federal-aid highway program with the primary purpose of achieving a significant reduction in fatalities and serious injuries on all public roads. Many states and local agencies are successfully implementing innovative approaches to HSIP planning, implementation and evaluation. The HSIP Noteworthy Practices Series presents case studies of these successful practices organized by specific HSIP topics. The individual case studies provide summaries of each practice, key accomplishments, results, and contact information for those interested in learning more.

HSIP Project Identification

States are required (23 U.S.C. 148) to perform safety project identification and analysis as part of the HSIP. However, the law does not specify the methodologies states shall use. The HSIP Manual (FHWA-SA-09-029) outlines the following steps for project identification: collect and analyze data; identify crash types and contributing factors; establish a crash pattern; conduct field reviews; identify countermeasures; assess countermeasure effectiveness; and use the current science (e.g., crash modification factors) to determine and prioritize project selection. The goal is to use data-driven decision making to identify and prioritize projects with the greatest potential for reducing deaths and serious injuries on all public roadways.

In practice, methods used to identify candidate project locations vary significantly from state to state. Many states identify potential locations for safety improvements based on crash frequency or rate, while some have begun to use more advanced methods that incorporate safety performance functions (SPFs) or the Empirical Bayes (EB) method. In addition, some states are changing focus from "hot spot" improvements to a systemic approach. Qualitative information commonly used to identify candidate safety projects include panel reviews, input from public and law enforcement, field reviews, and road safety audits (RSA).

Some state departments of transportation (DOT) select projects at the state level while others distribute funds to DOT District offices to use at each district's discretion. Many states selecting projects at the state level solicit projects from DOT District offices and local agencies for consideration. States commonly conduct benefit-cost analyses to select and prioritize projects and rank them first using the highest benefit-cost ratio or net present value.

One of the biggest challenges to effective project identification is the lack of data, particularly for local roadways. Even when quality data are available, many states do not have the training, resources, or tools to apply the more advanced and rigorous data analysis methods necessary to use them effectively. In addition, competing political or institutional realities could impose non-data driven factors on the decision-making process, making it difficult to select those HSIP projects with the greatest potential to improve safety.

While many considerations enter into project selection, quantitative analysis should be used whenever possible in the prioritization process (e.g., comparing cost, effectiveness, and lifespan of the project). Quantitative information lends objectivity to the decision making process and helps maximize the safety benefit for the resources invested.

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Noteworthy Practices

The following cases demonstrate noteworthy practices several states are using in HSIP project identification:

- The North Carolina DOT (NCDOT) developed four categories of safety warrants used in the network screening process to identify locations with severe crashes and crash patterns that can be addressed by engineering safety countermeasures. To provide a clear and consistent data-driven process, NCDOT developed a decision support tool to perform the initial prioritization of all candidate safety projects from across the state. (read more)
- The Missouri DOT (MoDOT) made the state's HSIP more proactive through the systemwide implementation of engineering strategies described in Missouri's Blueprint to Arrive Alive (Strategic Highway Safety Plan). Using HSIP funds, MoDOT incorporates the installation of rumble strips/stripes, improved signing and delineation, wider pavement markings, and improved shoulders into pavement resurfacing projects. Since 2007, almost two-thirds of MoDOT's HSIP funds have been allocated to systemic improvements, resulting in a safer system overall. (read more)
- The Minnesota DOT (MnDOT) restructured its HSIP to provide funding for local agencies to address the large proportion of severe crashes occurring on local roadways, and developed funding goals for proactive and reactive improvements. MnDOT developed a "proactive spectrum" to establish safety funding goals for the Metropolitan District (Minneapolis/St. Paul area) and rural districts. Minnesota has successfully increased the proportion of safety funding spent on proactive improvements. Almost 90 percent of projects programmed for fiscal year 2010-2011 are proactive. (read more)
- The Illinois DOT (IDOT), with the assistance of the University of Illinois, developed safety performance functions (SPFs) for all state routes and intersections using the Empirical Bayes (EB) method. IDOT uses the SPFs in the network screening process to identify locations with the highest potential for safety improvement. The use of SPFs in the network screening process enables the state to shift emphasis of the HSIP away from focusing on urban densely populated areas. The resulting broader focus includes low-cost safety improvements or systemic improvements that may not have been identified using previous screening methods. (read more)
- The Colorado DOT (CDOT) developed sophisticated predictive and diagnostic tools that incorporate calibrated SPFs for all public roadway types and intersections in the state. These tools enable CDOT to maximize potential crash reduction in the state within the constraints of available budgets. CDOT institutionalized the use of these tools by applying them to all CDOT projects. Over the seven years of applying these methods on all infrastructure projects, the state has achieved an unprecedented fatal crash reduction of 36 percent. (read more)

