ILLINOIS CENTER FOR TRANSPORTATION

CIVIL ENGINEERING STUDIES
Illinois Center for Transportation Series No. 10-071
UILU-ENG-2010-2012
ISSN: 0197-9191

2009 National Safety Performance Function Summit

Prepared By
Yanfeng Ouyang
University of Illinois at Urbana Champaign

Research Report ICT-10-071

A report of the findings of
ICT-R27-67
National Safety Performance Function Summit

Illinois Center for Transportation

July 2010

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-ICT-10-071		

4. Title and Subtitle 2009 National Safety Performance Function Summit	5. Report Date July 2010
	6. Performing Organization Code
7. Author(s) Yanfeng Ouyang	8. Performing Organization Report No. ICT-10-071 UILU-ENG-2010-2012
9. Performing Organization Name and Address Illinois Center for Transportation Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign 205 N. Mathews Ave, MC 250 Urbana, IL 61801	10. Work Unit (TRAIS) 11. Contract or Grant No. 13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Illinois Department of Transportation Bureau of Materials and Physical Research 126 E. Ash Street Springfield, IL 62704	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The Illinois Department of Transportation (IDOT) and the Illinois Center for Transportation (ICT) sponsored and hosted the first National Safety Performance Function Summit on July 29 and 30, 2009, in Chicago, Illinois. The goal of this summit was to disseminate information and facilitate discussions on various ongoing and emerging activities related to the development and implementation of Safety Performance Functions (SPFs). This report summarizes the attendee statistics, the conference program, the main activities (including 32 presentations and eight discussion sessions), and the attendees' feedback. Prospects for follow-up activities are also discussed.

17. Key Words	18. Distribution Statement
safety performance functions, SPF, crash prediction, roadway safety improvement	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	161	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGMENTS

This publication is based on the results of research project ICT-R27-67, *National Safety Performance Function Summit*. The summit was held in Chicago, IL on July 29-30, 2009. The Illinois Center for Transportation, the Illinois Department of Transportation, and the Federal Highway Administration provided financial support for the summit.

The contents of this report reflect the view of the authors, who are responsible for the facts and accuracy of the data presented herein, as well as the views of the attendees and presenters of the summit. The contents do not necessarily reflect the official views or policies of the Illinois Center for Transportation, the Illinois Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) and the Illinois Center for Transportation (ICT) sponsored and hosted the first National Safety Performance Function Summit on July 29 and 30, 2009, in Chicago, Illinois. The goal of this summit was to disseminate information and facilitate discussions on various ongoing and emerging activities related to the development and implementation of Safety Performance Functions (SPFs). This report summarizes the attendee statistics, the conference program, the main activities (including 32 presentations and eight discussion sessions), and the attendees' feedback. Prospects for follow-up activities are also discussed.

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

Safety Performance Functions (SPFs) are statistical models that describe the relationship among crash frequency, crash severity, crash type, traffic volumes, roadway geometric design, and other factors. SPFs provide a realistic and accurate prediction of crash frequency as a function of traffic volume and roadway geometries for different types of roadway sites (e.g., segments, intersections) over a network. The SPFs, often used together with the Empirical Bayesian method, can be used to calculate a roadway site's Potential for Safety Improvement (PSI) and thus help identify those locations that have the highest potential for improvement. Ultimately, sites with high PSI values could be given priority during the safety project planning process. The recently released Highway Safety Manual (HSM) uses the SPF methodology, and SPF-based tools are utilized in *Safety Analyst* and the Interactive Highway Safety Design Model (IHSDM). SPFs are consistent with the Strategic Highway Safety Plan (SHSP), and SPF-based safety analysis results can benefit the Highway Safety Improvement Program (HSIP) by focusing more accurately on locations that can potentially reduce severe crashes.

Across the nation, states are at various stages of SPF development and implementation to help manage their state-wide safety programs, which include site-specific and systematic safety improvements to prevent and reduce fatalities and severe injuries resulting from motor vehicle crashes. The Illinois Department of Transportation (IDOT) and the Illinois Center for Transportation (ICT) sponsored and hosted the first National SPF Summit to further advance these efforts. The summit was held on July 29 and 30, 2009, in Chicago, Illinois to disseminate information and facilitate discussions on various ongoing and emerging activities and issues regarding the development and implementation of SPFs. Thirty-two presentations followed by time for questions and answers facilitated open discussions and provided the opportunity for representatives of 34 states and other organizations to learn from leading states and federal initiatives. The summit provided a view of SPFs from the perspectives of decision makers, developers, and users, and by covering a range of topics such as:

- History of SPFs
- SPF development and data needs
- Possible SPF applications (planning and program development, project selection)
- Recent experiences and lessons learned from various states
- Policy level issues
- Tort liability issues
- Education, training needs, and opportunities

The summit included open communication and sharing of experiences, challenges, and successes. Participants left the summit enriched by the knowledge gained from others' experiences. The survey at the end of the summit showed that all respondents found the experience very positive and would like to participate in follow-up activities and events. It became clear that continued education and peer-to-peer sharing is necessary to continue the advancement in explicit quantification of safety.

This report is organized into five sections. Section 2 describes the attendee statistics. Section 3 presents the conference program and summarizes the main activities. Section 4 summarizes the attendees' feedback. Section 5 discusses next steps and recommends future events that will build on the current momentum and address needs of the safety community.

CHAPTER 2 ATTENDEE STATISTICS

IDOT and ICT extended invitations to each state and sponsored the travel of up to two people from each state DOT. Eighty-nine people attended the SPF summit. The attendees included safety engineers, data managers, safety analysts, agency statisticians, and local university researchers affiliated to state DOTs. In addition to State DOTs, representatives attended from the Federal Highway Administration (FHWA) division offices, the American Association of State Highway Transportation Officials (AASHTO), Transportation Research Board (TRB), and researchers and developers from the private sector. A list of attendees and their affiliations is enclosed as Appendix A.

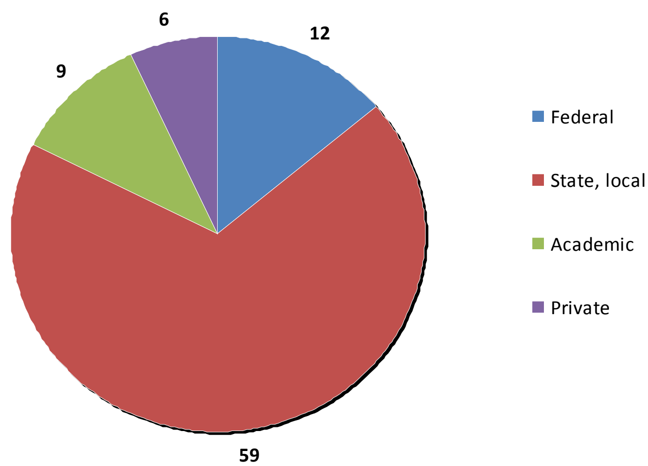


Figure 1. Representation of organizations at the SPF Summit 09.

On the registration page, each attendee was requested to provide personal information and answer two questions:

1. “Please briefly explain your experience with SPF.”
2. “Please briefly explain your perspective on implementing SPF in your organization.”

This section summarizes the answers provided by 71 attendees during the online registration process.

With regard to previous experience with SPF, the attendees can be classified into three categories.

- Safety and SPF are primary responsibility
- Have prior experience in SPF, but SPF is not a current or primary responsibility
- Have no prior experience in SPF

The number of responses in each category is summarized in Figure 2. Fifty-six of the respondents either had experience with or were working on SPF topics.

