

Roadway Safety Data Program



PENNSYLVANIA'S STATE-SPECIFIC SPFs AND CMFs

ROADWAY SAFETY DATA AND ANALYSIS

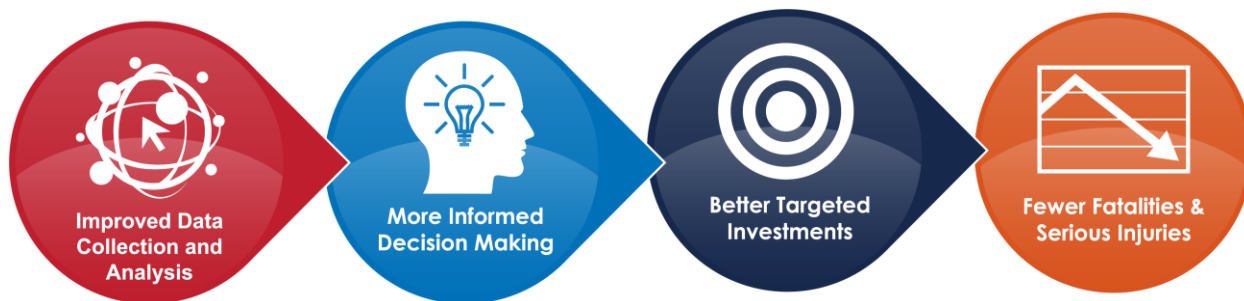
CASE STUDY

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ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
CMF	Crash modification factor
FHWA	Federal Highway Administration
HSM	Highway Safety Manual
PennDOT	Pennsylvania Department of Transportation
SPF	Safety Performance Function
TRCC	Traffic Records Coordinating Committee

EXECUTIVE SUMMARY

The Pennsylvania Department of Transportation (PennDOT) used Part C of the Highway Safety Manual (HSM) to develop State-specific safety performance functions (SPFs). For some facility types, PennDOT developed district/regional-level calibrations of the State-specific SPFs. PennDOT developed regional SPFs and calibrated State-specific SPFs for use at the regional level. They believe this is the best approach for dealing with the inherent differences among areas within the State.

The PennDOT Highway Safety and Traffic Operations Division developed a guide on the appropriate use of State-specific crash modification factors (CMFs). This guide is based on a critical review of the CMFs available in the FHWA CMF Clearinghouse to identify CMFs applicable to Pennsylvania. PennDOT's "Pennsylvania CMF Guide" includes information on these selection criteria as well as best practices to guide practitioners on how to use CMFs appropriately in various scenarios. As the list of countermeasures in the CMF Clearinghouse continues to grow, practitioners can use the criteria to select from among the newly added CMFs.

INTRODUCTION

The American Association of State Highway and Transportation Officials (AASHTO) published the 1st edition of the Highway Safety Manual (HSM) in 2010. The HSM describes the most up-to-date analytic tools and techniques for quantifying the safety effects of decisions made in the planning, design, operations, and maintenance phases of project development. In particular, Part C of the HSM provides crash prediction models that States can use to predict potential safety benefits of various design alternatives and engineering treatments. Part C also gives instruction on how to develop State-specific safety performance functions (SPFs) or calibrate the SPFs available in the HSM to a particular jurisdiction.

The Pennsylvania Department of Transportation (PennDOT) Highway Safety and Traffic Operations Division wrote a white paper to gain acceptance of the HSM. The paper explains the benefits of adopting the HSM, with a focus on using safety dollars more efficiently.

BACKGROUND

The Highway Safety and Traffic Operations staff members developed a one-year deployment plan in which they proposed revising the Department's design and procedure manuals to align with the HSM. Training sessions with relevant PennDOT staff members and business partners (FHWA, Turnpike, consultants, and local municipalities) took place throughout 2014 and 2015.