To access these full case studies, click on the individual links above or visit the FHWA Office of Safety on-line at: http://safety.fhwa.dot.gov/hsip.

Safety Warrants and Spot Safety Index

North Carolina

The North Carolina Department of Transportation (NCDOT) started to identify shortcomings in its problem identification method in the mid-1990s. The previous method focused on identifying locations with a potential safety issue based on factors such as crash frequency, crash rate, and crash severity. In many cases, the locations identified did not exhibit a correctable crash type and were congestion related issues. For example, NCDOT repeatedly identified signalized intersections exhibiting a high frequency of rear-end collisions, but attributed the collisions to congestion and driver inattention rather than a roadway factor.

Key Accomplishments

- Developed network screening method to identify locations with severe and correctable crash patterns.
- Continued to update network screening process to improve the identification of relevant safety issues and locations.
- Developed systematic project prioritization ranking method that considers benefit-cost analysis, departmental and regional priorities, and ease of constructability.

Intersection Warrants:

I-1: Frontal Impact

I-2: Last Year Increase

I-3: Frequency with Severity Index Min

I-4: Night Location without Streetlight

I-5: Chronic Pattern

Section Warrants:

S-1: Run Off Road- Wet Conditions

S-2: Run Off Road

S-3: Wet Road Conditions

S-4: Non-Intersection Night Location without Streetlight

Bridge Warrant:

B-1: Bridge

Bike/Ped Intersection Warrants:

P-1: Last 3 Years (pedestrians)

P-2: Darkness with Streetlights

P-3: Alcohol Involvement

P-4: Chronic Location

X-1: Last 3 years (bicyclists)

X-2: Darkness with Streetlights

X-3: Alcohol Involvement

X-4: Chronic Location

Beginning with the 1996 HSIP, a set of safety warrants was established for intersections and roadway segments to target locations exhibiting a pattern of correctable crash types or conditions, as well as locations with a significant increase in crash frequency during the past calendar year. NCDOT has continued to expand and modify the safety warrants throughout the years to improve the identification process.

NCDOT initially screens the network (including local roads) for potential safety improvement locations using four categories of safety warrants: intersections, sections, bridges, and bicycle and pedestrian intersections. The safety warrants are analyzed annually using 5 to 10 years of crash data by querying the crash database. The current warrant criteria are based on crash frequency, severity, conditions, and percentage of target crashes. When a location meets the warrant criteria, it is flagged. As an example, an interstate segment would be flagged based on run-off road crashes if a minimum of 30 total crashes occurred on the segment, the crash rate is greater than 60 crashes per mile, and a minimum of 60 percent of the total crashes were run off the road. After a location is flagged, a weighting factor is calculated based on the warrant criteria. The weighting factors are summed for locations meeting multiple warrants and are used to rank locations to determine which will receive priority for further analysis and investigation by the corresponding Regional Traffic Engineering and Highway Division staff. The Regional Traffic Engineers are responsible for identifying potential countermeasures and developing projects.

All safety projects are submitted to North Carolina's Safety Oversight Committee, which was established to help select projects to receive Spot Safety Program funding. To provide clear and consistent data-driven selection process, the Spot Safety Index (SSI) was developed as a decision support tool to perform an initial prioritization of all candidate projects from across the state. It ensures safety investments are focused on locations with the greatest need and potential for improvement. The SSI is calculated based on a 100-point scale and is composed of four parts: Safety Factor (60 points), Constructability (5 points – e.g., ROW acquisition needs), Department Goals (5 points) and Division/Region Priority (30 points). The Safety Factor is based on the benefit-cost ratio, Severity Index, and whether the project is identified in the HSIP List or identified through a Road Safety Audit (RSA). An initial list of prioritized projects is developed by ranking projects based on the SSI. However, the Committee must take other considerations into account to develop the final list, including distribution of funding to the 14 districts and the effectiveness of countermeasures identified in the projects based on results from the state's evaluation group.