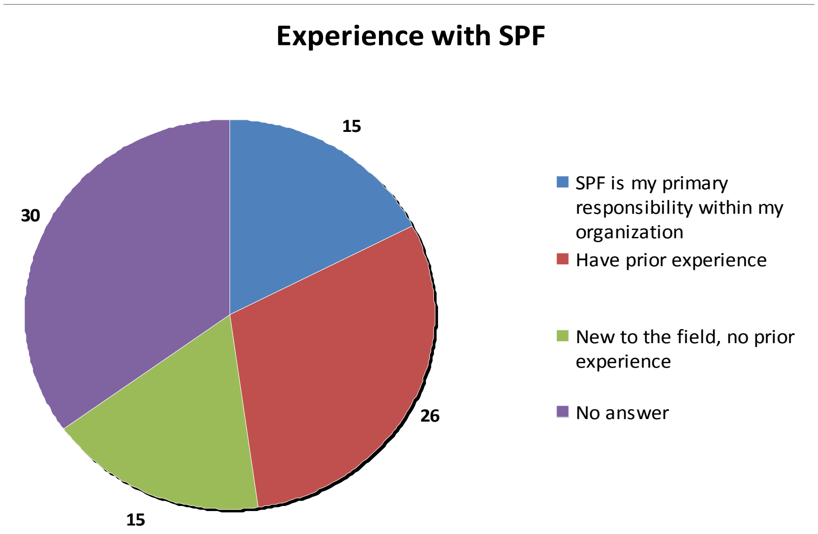


Figure 2. Attendees' prior experience with SPF.

Figure 3 illustrates the prospects of future SPF implementation in the attendees' organizations. According to respondents, SPF implementation is either a high priority or is being considered in their organizations, and the respondents will likely be directly involved with the implementation.

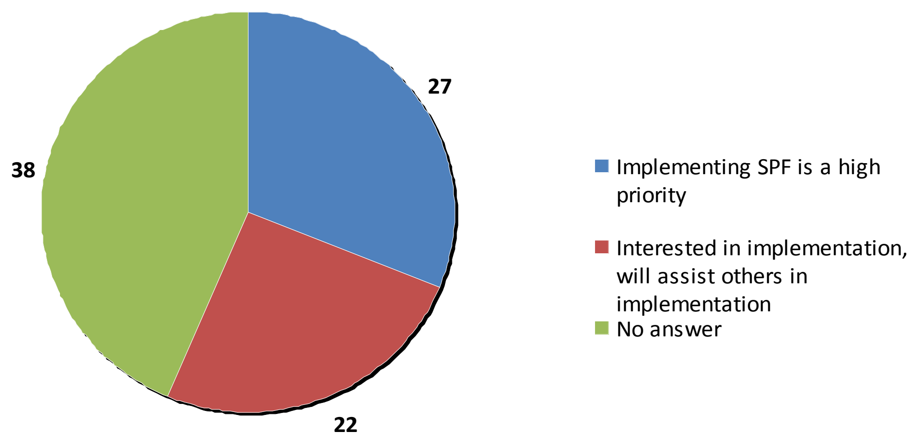


Figure 3. Attendee's future plans for SPF.

Respondents showed less knowledge on potential SPF applications such as *Safety Analyst*, HSM, IHSDM, HSIP, SHSP. Specifically, 27 respondents mentioned one or more specific applications. Figure 4 illustrates the percentages of applications mentioned in these 27 responses.

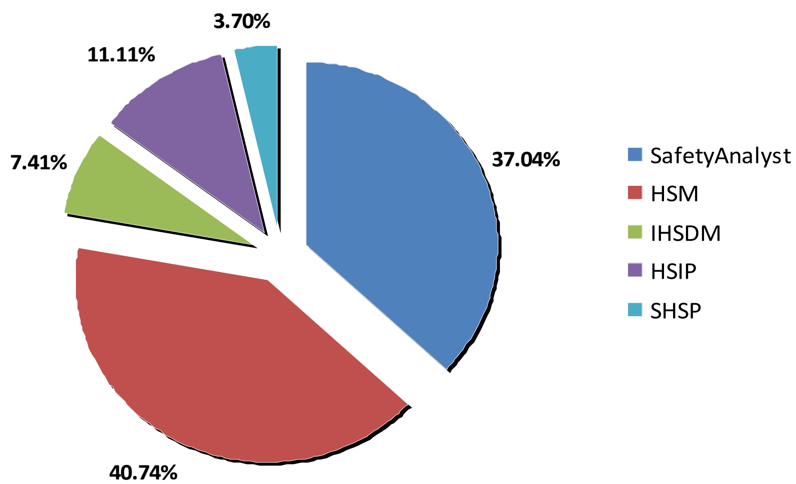


Figure 4. Potential SPF applications mentioned in the responses.

CHAPTER 3 THE SUMMIT

The summit planners began inviting speakers and attendees and conducting online registration in May 2009. The onsite registration was held from 3 - 6 p.m. on Tuesday, July 28, 2009, and 7 - 8 a.m. on Wednesday, July 29, 2009. The conference sessions (no breakout sessions) started at 8 a.m. on July 29, 2009, and concluded at noon July 30, 2009. In most sessions, the presentations were followed by a question and answer session or facilitated discussions. A basic tutorial document on SPFs (Hauer et al, 2002) was provided to all attendees in both hardcopy and electronic format (see Appendix B).

3.1. PROGRAM

Table 1 below provides a list of sessions and speakers/moderators at the SPF Summit. The presentation files and discussion records are enclosed in Appendices C and D respectively. Electronic versions of these files, as well as video footage of all sessions, are available at the conference website http://ict.illinois.edu/conferences/spfsummit09/schedule.htm.

Table 1. SPF Summit 2009 Program

Session	Presentation Title	Speaker / Moderator
Session 1: Opening	*Welcome to the SPF Summit*	Priscilla Tobias, Illinois DOT & 2009 SPF Summit Chair
Session 2: History		Moderator: Geni Bahar, NAVIGATS Inc.
	From Whence Cometh the HSM?	Rick Pain, TRB
	SPF History	John Milton, TRB, HSM Task Force Chair
	AASHTO Vision for Highway Safety	Joel McCarroll, AASHTO
	SPF History	Priscilla Tobias, Vice Chair AASHTO Joint Task Force for the HSM
	How Did SPF Come into Being and Why Is It Here to Stay?	Geni Bahar, NAVIGATS Inc.
Session 3: SPF Development and Data Needs (National and State Initiatives)		Moderator: John Milton, Washington DOT Recorder: Kim Kolody, CH2MHill
	Role of SPFs in the Highway Safety Manual	Mario Candia-Martinez, Kittleson & Associates, Inc.
	Role of SPFs in the Interactive Highway Safety Design Model (IHSDM)	Mike Dimaiuta, FHWA
	Role of SPFs in SafetyAnalyst	Ray Krammes, FHWA
	Calibration of SPFs in the HSM, IHSDM, and SafetyAnalyst	Doug Harwood, Midwest Research Institute
	SPF Development in Illinois	Yanfeng Ouyang, University of Illinois
	SPF Development and Data Needs	John Milton, Washington DOT
	SPF Development and 10 Years of Application: A Practical Approach	Jake Kononov, Colorado DOT
	Q & A	
Session 4: SPF Applications by State DOTs		Moderator: Jim Allen, Illinois DOT Recorder: Mario Candia, Kittleson & Associates, Inc.
	Virginia's Safety Modeling Story	Stephen Read, Virginia DOT
	SPF Applications for Safety Analysis in Illinois	Kim Kolody, CH2MHill for Illinois DOT