During this time, the Highway Safety and Traffic Operations Division developed State-specific SPFs and crash modification factors (CMFs). There are 38,000 miles of State-maintained roads for which PennDOT has some attribute data and 78,000 miles of local roads for which the Agency has no attribute data. PennDOT judged that the majority of safety projects would be on rural two lane roads; however, the State lacked detailed data on local roadway segments and so decided to begin by creating State-specific SPFs for State-maintained two-lane rural roads. Over the course of the project, they developed State-specific SPFs for other facility types, as well as regional SPFs and calibration factors.

Additionally, the Highway Safety and Traffic Operations Division developed a guide on the appropriate use of State-specific CMFs. This guide is based on a critical review of the CMFs available in the FHWA CMF Clearinghouse (www.cmfclearinghouse.org) to identify CMFs applicable to Pennsylvania.

OBJECTIVES

PennDOT developed State-specific SPFs in order to have SPFs based on State data rather than having to calibrate the models found in the HSM. This decision was based on an examination of the published SPFs and noting that they were not developed with Pennsylvania data. Attempts to calibrate the SPFs led to the realization that the published functions could be replaced with State-specific ones for about the same investment as calibration would have required. Ultimately, this effort led the State to recognize the need for regional calibration as well.

Agencies seeking guidance on whether to calibrate SPFs from the HSM or develop jurisdiction-specific SPFs can use the FHWA *SPF Decision Guide* to support this decision process at http://safety.fhwa.dot.gov/rsdp/downloads/spf_decision_guide_final.pdf.

There are a vast number of CMFs available in the CMF Clearinghouse, but PennDOT wanted to use only those that were most applicable to Pennsylvania, so they developed their own State-specific CMF list. PennDOT also recognized the need to train staff on the importance of CMFs and how to use them appropriately. To this end, they developed the “how to” guide for using CMFs.

AUDIENCE

The audience for this case study includes:

- State Departments of Transportation: Safety Engineering, Design, Planning, Maintenance, Geographic Information System (GIS), and Asset Management Units.
- Local and Regional: City and County Public Works/Engineering/Transportation Departments, Metropolitan Planning Organizations, and Regional Planning Commissions.
- Local Technical Assistance Programs.
- Consultants and private industries involved with safety.

DEVELOPING STATE-SPECIFIC SPFS

PennDOT started by developing statewide State-specific SPFs for rural two-lane roads. They found that the values of the statewide SPFs were not reliable for use across jurisdictions. Their solution, to develop regional SPFs, calibrates the State-specific SPFs for use at the regional level. They believe this is the best approach for dealing with the inherent differences among areas within the State.

As of January 2016, PennDOT, through contracts with Pennsylvania State University, has developed statewide State-specific SPFs as well as district-level and county-level calibration

factors for rural two-lane and multilane roads, urban/suburban arterials, and 18 different intersection types. To develop district-level and county-level calibration factors, PennDOT selected one county in each district to use as a control county. On a district-wide basis, and for the remaining counties, they based the calibration factors on the control county. This procedure resulted in over 100 SPFs with each SPF having several calibration factors.

The original results of this effort gave PennDOT a complementary document to the HSM that is entirely Pennsylvania-specific. Additionally, PennDOT developed an Excel spreadsheet tool that includes the State-specific SPFs and CMFs, as well as the SPFs from the current HSM and a function for calculating benefit-cost ratios.

COLLECTING THE DATA TO DEVELOP STATE-SPECIFIC SPFS

Developing State-specific SPFs for various segment facility types requires roadway data. PennDOT lacks some data elements for the State-maintained roads. Thus, they needed to collect all pertinent roadway data elements for the State-maintained roads that were not already included in the available databases. For example, the SPF for rural two-lane roads includes horizontal curve and grade data and roadside hazard rating as data elements. The pre-existing PennDOT databases did not include these data elements. PennDOT undertook an 18-month data collection effort for roughly 10,000 miles of rural two-lane roads, 6,000 miles of urban/suburban arterials, and 700 miles of rural multilane roads. The end product covers about 20,000 miles of the 40,000 miles of State-maintained roadways.

There are also many data elements needed to develop the State-specific SPFs for various intersection facility types. PennDOT has a roadway management system that includes an intersection database of State-maintained intersections, but not local intersections.