Results

The development of the safety warrants for use in the network screening process has enabled NCDOT to focus their analysis on the identification of locations with severe crashes and crash patterns correctable by infrastructure safety countermeasures. NCDOT also has successfully established a clear and consistent data-driven process for selecting and prioritizing projects for funding.

Contact

Stephen Lowry
Safety Improvement Engineer
North Carolina Department of Transportation
919-773-2892
slowry@ncdot.gov

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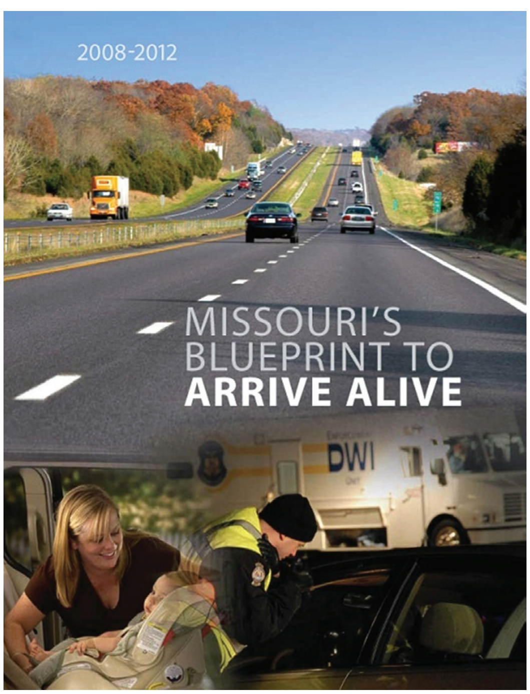
The Focus is Results

Implementation of Systemwide Improvements

Missouri

The Missouri Department of Transportation (MoDOT) has been successfully shifting the focus of its Highway Safety Improvement Program (HSIP) towards a more proactive approach through the implementation of systemwide improvements. Many of these efforts began through the implementation of the Smooth Roads Initiative in 2004. The original initiative included 2,200 miles of resurfacing, installation of reflective pavement markings and signage, improved shoulders with rumble strips/stripes, and safer guardrails. Given the safety benefits realized through these improvements, the state incorporated many of them into Missouri's Blueprint to Arrive Alive (the state's strategic highway safety plan).

Missouri's Blueprint is used to guide HSIP investments. The Blueprint identifies the state's "Targeted 10" strategies in education, enforcement, engineering, and public policy areas. These strategies were selected based on documented evidence supporting their life-saving and injury reduction potential. Six of the strategies are engineering countermeasures being implemented on a systemwide basis, including:



Key Accomplishments

- Allocated almost two-thirds of HSIP funds to systemwide improvements.
- Created a safer roadway system overall.

- Expand the installation of shoulder and centerline rumble strips/stripes;
- Expand, improve, and maintain roadway visibility features (pavement markings, signs, lighting, etc);
- Expand installation and maintenance of roadway shoulders;
- Remove and/or shield fixed objects along roadside right of way;
- Improve and expand intersection safety with the use of innovative engineering designs (e.g., J-turns, roundabouts); and
- Improve curve recognition through the use of signs, markings, and pavement treatments.

The state uses HSIP funding for many of these strategies proactively incorporating the installation of rumble strips/stripes, improved signing and delineation, wider pavement markings, and improved shoulders into pavement resurfacing projects.