	SPFs Applications by State DOTs *CDOT: 10 Years of SPF Applications and Experience* Facilitated Discussions	John Milton, Washington DOT Jake Kononov, Colorado DOT
Session 5: Policy Level Issues Related to Safety in the Scheme of Planning, Design and Operations, Forecasting and Prevention	 *Quantitative Safety Information and Project Development:* *Policy Level Issues Related to Safety in the Project & Program Development Stages* Facilitated Discussion	Moderator: Robert Hull, Utah DOT Recorder on Computer and Projector: Kim Kolody, CH2MHill Tim Neuman, CH2MHill John Milton, Washington DOT
Session 6: Tort Liability Issues Related to Safety in the Scheme of Planning, Design and Operations, Forecasting and Prevention	 *Tort Liability Issues Related to Safety in Project & Program Development Stages* *Legal Implications of Use and Non-Use of SPFs* Facilitated Discussion Closing Remarks	Moderator: Tim Neuman, CH2MHill Recorder on Computer and Projector: Kim Kolody, CH2MHill John Milton, Washington DOT Brelend Gowan, TRB HSM Task Force, Policy Subcommittee Priscilla Tobias, Illinois DOT
Session 7: Opening Session		Priscilla Tobias, Illinois DOT Geni Bahar, NAVIGATS
Session 8: Examples of Use of Default SPFs in HSM, Safety Analyst, and Interactive Highway Safety Design Model (IHSDM)	 *Development of State or Local Agency SPFs for Use in the HSM, IHSDM, and Safety Analyst* *Use and Modification of Default SPFs in the Interactive Highway Safety Design Model (IHSDM)* Q & A Panel	Moderator: Ray Krammes, FHWA Recorder: Kim Kolody, CH2MHill Doug Harwood, Midwest Research Institute Mike Dimaiuta, FHWA
Session 9: Use of the State-Developed SPFs in Their Own Tools and the National Perspective	 *Uses of Safety Performance Functions and Potential for Safety Improvement Values* *CDOT: SPF Use at the Project and Program Levels in Colorado* *Use of Own State Developed SPFs in their Own Tools & the National Perspective* *Local SPF Use -- Iowa* *The National Perspective*	Moderator: Priscilla Tobias Recorder: Kim Kolody, CH2MHill Dave Piper, Illinois DOT Jake Kononov, Colorado John Milton, Washington DOT Michael Pawlovich, Iowa DOT Mike Griffith, FHWA
Session 10: Training Opportunities	 *Brief Overview of Related Courses in USA/Canada* *HSM Use and Training*	Moderator: Geni Bahar, NAVIGATS Inc. Geni Bahar, NAVIGATS Karen Dixon, Oregon State University & Principal Investigator for the NCHRP 17-38
Session 11: Implementation Next	*Establish your goal(s) for the year such as:*	Moderator: Mike Griffith, FHWA Recorder: Geni Bahar, NAVIGATS

Steps and Closing Remarks	• *development of SPF such as crash data preparation* • *traffic volume data preparation* • *roadway inventory preparation* • *SPF development* • *SPF calibration* • *base models etc.* *2. Develop training – internal and external resources* *3. Interactions between agencies*	Panel: Priscilla Tobias, Illinois DOT; Stephen Read, Virginia DOT; Jake Kononov, Colorado DOT

3.2. SUMMARY OF THE SESSIONS - PRESENTATION AND DISCUSSION

The sessions and discussions are summarized in this section of the report and the complete discussion records are enclosed in Appendix D.

Session 1: Opening

Ms. Priscilla Tobias, Illinois DOT and 2009 SPF Summit Chair, welcomed the attendees and briefly introduced the safety program in Illinois and the information to be presented at the summit.

Session 2: History

In this session, five speakers presented the history of SPFs and discussed how to bridge the research and practice of safety performance functions.

Mr. Rick Pain and Mr. John Milton represented the TRB and HSM Task Force and talked about their organizations' perspective on the SPFs. Mr. Joel McCarroll from AASHTO and Ms. Priscilla Tobias, Vice Chair AASHTO Joint Task Force for the HSM, presented AASHTO's vision of utilizing SPFs to improve highway safety. Ms. Geni Bahar from NAVIGATS Inc. provided a thorough review on the history of SPF and its importance as compared with the traditional crash rate approach.

At the end of the session, a short discussion was stimulated regarding the differences between the SPF approach and the traditional crash rate approach.

Session 3: SPF Development and Data Needs (National and State Initiatives)

In this session, Mr. Mario Candia-Martinez from Kittleson & Associates Inc., Mr. Mike Dimaiuta from FHWA, and Mr. Ray Krammes from FHWA respectively introduced the roles of SPFs in the HSM, the IHSDM, and the *Safety Analyst*. Mr. Doug Harwood from Midwest Research Institute further talked about the calibration of SPFs in the HSM, IHSDM, and *Safety Analyst*. The next three speakers introduced their experiences with regard to SPF development in their states. Mr. Yanfeng Ouyang from the University of Illinois gave a 20-minute presentation on the SPF Development in Illinois, and Mr. John Milton from WSDOT presented the SPF Development and Data Needs in Washington. Finally, Mr. Jake Kononov from Colorado DOT talked about the development and 10 years of application of SPF as a practical approach.
This session was concluded with a 20-minute Q & A that included how the crashes should be counted (during and out of congestion), how to establish a roadside hazard rating, how to enhance training and understanding of calibration factors, and what to do in case intersection data is lacking.

Session 4: SPFs Applications by State DOTs

In this session, experts from various states discussed SPF applications and experiences. Mr. Stephen Read from Virginia DOT talked about the past, present, and future initiatives of safety modeling in Virginia. Ms. Kim Kolody from CH2M Hill representing Illinois DOT discussed the SPF applications for safety analysis in Illinois. Mr. John Milton from Washington DOT talked about SPF Applications by state DOTs. Mr. Jake Kononov from Colorado DOT talked about CDOT's 10 years of SPF applications and experience.

The discussion after the presentations included other states' experiences with SPFs versus crash rates. The audience was very interested in how to develop and calibrate SPFs for local roads and specifically whether a separate set of SPFs should be developed for local roads or be integrated with facilities under state jurisdiction.

Session 5: Policy Level Issues Related to Safety in the Scheme of Planning, Design, and Operations, Forecasting and Prevention

In this session, policy issues were discussed in two presentations. Mr. Tim Neuman from CH2M Hill talked about quantifying safety in project development. Mr. John Milton from Washington DOT discussed policy level issues related to safety in the project and program development.

Finally, a 25-minute facilitated discussion about policy issues wrapped up this session. It is the current practice to use pavement condition rating as the driving force behind roadway improvement projects. It was generally agreed that safety performance should also be driving roadway improvements.

Session 6: Tort Liability Issues Related to Safety in the Scheme of Planning, Design, and Operations, Forecasting and Prevention

In this session, Mr. John Milton of Washington DOT gave a presentation on "Tort Liability Issues Related to Safety in Project & Program Development Stages." Brelend Gowan from TRB HSM Task Force, Policy Subcommittee discussed the "legal implications of use and non-use of SPFs."

Facilitated discussions continued to explore the tort liability issues at the end of this session. The audience discussed the proper use of safety-related terms such as LOSS, and how state agencies can be protected while they prepare safety assessment reports and address safety within available budget.

Session 7: Opening Session on Day Two

Ms. Priscilla Tobias representing the Illinois DOT gave an opening speech for the second day of the Summit. Geni Bahar summarized the highlights from the sessions on the first day.

Session 8: Examples of Use of Default SPFs in HSM, *Safety Analyst*, and Interactive Highway Safety Design Model (IHSDM)

This session included two presentations and a panel Q & A section. The first presentation, given by Doug Harwood from Midwest Research Institute, explored the development of state or local agency SPFs for use in the HSM, IHSDM, and *Safety Analyst*. The next presentation by Mike Dimaiuta from FHWA discussed the use and modification of default SPFs in the Interactive Highway Safety Design Model (IHSDM).

This session ended with a 15-minute Panel Q & A, in which possible FHWA support for the states to acquire *Safety Analyst* and IHDSM was discussed.

Session 9: Use of the State-Developed SPFs in Their Own Tools and the National Perspective

This session included five presentations, and started with a discussion on “Uses of Safety Performance Functions and Potential for Safety Improvement Values” by Dave Piper from Illinois DOT. Both Mr. Jake Kononov from Colorado DOT and Mr. Michael Pawlovich from Iowa DOT provided their local SPF uses at the project and program levels. John Milton from Washington DOT also discussed the use of state-developed SPFs in their state-specific tools and the national perspective.

Mr. Mike Griffith from FHWA concluded this session by hosting a 10-minute Q & A session. The audience asked about the speakers’ experience with SPF-based decision-making, how the trade-offs between safety and capacity are addressed, and whether detailed safety analysis is conducted centrally or outsourced.

Session 10: Training Opportunities

This session discussed training opportunities. Geni Bahar, NAVIGATS, outlined a brief overview of related courses in USA/Canada. Karen Dixon, Oregon State University and as a Principal Investigator for the NCHRP 17-38, provided experiences of HSM use and training.