DEVELOPMENT OF STATE-SPECIFIC CMFS AND CMF “HOW TO” GUIDE

The CMF Clearinghouse contains over 5,000 CMFs for various engineering countermeasures. In order to give Pennsylvania practitioners a way to easily navigate the CMF Clearinghouse, a team of staff members critically reviewed each CMF in the Clearinghouse to determine if it was applicable to Pennsylvania. Criteria for inclusion in the State-specific CMF listing were:

- If a CMF used Pennsylvania data in its development, PennDOT included the CMF in the Pennsylvania list in lieu of other CMFs with similar characteristics developed in other States.

- If a CMF used no Pennsylvania data in its development, PennDOT used the star rating (quality of the CMF assigned by Clearinghouse reviewers) to determine if the CMF was included in the Pennsylvania list.
 - If there was only one CMF with a 5-star rating for a particular countermeasure, they used that CMF.
 - If there were several highly rated CMFs for a particular countermeasure, staff reviewed each report to determine which were most applicable to Pennsylvania.
 - PennDOT reviewed only CMFs with at least a 3-star rating.
- PennDOT uses CMFs in the project development stage when there is not much detail known and therefore, more generalized countermeasures are more applicable. So, they selected only generalized countermeasures from the Clearinghouse (not too narrowly defined for specific roadway features or crash types).
- PennDOT selected only countermeasures with characteristics that apply to Pennsylvania. For example, if a particular countermeasure applies to roadways of a certain traffic volume that does not exist in Pennsylvania, PennDOT did not include the countermeasure.
- PennDOT selected only studies without a lot of variability (large standard errors).
- PennDOT only included CMFs developed in the United States.

PennDOT's "Pennsylvania CMF Guide" includes information on these selection criteria as well as best practices to guide practitioners on how to use CMFs appropriately in various scenarios. As the list of countermeasures in the CMF Clearinghouse continues to grow, practitioners can use the criteria to select from among the newly added CMFs as well.

TRAINING COURSES

To train staff on CMF use and interpretation, PennDOT ran lunchtime webinars sponsored by the American Society of Highway Engineers. Approximately 200 people (mostly consultants) attended the lunchtime webinars.

PennDOT also sponsored PennDOT-specific HSM training classes, offered seven times between December 2014 through June 2015. The developers of the training class adapted material from NCHRP 17-38 *Highway Safety Manual Implementation and Training Materials* to make it specific to Pennsylvania. Approximately 200 people participated in the trainings. Of those, 140 were PennDOT employees (safety, traffic, and design personnel from Headquarters and the Districts), and the remaining were business partners (FHWA, Turnpike, consultants, and local municipalities). Content for the seven HSM training classes focused on two-lane rural road SPFs, CMFs, and a preliminary version of the Excel spreadsheet tool including crash prediction and benefit-cost analysis, .

PennDOT intends to offer the PennDOT specific HSM training class nine more times by the end of December 2017. These additional classes will be broader in scope and will include information on design exceptions and alternatives analysis. The target audience is PennDOT district engineering staff, including design, safety, and traffic engineering professionals.

RESULTS

The following sections describe the funding sources, benefits, barriers and how they were overcome, lessons learned, and next steps for the development of PennDOT's state-specific SPFs and CMFs. From a PennDOT perspective, this was a valuable and necessary effort, as it gives them the information they need to make valid, reliable decisions and shows them how to best use the Federal publications and guidance.

FUNDING

The funding for the State-specific SPF development came from the National Highway Traffic Safety Administration (NHTSA) traffic records (Section 405c) grant funds. The Traffic Records Coordinating Committee (TRCC) approved the project as part of the traffic records strategic plan and assisted PennDOT with the grant application.

The cost of development and delivery of the initial seven HSM training classes was approximately \$110,000. Of that, PennDOT spent \$40,741 on training development, and the remainder covered delivery in the seven sessions.