Currently the state focuses its funding on the state roadway system since, historically, 77 percent of the fatalities in Missouri occur on state roads. In order to achieve the greatest benefit for the funds invested, Missouri originally focused on incorporating the safety enhancements into resurfacing projects on major roadways (about 5,600 centerline miles) experiencing a disproportionate 45 percent of all fatal crashes. Following positive results from those original efforts, MoDOT is currently considering incorporating two-foot shoulders into future resurfacing projects on less traveled roadways (e.g., minor arterials, major collectors). Missouri also has become a national leader in the installation of cable median barrier to reduce cross-median fatalities on the majority of the interstate system throughout the state.

Results

Since 2007, almost two-thirds of Missouri's HSIP funds have been allocated to systemwide improvements. By focusing more on systemwide improvements, the state has been able to create a safer system overall. Between 2005 and 2010, Missouri has seen a 30 percent drop in overall fatalities and a 41 percent reduction in lane departure fatalities. In addition, the installation of cable median barriers on the interstate system throughout the state resulted in an 80 percent reduction in cross median crash fatalities on Missouri freeways.

Contact

John Miller
Traffic Safety Engineer
Missouri Department of Transportation
573-526-1759
John.p.miller@modot.mo.gov

U.S. Department of Transportation
Federal Highway Administration

Highway Safety Improvement Program
Data Driven Decisions

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The Focus is Results

Funding Goals for Proactive Improvements

Minnesota

The data analysis conducted for the development of Minnesota's original Strategic Highway Safety Plan (SHSP) in 2004 indicated a large percentage of severe crashes were occurring on local roadways. All Highway Safety Improvement Program (HSIP) funding was managed by eight Area Transportation Partnerships (ATP)[1], and a small portion of the funding was allocated to local road safety improvements. To ensure the state was using HSIP funding in the best way possible, Minnesota restructured the program to provide funding for local agencies in Greater Minnesota (areas not within the Minneapolis-St. Paul metro area) and developed funding goals for proactive and reactive improvements.

Key Accomplishments

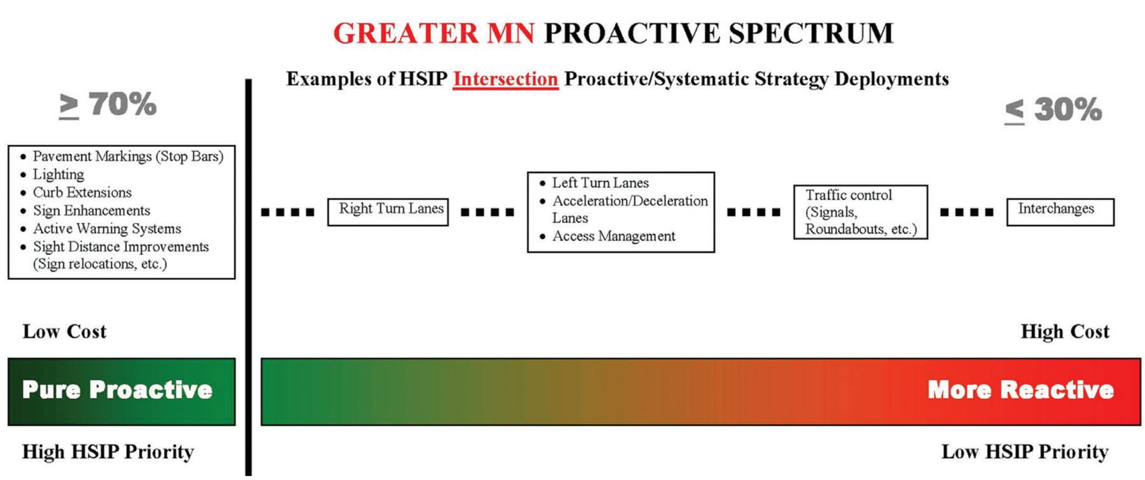
- Implemented proactive approach to the HSIP project selection process.
- Shifted funding to local jurisdictions.

Minnesota distributes HSIP funding to each district based on the proportion of fatal and serious injury crashes occurring in the district. The district funds are then allocated to local roads and state highways based on the proportion of fatal and serious injury crashes occurring on the corresponding roadways. The split ranges from 28 percent to state highways and 72 percent to local roadways in the Metropolitan District, to a 50/50 split in District 1 (average across districts is 35 percent to state highways and 65 percent to local roadways).