Session 11: Implementation Next Steps and Closing Remarks

Mr. Mike Griffith started this session by presenting the national perspective on SPFs. A panel was formed to talk about next steps of SPF implementation. The panelists included Ms. Priscilla Tobias from Illinois DOT, Mr. Stephen Read from Virginia DOT, and Mr. Jake Kononov from Colorado DOT.

At the end of this session, suggestions regarding SPF implementation and several closing remarks were made by the attendees. More details can be found in Appendix E.

CHAPTER 4 SURVEY FEEDBACK

At the summit, the attendees were requested to fill out a 1-page, double-sized survey which provided valuable feedback to the summit organizing committee. A copy of the survey is available in Appendix E. A total of 58 responses were collected at the end of the summit.

The attendees were asked about their satisfaction with a few key aspects of the summit. As shown in Table 2, almost all respondents (97%) said that they were very satisfied or satisfied with all aspects of the summit, including registration process, materials/handouts, speakers/presenters, and venue/facility.

Table 2. Respondents' Overall Satisfaction

Overall Satisfaction	**Very Satisfied**	**Somewhat Satisfied**	**Neutral**	**Somewhat Dissatisfied**	**Very Dissatisfied**	**Total**
Registration Process	50	6	2			58
Materials/Handouts	41	17				58
Speakers/Presenters	43	13	1	1		58
Venue/Facility	41	16	1			58

The survey included a question on how the attendees would like the summit to improve. Only 29 responses were provided. About five respondents suggested reducing overlaps among topics, broadening the range of speakers, and providing more basic information or elementary discussion. A few respondents suggested adding breakout sessions for detailed discussion, etc. These comments will be carefully considered when planning for future summits.

A total of 52 attendees responded to Question 2: "What did you like most about the summit, and what is your most important gain from this summit?" The answers are summarized in Table 3. More than half of the respondents stated that they benefited from learning about basic information and an overview of SPF experiences in different states. SPF applications in HSM, IHDSM and *Safety Analyst* were also important to the attendees. Some attendees also reported that they benefited from good presentations and networking opportunities.

Table 3. Respondents' Most Important Gain

Most Important Gain	**Number of Suggestions**
Introduction and Overview of SPF's	8
SPF's in Different States	29
Great Presentations	5
National, State, Private Sector Levels	2
HSM, IHDSM, *Safety Analyst* Information	5
Networking Opportunities	3
Policy/Tort Session	4
TOTAL	52

The attendees were asked "Do you plan to attend the summit again in the near future (e.g., next year)?" An absolute majority of the attendees stated that they would plan to come next year; as shown in Table 4. During the course of the conference, many attendees also stated they were interested in bringing more participants from their states to benefit from the (next) summit.

Table 4. Respondents' Plan on Attending Next Year

Plan on Attending Next Year	
Yes	47
No	2
Undecided	4

Table 5 shows a summary of 45 responses to Question 3 on the kinds of sessions to be included next year. Training and hands-on exercises and positive SPF experiences are the two sessions most frequently proposed by attendees. Other major suggestions focus on model development, implementation and use of SPF, SPF experiences from more states, and further progress of states.

Table 5. Respondents' Preference of Sessions to be Included Next Year

Kinds of Session to be Included Next Year	
Model Development	8
Diagnostic Applications	3
Implementation and use	7
More States	7
Further Progress of States	7
Training and Hands-On Exercises	10
Positive SPF Experiences of States	10
HSM, IHDSM, *Safety Analyst*	5
Long Technical Session	2
Organizational Challenges of SPF	1
Local Level	4
Basic Information on SPF and Software	3
TOTAL	45

The last question in the survey asks the attendees what types of assistance they anticipate needing in the coming year to develop and implement SPFs. The responses included a variety of suggestions and ideas about resources and support needs. Among them, nearly half of the attendees suggested training sessions as resources and support of the conference. In addition, 15 out of 37 responses supported either webinars/web conferences or necessary tutorials at next year's SPF summit. Table 6 details the suggested resources and support.

Table 6. Respondents' Perception on Resource and Support Needs

Kinds of Resources and Support	
Training	18
Webinars/ Web Conferences	7
Tutorials	8
Funding	3
Funding-State and Local Level	6
Funding-National Level	2
Discussion Forum	1
Meetings	3
Technical Expertise	1
Data Collection	4
TOTAL	37

Overall, the survey feedback demonstrates that the 2009 SPF summit has very successfully achieved its objective. The attendees have benefited significantly from this event and they look forward to attending future summits so they can benefit from the momentum and engage in activities to continue the advancement in the explicit quantification of safety.

CHAPTER 5 NEXT STEPS[1]

The vision for follow-up to the first Safety Performance Function Summit has four elements: another summit learning and exchange event, webinars, CEO materials, and an SPF clearinghouse. These elements are described in more detail below.

5.1 NEXT PEER-TO-PEER SAFETY PRACTICES EVENT

Hosting a second safety analysis learning summit would fulfill some of the need for additional learning and exchange support, and it would address the requests of the 2009 summit participants on further extending their state and national program goals of reducing fatal and severe crashes on the nation's highways. Almost all of the 2009 summit survey respondents said that they would like to attend another SPF summit, and of those, several indicated an interest in bringing additional staff from their agencies and partnering agencies. Participants of the first SPF summit also indicated an interest in learning about a wide range of topics – from the basics of safety analysis techniques to more advanced principals and applications. Attendees were also interested in participating in hands-on activities to apply the lessons learned.

As a result, the next summit may be a workshop format covering a variety of topics with parallel exercises to enhance the learning process. Some of the meeting topics may include:

- basic introduction to SPFs – modeling, calibrations etc. – with hands-on examples
- advanced use of SPFs with hands-on examples
- basic introduction to explicit safety with hands-on examples
- basic introduction to HSM – use 17-38 project on how to use HSM
- use of *Safety Analyst* software – with existing training
- use of IHSDM – with existing software training

To accommodate various needs of the participants, from analysts to leaders, the summit may be held for three days with the first 1.5 days focusing on more basic information and the second 1.5 days intended for the more advanced users. The goal would be to support two people from each lead state (10 to 12) and additional staff from the Illinois Department of Transportation (IDOT). This would allow a representative from headquarters and district safety analyst from each of the lead states as well as staff from IDOT central and district offices. In the future, it would be desirable to include representatives from local municipalities as well as to promote best safety practices and reduce fatalities on the state and local roadway system. For budgeting purposes, approximately 130 participants are anticipated. To maximize attendance, the summit would likely be held in the fall to allow coordination with other national and local events and avoid the peak of the summer months. Although the summit would help to institutionalize the science of safety, it became clear that the benefit of periodic interactive learning events would be enhanced by offering educational webinars to continue the learning and exchange process between summits.

[1] This section was prepared by Kimberly Kolody with CH2M HILL.

5.2. SAFETY ANALYSIS WEBINARS

Building on the momentum of the first summit and leading into the next, national webinars may be provided approximately every two months for a total of four to six depending on the schedule. Webinar content would vary to address the needs of safety professionals at various levels of agencies: executive, management, and analyst. The overall approach for the webinars would be addressed in the first session so the appropriate attendees would be notified of the topics in advance of the upcoming sessions. The topics for the webinars would come directly from the feedback received at the summit and therefore result in a productive second summit. (See Table 7 for potential Safety Analysis webinar topics.)

Table 7. Potential Safety Analysis Webinar Topics

Executive Level	Management Level	Analyst Level
Institutionalizing the science of safety: Implementation of safety techniques into DOT processes i.e. planning, design, construction	Defining the global umbrella of SPFs	Defining the global umbrella of SPFs
	Understanding available tools and resources and their applications i.e. HSM, SA, IHSDM	Basic safety analysis techniques
	Understanding the benefits of SPF over traditional safety analysis methods like crash rate and frequency	Advanced safety analysis techniques including data requirements and minimums
	SPF applications in policy and the planning process; EA, EIS, 3R	Use of advanced techniques in Safety Analyst / HSM

Some of the webinars would utilize presentation materials that have been developed for other specific training courses. The following potential resources may be the starting point for the Safety Analysis webinars:

- *Safety Analyst*
- National Highway Institute
- National Transportation Highway Safety Association
- Highway Safety Manual

Training courses are being developed for the Highway Safety Manual, *Safety Analyst,* and the Highway Safety Improvement Program. While these training sessions serve specific needs, they will be taught over a couple of days in a classroom setting that may not be as widely distributed. It is anticipated that the *Safety Analysis* webinars would be an hour long and each presentation would be provided twice to accommodate different time zones and attract a wider audience.