The cost of State-specific SPF development was \$950,000, including data collection, data analysis, draft and final reports, "Pennsylvania CMF Guide", and the Excel spreadsheet tool. Specifically, SPF and CMF development was \$696,000, and development of the Excel spreadsheet tool was \$253,000.

PennDOT is aware that they may need to reinvest in this research every three to five years; however, at this time, they have no formal plans to do so.

BENEFITS

PennDOT identified the following benefits of State-specific SPF and CMF development:

- After developing State-specific and regional SPFs and calibration factors for all desired facility types in Pennsylvania, PennDOT has a document and a spreadsheet tool that are entirely Pennsylvania specific.
- PennDOT plans to use the State-specific SPFs to aid in network screening in order to select (for example) HSIP project locations. Rather than using just historical crash data

to identify HSIP project locations, they will be able to use State-specific SPFs that account for variables such as traffic volume and roadway classification.

- State-specific SPFs and CMFs will be useful in benefit-cost analyses. PennDOT has a publication that gives costs for specific items, and combining this document with the treatments derived from the selected State-specific CMFs will assist in estimating costs for projects. The State-specific SPFs and CMFs will provide more realistic estimated benefits for the benefit-cost ratio analysis because they are based on Pennsylvania data.
- More realistic benefit-cost ratio analyses could help with public education since PennDOT has more confidence in the numbers they present. It will be easier to illustrate to the public the benefits of engineering safety treatments.

BARRIERS AND HOW THEY WERE OVERCOME

PennDOT is still trying to educate designers and engineers on the HSM. It is a tough transition for many who have over 20 years of experience using the AASHTO “A Policy on Geometric Design of Highways and Streets” (Green Book). The HSM gives the State more reliable estimates of safety benefits of various countermeasures. This helps them be more effective and efficient when identifying and addressing safety issues. PennDOT is trying to make sure the designers and engineers get the information early enough to have time to understand and implement the new methods successfully.

LESSONS LEARNED

The State has determined that there is no one-size-fits-all approach to SPFs and CMFs. PennDOT found it necessary to tailor the information to their State, and again to different regions within the State. The national studies and publications are usually based on a core sample, making it important to understand how similar a particular State—in this case Pennsylvania—is to the States participating in the study. If there are not enough similarities, decision-makers must make the decision whether to apply that national-level guidance or use their own data.

It may not be necessary or practical for all States to develop State-specific SPFs and/or CMFs. It is beneficial for States who are considering this effort to gather as much information as possible from other States who have already developed State-specific SPFs or CMFs to see if it is valuable for their State. Agencies can also use the FHWA *SPF Decision Guide* to support this decision process at http://safety.fhwa.dot.gov/rsdp/downloads/spf_decision_guide_final.pdf.

NEXT STEPS

PennDOT will continue to train relevant staff on State-specific SPFs, “Pennsylvania CMF Guide”, and Excel spreadsheet tool.

REFERENCES

The following resources were consulted in development of this case study:

1. PennDOT Highway Safety & Traffic Operations – Gary Modi. Telephone Interview. June 10, 2015.
2. PennDOT Highway Safety & Traffic Operations – Gavin Gray, Jason Hershock, and Eric Donnell. Telephone Interview. October 9, 2015.
3. PennDOT Highway Safety Manual Workshop. PowerPoint Presentation. December 8-9, 2014. Riverfront Office Center. Harrisburg, PA.
4. Gayah, V.V., and E.T. Donnell. “Establishing Crash Modification Factors and Their Use (Pennsylvania CMF Guide)”. PennDOT Final Report. August 2014.
5. Donnell, E., V. Gayah, and P. Jovanis. “Safety Performance Functions”. PennDOT Final Report. October 2014. Accessible at <http://www.mautc.psu.edu/docs/PSU-2013-09.pdf>.
6. Donnell, E., V. Gayah, and L. Li. “Regionalized Safety Performance Functions.” PennDOT Final Report. January 2016. Accessible at http://www.dot7.state.pa.us/BPR_PDF_FILES/Documents/Research/Complete%20Projects/Operations/Regionalized_Safety_Performance.pdf.

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