In Minnesota approximately 70 percent of all crashes occur in urban areas; however, approximately 70 percent of the fatal crashes occur in rural areas. To address the inherent differences in the safety issues of urban and rural areas, Minnesota has established two separate goals to guide safety investments:

- Metropolitan District (Minneapolis/St. Paul area): at least 30 percent of the safety funds go towards proactive low-cost safety improvements, and
- Greater Minnesota (8 Rural Districts): at least 70 percent of the safety funds go towards the proactive deployment of low-cost strategies.

Minnesota developed a "proactive spectrum" decision support tool for use in project selection, which has been in use since 2007. The spectrum ranges from proactive low-cost projects (e.g. pavement markings, rumble strips, lighting, sign enhancements, etc.) to reactive/high-cost improvements (e.g., interchanges, roadway realignments, etc.). The proactive improvements are focused on improving the safety of the system overall, rather than focusing on a high crash location.



[1] An ATP is a group of traditional and non-traditional transportation partners, including representatives from MnDOT, Metropolitan Planning Organizations, Regional Development Commissions, counties, cities, tribal governments, special interests, and the public, with the responsibility of developing a regional transportation improvement program (TIP) for their area.

Projects are selected for funding through a competitive selection process. Proactive projects are prioritized using a point system based on factors such as whether the project meets the intent of the SHSP, fatal and serious injury crashes per mile, cost per mile or per intersection, and traffic levels. Additional points are awarded if the location was identified in the High Risk Rural Roads Program or the Five Percent report. Reactive projects are prioritized based on the project's benefit-cost ratio and other factors. The objective of this process is to prioritize and fund safety projects with the greatest impact on reducing fatal and serious injury crashes.

Results

Minnesota has successfully shifted the focus of its HSIP to a proactive approach through the development of the "Proactive Spectrum." This enables the state to focus on projects with the greatest potential impact on safety.

The proportion of funding spent on proactive improvements has been increasing over the last few years. Of the projects programmed for fiscal year 2010-2011, almost 90 percent were proactive. Since 2007, Minnesota has funded safety projects on local and state roads to implement over: 6,714 miles of 6-inch wide edge lines; 80 miles of edge line rumble strips; 594 miles of edge line rumble stripes; 236 rural intersections with street lighting; 1,347 curves with chevron signing; and 230 miles of cable median barrier.

Contact

Julie Whitcher
Minnesota Department of Transportation
651-234-7019
julie.whitcher@state.mn.us

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Federal Highway Administration

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The Focus is Results

Development of SPFs for All State Routes and Intersections

Illinois

While the development of SafetyAnalyst and the Highway Safety Manual was still underway, Illinois decided to incorporate a new analysis technique to assist the state in moving forward with the implementation of SafetyAnalyst. Within a year, the Illinois Department of Transportation (IDOT), with the assistance of the University of Illinois, developed safety performance functions (SPF) for state routes and intersections throughout the state using the Empirical Bayes (EB) method. The SPFs have been used in the HSIP network screening process since 2008 to identify potential locations for safety improvement projects.

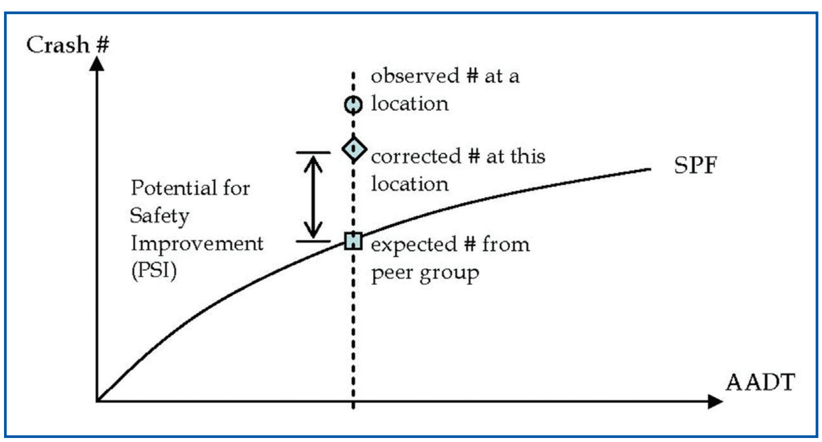
SPF equations were developed for 12 peer groups of roadway segments (e.g., rural two-lane highway, rural multilane undivided highway, rural multilane divided highway, etc.) and eight peer groups for intersections (e.g., rural minor leg stop control, rural all-way stop control, rural signalized, etc.). The SPFs are used in the network screening process to calculate a Potential for Safety Improvement (PSI) for all locations. The PSI is the difference between the corrected crash frequency (calculated using the EB method) and the expected crash experience (based on the SPF) for a given traffic volume within the peer group.