5.3. SAFETY ANALYSIS MARKETING MATERIALS FOR CEOS

It is important to provide information to safety professionals at all levels, including executives at the DOTs. Marketing materials would be prepared to educate executives on safety analysis techniques and gain their support for integrating the science of safety into business practices. Marketing materials would be complied to present at the Annual Spring CEO meeting and similar information would be provided to agencies to share with their CEOs.

5.4. SAFETY PERFORMANCE FUNCTION CLEARINGHOUSE

Hundreds of safety performance functions have been developed to analyze safety around the world. The AASHTO Safety Management Subcommittee would initiate an SPF clearinghouse to share the SPFs that have been developed for potential use by other agencies. The AASHTO Subcommittee would pursue the development of a web portal, develop a template for submission of information, provide a team to review and accept/reject submissions, and send an invitation to those who have SPFs to submit to the review group.

APPENDIX A: SUMMIT ATTENDEES (BY STATE AND ORGANIZATION) AND SPEAKER BIOGRAPHIES

2009 National SPF Attended List

James Allen
Illinois Department of Transportation

Bryan Allery
Colorado Department of Transportation

Cemal Ayvalik
Cambridge Systematics

Dennis Bachman
Woodford County Highway Department

Geni Bahar
NAVIGATS Inc.

Charity Belford
Georgia Department of Transportation

Darryl Belz
Maine Department of Transportation

Duane Brunell
Maine Department of Transportation

Steven Buckley
Kansas Department of Transportation

Tom Buckley
Louisiana Department of Transportation and Development

Mario Candia
Kittleson & Associates, Inc.

James Ceragioli
Nevada Department of Transportation

James Chapman
Louisiana Department of Transportation

Shaila Chowdhury
California Department of Transportation

Norm Cressman
Georgia Department of Transportation

Mike Curtit
Missouri Department of Transportation

Michael Dimaiuta
LENDIS Corp.

Karen Dixon
Oregon Department of Transportation

Patrick Dolan
Tennessee Department of Safety

Faria Emamian
Oklahoma Department of Transportation

2009 National SPF Attended List

Michael Fontaine
Virginia Department of Transportation

Terrence H. Fountain
Illinois Department of Transportation

Albert Gan
Florida International University

Michael Gillette
Illinois Department of Transportation

Mehrdad Givechi
Kansas University Transportation Center

David Glabas
Oklahoma Department of Transportation

Brelend Gowan
California Department of Transportation
Emeritus

Michael Griffith
Federal Highway Administration

Kevin Haas
Oregon Department of Transportation

Brett Harrelson
South Carolina Department of Transportation

Douglas Harwood
Midwest Research Institute

Patrick Hasson
Federal Highway Administration

Alan Ho
Federal Highway Administration

Robert Hull
Utah Department of Transportation

Kurt Johnson
North Dakota State University

W. Scott Jones
Utah Department of Transportation

Dean Kanitz
Michigan Department of Transportation

Anthony Khawaja
IACE

Kimberly Kolody
CH2M HILL

Jake Kononov
Colorado Department of Transportation

2009 National SPF Attended List

Ray Krammes
Federal Highway Administration

Dale Lighthizer
Michigan Department of Transportation

Ron Lipps
Maryland State Highway Administration

Tracy Lovell
Kentucky Transportation Cabinet

Joel McCarroll
AASHTO

Thomas McDonald
Iowa State University

John Miller
Missouri Department of Transportation

John Milton
Washington State Department of Transportation

Ian Morris
Tennessee Department of Safety

Murray Mullen
California Department of Transportation

Brian Murphy
North Carolina Department of Transportation

Roseanne Nance
Illinois Department of Transportation

Timothy Neuman
CH2M HILL

Chimai Ngo
Federal Highway Association

Chuck Niessner
Transportation Research Board

Barbara O'Rourke
New York State Department of Transportation

Yanfeng Ouyang
University of Illinois

Richard Pain
Transportation Research Board

Jawad Paracha
Maryland State Highway Administration

Shaun Parkman
Kansas Department of Transportation

2009 National SPF Attended List

Michael Pawlovich
Iowa Department of Transportation

Greg Piland
Federal Highway Administration

David Piper
Illinois Department of Transportation

Bonnie Polin
MassHighway

Stephen Read
Virginia Department of Transportation

Charles Reider
Nevada Department of Transportation

Rob Robinson
Illinois Deptartment of Transportation

Joe Santos
Florida Department of Transportation

Cathy Satterfield
Federal Highway Association

Andrew Sattinger
New York State Department of Transportation

Lisa Schletzbaum
Massachusetts Highway Department

Hadi Shirazi
Louisiana Department of Transportation and Development

David Speicher
Illinois Department of Transportation

Raghavan Srinivasan
University of North Carolina

Esther Strawder
Federal Highway Association

Frank Sullivan
Florida Department of Transporation

Rebecca Szymkowski
Wisconsin Department of Transportation

Tim Tharpe
Kentucky Transportation Cabinet

Gordon Thompson
New Hampshire Department of Transportation

Nicole Thompson
Champaign County Regional Planning Commission

2009 National SPF Attended List

Priscilla Tobias
Illinois Department of Transportation

Nsima Udoko
Tennessee Department of Safety

Rudy Umbs
Federal Highway Administration

Kimberly Vachal
North Dakota State University

Sarah Weissman
Rutgers University

Roger Wentz
ATSSA

Julie Whitcher
Minnesota Department of Transportation

Hugo Zhou
Southern Illinois University

Jim Allen, P.E.

Jim Allen is the Safety Implementation Engineer for the IDOT Central Bureau of Safety Engineering. His experience includes work as a Safety and Health Engineer with the Oklahoma State University Extension Service, IDOT Bureau of Bridges and Structures, IDOT Bureau of Local Roads and Streets, and Assistant County Engineer for Logan County, Illinois. He is also a Major in the U.S. Army Reserves and is currently an Instructor at the Command and General Staff College. Jim graduated from Texas A&M University and is a Registered Professional Engineer in the state of Illinois.

Bryan Allery, P.E.

Bryan Allery is a long time student of Dr. Ezra Hauer. He is Safety Programs Engineer at CDOT and has over 20 years of experience in transportation engineering, 7 years at CALTRANS, and 13 years at CDOT. Bryan is nationally recognized expert on traffic records, accident analysis, and safety program management. He has extensive experience in developing Safety Management Systems and related computer programming. Bryan is highly experienced transportation engineer in the areas of design, construction management, materials, geometric design, and traffic engineering. He has served as a research study panel member at the National Cooperative Highway Research Program (NCHRP). Bryan together with Dr. Kononov has coauthored a number of research papers on road safety published by the TRB. Bryan is a Registered Professional Engineer in Colorado and California.

Geni Bahar

Ms. Geni Bahar, P.Eng., P.E. of NAVIGATS Inc. is a civil engineer specializing in road safety, with 30 years of professional experience. Geni has led over 100 projects and many included office and field investigations for identification of the specific issues of the site operations and possible shortcomings toward the selection of effective treatments. Geni has also been involved in many systemic screenings for wide application of treatments and programming for cost-effective application of available funds. Her work has included safety treatments and other enhancements in rural hamlets, suburban corridors, small to large urban centres, rural two-lane to multi-lane highways, and simple and complex freeways. The Transportation Association of Canada awarded Geni the 2007 Transportation Person of the Year award in recognition of her leadership, excellence, and achievements. Geni is an active member of key professional associations and committees: ITE and the Transportation Safety Executive Council (since 2000); TRB Committee for Transportation Safety Management, TRB Committee for Safety Data and Statistics, TRB Task Force for Highway Safety Manual, Canadian Association of Road Safety Professionals, PIARC, TAC Standing Committees for Road Safety, and TAC's Standing Committee for Geometric Design Standard

Mario Candia-Martinez

Mario is an Engineering Associate at Kittelson & Associates' Orlando, Florida office. He has a diverse background in transportation planning, traffic operations, and research and has been involved in a variety of projects throughout the U.S. and abroad. Mario has experience in the conduction of roadway safety audits, and has recently served as a key team member in the development of the first edition of the Highway Safety Manual. Mario holds Bachelors and Masters degrees from the University of Idaho.

Mike Dimaiuta

Mike Dimaiuta has managed the Geometric Design Lab at FHWA's Turner-Fairbank Highway Research Center in McLean, Virginia since 1995. The Lab provides support to FHWA's Office of Safety Research and Development in developing, enhancing and facilitating implementation of the Interactive Highway Safety Design Model (IHSDM).
Mike is a member of TRB's Highway Safety Manual Task Force and the Committee on the Operational Effects of Geometrics.

Karen Dixon

Karen Dixon, Ph.D, P.E. is an Associate Professor in the School of Civil and Construction Engineering at Oregon State University. Dr. Dixon both teaches and performs research in the areas of highway design, traffic operations, and safety. Prior to joining the faculty at Oregon State University, Dr. Dixon was a tenured Associate Professor at the Georgia Institute of Technology. In the initial stages of her career in transportation, Dr. Dixon worked as an engineering consultant where she was directly responsible for the design of numerous road systems in the rural and urban environment. Dr. Dixon's practical engineering experience spans from the design of low-speed access-oriented local roads up to the high-speed mobility-emphasis urban freeway interchange. She is a Registered Professional Engineer in the states of Georgia, Arizona, and Texas. She has degrees from Texas A&M and North Carolina State University.

Brelend C. Gowan

Brelend received his Bachelor of Arts degree from the University of California at Davis in 1967. He received his Juris Doctor degree in 1971 from the University of the Pacific, McGeorge School of Law, where he was an editor and founding member of its Pacific Law Journal. From 1999 to 2004, Brelend was also an Adjunct Professor of Law teaching Government Tort Liability. In 2005, Brelend retired from a 33-year career as a tort litigation attorney with the Legal Division of the California Department of Transportation, the last 12 years of which he served as its Deputy Chief Counsel. He continues to work on special projects for the Department. Brelend is a member of the American Bar Association's Litigation Section and Tort and Insurance Practice Section. He is an Emeritus Member and former Chair of the Transportation Research Board's Committee on Tort Liability and Risk Management and member and former Chair of the Legal Resources Group Executive Board. Finally, Brelend is the Chair of the Policy Subcommittee of the TRB Task Force for the Development of the Highway Safety Manual.

Michael Griffith

Michael Griffith is the Director of the Office of Safety Integration with FHWA's Office of Safety

Douglas W. Harwood

Douglas W. Harwood directs the Transportation Research Center at Midwest Research Institute in Kansas City, Missouri. Mr. Harwood has nearly 36 years of experience in highway safety research for Federal, State, and local agencies. He is a member of the TRB Committee on Operational Effects of Geometrics and the TRB Task Force on Development of the Highway Safety Manual. He holds a B.S. in Civil Engineering from Clarkson University and an M.S. in Transportation Engineering from Purdue University.

Robert E. Hull

Director of Traffic and Safety
Utah Department of Transportation
Education:
-Bachelors of Science Degree in Civil Engineering, University of Utah, 1990

-Bachelors of Science Degree in Marketing, Utah State University, 1984
Professional Experience:
-Mr. Hull has served with the Utah DOT for 20 years. He is responsible for developing and issuing statewide direction, policies, and procedures for all traffic and safety management related programs. He manages all planning and programming of Federal and State funding used in transportation safety programs and projects. In addition, he is responsible for all engineering standards related to traffic and safety.
-Mr. Hull developed and directs the Zero Fatalities program for Utah. This program represents the umbrella program to all other traffic safety programs in Utah and provides the goal and direction for improving safety through the Utah Comprehensive Safety Plan. The Zero Fatalities program won a 2008 Emmy for Community/Public Service programs.
-Mr. Hull has held several positions within UDOT. His experience includes statewide and region service in Maintenance, Urban Planning, Materials, Traffic Operations, and Safety.
-He is a licensed professional engineer in Utah.
Professional Affiliations:
-Transportation Research Board Committee on Transportation Safety Management, Co-Chair
-National Cooperative Highway Research Program, Project 08-76, Institutionalizing Safety in Transportation Planning Processes: Techniques, Tactics, and Strategies, Panel Chair
-AASHTO Subcommittee on Traffic Engineering
-AASHTO Subcommittee on Safety Management, Technical Information and Resources Task Group Chair
-AASHTO Highway Safety Manual Joint Task Force
-National Committee on Uniform Traffic Control Devices, Guide and Motorist Information Technical Committee Secretary
-World Road Association (PIARC), Former Safety Technical Committee Member
Honors:
-AASHTO President's Transportation Award in Highway Traffic Safety, 2007

Kimberly Kolody Silverman, PE
Kim has worked with CH2M HILL for the past 12 years as project manager and transportation engineer focusing mainly on transportation planning and safety studies. Over the past three years she has assisted the Illinois Department of Transportation Bureau of Safety Engineering in the implementation of their Strategic Highway Safety Plan, including leading implementation teams, reviewing and preparing policies and providing technical guidance and support. Kim is the Secretary of the Illinois Chapter of the Institute of Transportation Engineers and has served as the ITE Technical Director and on the Technical Committee. She has authored research papers on the subjects of transportation planning and safety, and has participated in technical training programs.

Jake Kononov, Ph.D., P.E.
Jake is a long time student of Dr. Ezra Hauer, he has over 25 years of experience in all aspects of highway and traffic engineering at the Colorado DOT. He spent 5 years as the Denver Metro Area Chief Traffic and Safety Engineer and is currently Director of Research for the Colorado Department of Transportation. Jake is a chairman of the TRB Committee on Safety Management and served on a number of research study panels at the National Cooperative Highway Research Program (NCHRP). Dr. Kononov is an author of numerous research papers on road safety published by the TRB, Swedish National Road and Transport Institute (VTI), German Road Research Institute (BAST), Italian Society of Highway Infrastructure (SIIV) and Publics Works Magazine. Dr. Kononov is an Associate Professor-adjunct at the Graduate School of Civil Engineering at the University of Colorado in Boulder. Jake is a member of the Colorado/Wyoming ITE Chapter.

Raymond A. Krammes
Ray Krammes is Technical Director in the Federal Highway Administration Office of Safety Research and Development. Ray has worked with the TRB Task Force on Development of the Highway Safety Manual since its inception and the panels overseeing the NCHRP projects that produced materials for the Manual. He also managed development of the SafetyAnalyst software package that will support implementation of Part B of the Manual and the Interactive Highway Safety Design Model, whose Crash Prediction Module will be a faithful implementation of the Part C Predictive Methods. Ray received his B.S., M.S., and Ph.D. in Civil Engineering from the Pennsylvania State University. Prior to joining FHWA in 1997, he taught in the Civil Engineering Department at Texas A&M University and conducted research through the Texas Transportation Institute.

John C. Milton, Ph.D., P.E. – Director of Enterprise Risk Management, WSDOT
John currently serves as the Director of Enterprise Risk Management for the Department of Transportation. He is a licensed engineer with 20 years of experience in transportation and traffic engineering, and recently served as Project Director, for the SR 520 Bridge Replacement and HOV Program, a $4.4 billion project. He has held a number of engineering positions in WSDOT's design, traffic and planning sections. John holds a B.S. in Civil Engineering and a Masters in Engineering Management from St. Martin's College; he also holds a M.S. and Ph.D. in Civil Engineering from the University of Washington. His research has focused on econometric and statistical modeling of the frequency and severity of collisions. John serves on five separate National Academy of Engineering research panels with an emphasis on highway safety and data analysis and serves on three national committees with the Transportation Research Board. He is the Chair of the Transportation Research Board Task Force for the Development of a Highway Safety Manual.