Since the focus of the HSIP is to reduce fatalities and serious injuries, the PSI calculation is weighted to emphasize the most severe crashes. The weighted PSI calculations are then ranked in ascending order by location and peer group to identify locations with the greatest safety need or highest PSI value. Once the sites with the greatest potential for safety improvement are identified, the IDOT Districts review the locations and make recommendations for improvement. Candidate HSIP projects on the state roadway system are selected by the District's Safety Committee and submitted to the Bureau of Safety Engineering.

Key Accomplishments

- Developed SPFs for state routes and intersections throughout the state.
- Expanded knowledge and acceptance of analysis techniques.
- Provided data-driven safety decision making tools.

When the SPFs were originally developed, there was not enough data to develop SPFs for the local roadway system. Illinois has been expanding the crash database for local roadways and, in the near future, the state will begin discussions about the development of SPFs for local roadways, as well as updating the existing SPFs for state roadways. Currently, local roadways are evaluated using an aggregate level analysis to identify potential safety issues (e.g., counties with overrepresentation of a particular crash type, crash severity, behavioral issue, etc.). Local agencies can submit safety improvement projects to the State Safety Committee for funding consideration through the Local Road Program component of the HSIP.



Results

Incorporating SPFs into the network screening process for safety improvement projects has led to several positive outcomes. Although other factors may involved, Illinois has seen a significant reduction in fatalities. In 2009, Illinois had the lowest number of fatalities since 1921. Transportation professionals are embracing the analysis results and making data-driven safety decisions. Using SPFs has helped shift the focus of the state's program away from the urban, densely populated areas and provided a broader focus for safety projects, including low-cost safety improvements or systemic improvements that may not have been identified using previous analysis methods. Engineers throughout the state have become more familiar and comfortable with the use of SPFs through the state's efforts, leading to a greater acceptance of SPFs and appreciation for improved quantitative data.

Contact

Roseanne Nance
Illinois Department of Transportation
217-785-5875
nancer@dot.il.gov

U.S. Department of Transportation
Federal Highway Administration

HSIP
Highway Safety Improvement Program
Data Driven Decisions

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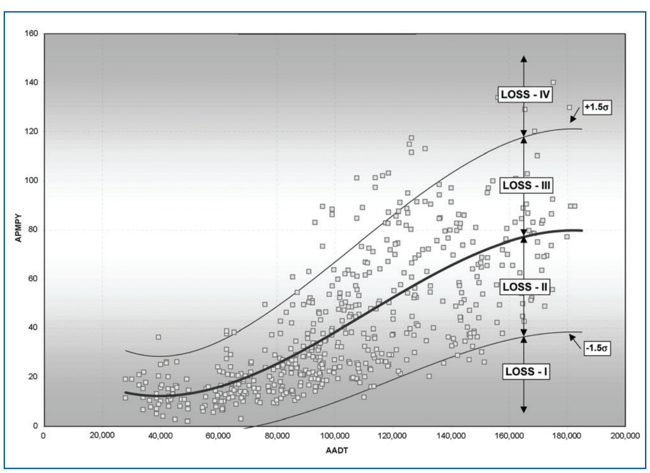
Level of Service of Safety and Diagnostic Analysis

Colorado

The Colorado Department of Transportation (CDOT) uses two methods for identifying locations with potential for safety improvement: Level of Service of Safety (LOSS) and Diagnostic Analysis. LOSS is based on the concept of Safety Performance Functions (SPF), while Diagnostic Analysis is developed around the idea of statistical pattern recognition.