Timothy R. Neuman, PE
Timothy Neuman is Vice President and Chief Highway Engineer for CH2M HILL. He has over 34 years of experience in the planning and design of major highways, freeways and interchanges for over 20 state DOTs. Freeway and interchange projects in which he played a leadership role include the Marquette Interchange in Milwaukee, WI; I-70/I-75 in Montgomery County, OH; I-235 in Des Moines, IA; the North Central Expressway (US 75) in Dallas, TX; I-74 in Moline, IL; SR 520 and SR 202 in Redmond, WS and I-75/M 59 in Oakland County, MI. He participated in a number of FHWA's ACTT workshops on complex freeway corridor projects around the country; and has developed and taught professional courses on interchange planning and design for the FHWA and the American Society of Civil Engineers.
Mr. Neuman is also a nationally recognized expert in highway safety and traffic operations related to geometric design. He has led or participated in many significant research projects for the NCHRP and FHWA, including NCHRP 362 *Roadway Widths for Low Traffic Volume Roads*, NCHRP Project 20-7 Task 75 "Geometric Design for Very Low Volume Local Roads" and NCHRP 430 on *Improved Safety Information to Support Highway Design*. Mr. Neuman served as project director for NCHRP Project 17-18(3) on "Implementation of AASHTO's Strategic Highway Safety Plan." This project has produced a series of guidance documents published as NCHRP Report 500, and web-based guides maintained by AASHTO. He was a special consultant to the FHWA on numerous aspects of the development of their Interactive Highway Safety Design Model. Tim Neuman is a nationally recognized expert in the Context Sensitive Design field, through both project work and research. He served as co-principal investigator for NCHRP 15-19, "Application of Context Sensitive Design Principles," which resulted in the publication of NCHRP Report 480, *Best Practices for Achieving Context Sensitive Solutions*. He assisted in development of a CH2M HILL 's two-day training course on Context Sensitive

Solutions, which has been taught to over 20 state DOTs and other agencies around the country on behalf of FHWA. He also served as technical editor for AASHTO on development of a companion policy document to FHWA's *Flexibility in Highway Design*, published as *A Guide for Achieving Flexibility in Highway Design, May 2004*. He has been a featured speaker on CSS and highway design at national and international conferences, including most recently the keynote speaker at the University of Vermont sponsored national conference in June 2007 'Transportation and Historic Preservation – The Road to Affordable Context Sensitive Solutions.' He served on the national AASHTO-led 'Thinking Beyond the Pavement/Context Sensitive Solutions' Task Force. He has also served as a special highway technical advisor to *Scenic America*. Mr. Neuman has authored a number of widely used references, including NCHRP Report 279, *Intersection Channelization Design Guide*, the chapter on Geometric Design in both the 4th and 5tth editions of ITE's *Traffic Engineering Handbook*, and chapter on urban intersections in ITE's *Traffic Safety Toolbox*. He is recipient of ITE's Past Presidents' Award, and TRB's D. Grant Mickle Award. Mr. Neuman recently completed an appointment on the TRB/FHWA Research and Technology Coordinating Committee. He is a former member of TRB Committee A2A02, Committee on Geometric Design of Highways, and a member of the TRB Task Force for the Development of a Highway Safety Manual.
Tim Neuman is a graduate of the University of Michigan, with B.S in Civil Engineering and M.S. in Engineering, and is a registered professional engineer.

Yanfeng Ouyang
Yanfeng Ouyang is an assistant professor and the Paul F. Kent Endowed Faculty Scholar in the Department of Civil and Environmental Engineering at the University of Illinois, Urbana-Champaign. His research interests lie in transportation planning, logistics systems, traffic operations, and safety modeling. In the past years, he worked with IDOT to develop SPFs and local application tools for the state of Illinois. He currently serves on the editorial advisory board for the journals Transportation Research Part B, ASCE Journal of Infrastructure Systems, and is a member of the Transportation Research Board's Network Modeling Committee (ADB30). Yanfeng received the Faculty Early Career Development (CAREER) Award from the U.S. National Science Foundation in April 2008, and the Gordon F. Newell Award from the University of California at Berkeley in 2005. He received his Ph.D. in civil engineering from Berkeley in 2005.

Michael D. Pawlovich
Michael D. Pawlovich, Ph.D., P.E. joined the Iowa Department of Transportation Office of Traffic and Safety in March 2000. He holds a Ph.D. in Civil Engineering from Iowa State University. While a graduate student at the ISU Center for Transportation Research and Education, Michael initiated work on Iowa's GIS safety data analysis software. In his current position as Traffic Safety/Crash Engineer, he has continued to work on GIS development personally and via contract technical management. GIS-SAVER (Safety Analysis, Visualization, and Exploration Resource) has expanded beyond crash and roadway data to reflect a broader safety aim with influences from engineering, enforcement, emergency response, education, and other disciplines. Over the past several years, he has also played a role in revamping Iowa's crash reporting form to reflect MMUCC guidelines. As part of this, he helped redevelop the process used to transfer the data from mainframe to PC applications and validate or edit the crash records for inconsistencies or errors. Having primary access to the data, he has played an integral role in many analyses done using the new crash form data, including a recent 4-lane to 3-lane study, as well as several responses to data requests by various NCHRP projects.

Dave Piper
Dave Piper is the Safety Design Engineer in the IDOT Bureau of Safety Engineering. He works with IDOT Districts and others to assist in developing Highway Safety Engineering Program (HSIP) from screening to coordination of projects, and other responses to safety concerns. Dave has responsibilities for RSAs and roadside safety hardware, such as guardrail, cable median barrier, and crash cushions approved for use by the Department. In 1980 Dave graduated the University of Illinois with a BS degree in Civil Engineering. As a result of coming in through the cooperative program between the University of Illinois and Illinois College, he also received a concurrent BA degree in Mathematics from Illinois College. Dave has worked continuously with IDOT since his graduation, first in District 5, Paris for almost 22 years in Construction, Land Acquisition and Design in various responsibilities. In 2002 he accepted a position in the IDOT Headquarters working in the Highway Policy section in Design and Environment. He worked there with pavement design and roadside safety issues. When the Bureau of Safety Engineering was founded in 2005 he came along to work in his current position. Much is happening in the developing field of safety engineering and Dave hopes to be involved in bringing better tools and processes to improve safety for those using our roadways, and to make the work easier and more productive for planners and designers.

Stephen W. Read, P.E. (VA), P. Eng. (ON, CANADA)
Position: Highway Safety Improvement Programs Manager
VDOT – Traffic Engineering Division
Education: B. Sc. Civil Eng. (Univ. of New Brunswick, CAN)
M.A. Sc. Civil Eng. (Univ. of Waterloo, CAN)
Experience: 22 years of traffic engineering and multi-modal transportation planning projects, research and management. Project consulting and research work in London, UK; Toronto and Ottawa, ON; and Alexandria, VA. VDOT experience conducting and managing multi-modal corridor environmental, planning, operational, safety studies and research; design project travel forecasting and traffic operations and safety assessments; regional long-range plan development and documentation. Presently leads the highway, bicycle and pedestrian, and rail-grade crossing crash data analysis and safety improvement programs for VDOT.
Other info/activities: Travel, reading, hiking, biking, hockey, lacrosse, tennis.

APPENDIX B: LIST OF ACRONYMS

A list of useful acronyms can be found below.

AADT- Annual Average Daily Traffic

BOD- Biological Oxygen Demand (mg/L)

CHSIM - Comprehensive Highway Safety Improvement Model

CRF- Crash Reduction Factor

DHV- Design Hourly Volume (traffic)

EA- Environmental Assessment

EB - Empirical Bayes(ian)

EIS- Environmental Impact Study/Statement

HSM - Highway Safety Manual

IHSDM- Interactive Highway Safety Design Model

LOSS- Levels of Service for Safety

MRI- Midwest Research Institute

NEPA- 1969 National Environmental Policy Act

PH- Alkalinity Acidity

PHF- Peak Hour Factor

PSI- Potential for Safety Improvements

RTM- Regression to the Mean

SPF- Safety Performance Function

TSS- Total Suspended Solids (mg/L)

APPENDIX C: TUTORIAL (HAUER ET AL., 2001)

Attached is a copy of an excellent SPF tutorial by Dr. Hauer et al (2001).