Design engineers at CDOT pioneered development of the LOSS concept to quantify the magnitude of the safety problem. A crash rate implies a linear relationship between safety and exposure. While crash rates are commonly used to measure safety, they are often misleading since rates change with Annual Average Daily Traffic (AADT). To capture how this rate change takes place, CDOT engineers began calibrating SPFs in the late 1990s based on the work of Dr. Ezra Hauer. By 2001, CDOT had calibrated SPFs for all public roadways in Colorado, which were stratified by the number of lanes, terrain, environment, and functional classification. In 2009, in collaboration with consultants, CDOT developed SPFs for all intersection types.

Development of SPFs supports the conceptual formulation of the LOSS concept. It uses qualitative measures to characterize the safety of a roadway segment in reference to its expected performance. If the number of crashes



Key Accomplishments

- Calibrated SPFs for all highways.
- Developed sophisticated predictive and diagnostic tools to maximize crash reduction in the state within budget constraints.
- Institutionalized use of these tools throughout the state of Colorado.
- Achieved unprecedented fatal crash reduction of 36 percent over the seven years of sustained application of these advanced methods on all infrastructure and behavioral projects at CDOT.
- Provided substantive conceptual and analytical input for the development of the Highway Safety Manual (HSM).

predicted by the SPF represents normal or expected crash frequency at a specific level of AADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety. To describe road safety from the frequency and severity standpoint, two different SPFs were calibrated: one for the total number of crashes and the other for injury and fatal crashes. When the magnitude of the safety problem is assessed, it is described from the frequency and severity standpoint. The figure (Kononov and Allery, 2003) illustrates the LOSS concept using an SPF calibrated for total crashes expected on the 6-lane urban freeways. The delineated boundary line is located 1.5 standard deviations from the mean, reflecting a Negative Binomial error structure. Four LOSS categories were introduced:

- LOSS-I - Indicates low potential for crash reduction;
- LOSS-II - Indicates low to moderate potential for crash reduction;
- LOSS-III - Indicates moderate to high potential for crash reduction; and
- LOSS-IV - Indicates high potential for crash reduction.

LOSS reflects how the roadway segment is performing in regard to its expected crash frequency and severity at a specific level of AADT. However, it only describes the magnitude of the safety problem; it does not provide any information related to the nature of the problem itself. To investigate the nature of the problem, Colorado uses Direct Diagnostics and Pattern Recognition techniques.

A comprehensive methodology was developed to conduct diagnostic analyses of safety problems. The Direct Diagnostics and Pattern Recognition methods calculate a cumulative binomial probability of the crash types and related characteristics to identify overrepresented elements in the crash data (e.g., dark conditions, overturning vehicles) that may be related to abnormal crash patterns and crash causation. Direct Diagnostics is used for intersection analysis, and Pattern Recognition is used for roadway segments.

CDOT initially used the combination of LOSS and Direct Diagnostics and Pattern Recognition to identify sites with potential for safety improvement only on safety motivated projects. Beginning in 2001, they are applied to all projects at CDOT, including resurfacing, reconstruction, realignment, widening, Environmental Assessments (EA) and Environmental Impact Statements (EIS). CDOT conducts a statewide analysis using Direct Diagnostics and Pattern Recognition and recalibrates SPFs about every five years.

Results

CDOT developed sophisticated predictive and diagnostic tools to maximize potential crash reduction in the state within constraints of available budgets and institutionalized use of these tools throughout the state of Colorado. Over the seven years of application of the advanced methods on all infrastructure and behavioral projects at CDOT, the state has achieved an unprecedented fatal crash reduction of 36 percent, without reduction in travel or increase in safety expenditures. Additionally, these efforts provided substantive analytical and conceptual input for development of the Highway Safety Manual.

Contact

Bryan Allery
Colorado Department of Transportation
303-757-9967
bryan.allery@dot.state.co.us

Jake Kononov
Colorado Department of Transportation
303-757-9973
jake.kononov@dot.state.co.us

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