We acknowledge and thank Dr. Hauer for allowing us to share this excellent and user-friendly tutorial with all the participants of the 2009 National SPF Summit, Chicago, Illinois.

Estimating Safety by the Empirical Bayes Method: A Tutorial.

Ezra Hauer, 35 Merton Street, Apt. 1706, Toronto, ON., Canada. Ezra.Hauer@utoronto.ca
Douglas W. Harwood, Midwest Research Institute, 425 Volker Blvd.,Kansas City, MO 64110. Dharwood@mriresearch.org
Forrest M. Council, Highway Safety Research Center, The University of North Carolina, Chapel Hill, N.C. , council@claire.hsrc.unc.edu
Michael S. Griffith, FHWA, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101. Mike.Griffith@fhwa.dot.gov.

Abstract

The Empirical Bayes method addresses two problems of safety estimation; it increases the precision of estimates beyond what is possible when one is limited to the use of a two-three year history accidents, and it corrects for the regression-to-mean bias. The increase in precision is important when the usual estimate is too imprecise to be useful. The elimination of the regression to mean bias is important whenever the accident history of the entity is in some way connected with the reason why its safety is estimated. The theory of the EB method is well developed. It is now used in the Interactive Highway Safety Design Model (IHSDM) and will be used in the Comprehensive Highway Safety Improvement Model (CHSIM). The time has come for the EB method to be the standard and staple of professional practice. The purpose of this paper is to facilitate the transition from theory into practice

1. INTRODUCTION

The safety of an entity (a road section, an intersection, a driver, a bus fleet etc.) is "the number of accidents (crashes), or accident consequences, by kind and severity, expected to occur on the entity during a specified period." (*1*, p.25). Since what is 'expected' cannot be known, safety can only be estimated, and estimation is in degrees of precision. The precision of an estimate is usually expressed by its standard deviation.

The safety of entities on which many accidents occur during a short period can be estimated quite precisely by using only accident counts. Thus, e.g., if on a road one expects 100 accidents per year, then, with three years of accident counts, one can estimate the average yearly accident frequency with a standard deviation of about /(100/3)=±5.7 accidents/year or 5.7% of the mean. (This is based on the assumption that accident counts are Poisson distributed). Conversely, when it takes a long time for few accidents to occur, the estimate is imprecise. Thus, e.g., if one expects a rail-highway grade crossing or a driver to have one accident in ten years then, with three years of accident counts, the estimate of average yearly accident frequency has a standard deviation of /(0.1/3)=± 0.18. Since the mean is 0.1 accidents/year the standard deviation is 180% of the mean. Thus, one shortcoming of safety estimates that are based on accident counts only is that they may be too imprecise to be useful.

The other shortcoming of safety estimates that are based only on accident counts is that they are subject to a common bias. For practical reasons one is often interested in the safety of entities that either require attention because they seem to have too many accidents, or merit attention because they have fewer accidents than expected. In both cases, were one to estimate safety using accident counts only, the estimate would be biased. The existence of this 'regression-to-mean' bias has been long recognized; it is known to produce inflated estimates of countermeasure effectiveness. Yet, incorrect claims caused by failure to recognize this bias are still being published in the literature. (A recent example is, e.g., Datta et al. (*2*) who claim that low-cost treatments at three intersections in Detroit reduced total accidents by 44%, 48% and 57%. Yet, the three intersections were selected for treatment because their crash frequency, crash rate or casualty rate was higher than that of 95% of intersections and no correction for the regression-to-mean has been applied. Additional recent examples could be cited) Rational management of safety is not possible if published studies give rise to unrealistic expectations about the effectiveness of safety improvements.

The Empirical Bayes (EB) method for the estimation of safety increases the precision of estimation and corrects for the regression-to-mean bias. It is based on the recognition that accident counts are not the only clue to the safety of an entity. Another clue is in what is known about the safety of similar entities. Thus, e.g., consider Mr. Smith, a novice driver in Ontario who had no accidents during his first year of driving. Let it also be known that an average novice driver in Ontario has 0.08 accidents/year. It would be silly to claim that Smith is expected to have zero accidents/year (based on his record only). It would also be peculiar to estimate his safety to be 0.08 accidents/year (by disregarding his accident record). A sensible estimate must be a mixture of the two clues. Similarly, to estimate the safety of a specific segment of, say, a rural two-lane road, one should use not only the accident counts for this segment, but also the knowledge of the typical accident frequency of such roads in the same jurisdiction.

The theoretical framework for combining the information contained in accident counts with the information contained in knowing the safety of similar entities is the EB method. Starting with its application to road safety by Abbess et al. (3) the method is now well developed (*1*, Chapters 11 and 12) and has been widely applied. A recent application of the EB method of safety estimation is the Interactive Highway Safety Design Model (IHSDM, *4*). Another application will be to the Comprehensive Highway Safety Improvement Model (CHSIM) now under development. The time has come for the EB method to be the standard of professional practice; it should be be used whenever the need to estimate road safety arises, whether in the search for sites with promise, the evaluation of the safety effects of interventions, or the assessment of potential safety savings due to site improvements. The purpose of this paper is to be the bridge between theory and practice.

2. THE EB PROCEDURE

The task is to make joint use of two clues to the safety of an entity: the accident record of that entity and the accident frequency expected at similar entities. This expected accident frequency at similar entities is determined by the Safety Performance Function (SPF) about which more will be said in section 3. In the EB estimate the joint use of the two clues is implemented by a weighed average. That is,

Estimate of the Expected Accidents for an entity =
Weight×Accidents expected on similar entities + (1-Weight)×Count of accidents on this entity

where 0#Weight#1 **... 1**

The result is determined by how much 'weight' is given to the accidents expected on similar entities. The strength of the EB method is in the use of a 'weight' that is based on sound logic and on real data. This 'weight' will be seen to depend on the strength of the accident record (how many accidents are to be expected), and on the reliability of the SPF (how different may be the safety of a specific site from the average which the SPF represents).

The EB estimation procedure can be abridged or ***full***. The abridged version makes use of the recent 2-3 years of accident counts and of the average traffic flow for that period. This reflects the now common belief that accident counts that are older than 2-3 years may not represent current conditions. However, the EB procedure removes most reasons for not using older data. Accordingly, the full version of the EB procedure makes use of a longer accident and traffic flow history. Because the full procedure uses more accident counts, the estimate of the full procedure is more precise than the estimate produced by the abridged procedure. Therefore, if data is available, one should strive to use the full procedure.

3. SAFETY PERFORMANCE FUNCTION AND WEIGHT.

The average accident frequency of 'similar sites' and the variation around this average are brought into the EB procedure by the Safety Performance Function (SPF). The SPF is an equation giving an estimate of μ, the average accidents/(km-year) for road segments or accidents/year for intersections, as a function of some trait values (e.g., ADT, Lane width, . . .) and of several regression parameters.

To illustrate, consider the SPF: estimate of $\mu=0.0224\times ADT^{0.564}$ for a certain kind of road in a given jurisdiction. Here ADT plays the role of one traits value, no additional trait values are represented in the SPF, the estimate of one regression parameter is 0.0224, and the estimate of the second regression parameter 0.564. If on a road of this kind ADT=4000 vehicles per day, then one should expect $0.0224 \times 4000^{0.564} = 2.41$ accidents/(km-year).

SPFs are calibrated from data by statistical techniques. In the past it was common to assume that accident counts come from a Poisson distribution. However, researchers found that the accident counts used in the calibration of SPFs are usually more widely dispersed than what would be consistent with the Poisson assumption. This is why it is nowadays common to assume that the accident counts which serve as data come from a negative binomial distribution. One of the parameters of this distribution is the 'overdispersion parameter', denoted here by 'ν'. For road segments, the overdispersion parameter is estimated per-unit-length. That is, the dimension of ν is [1/km] or [1/mile]. The meaning of ν comes from the following relationship: if L is the length of a segment and 0 is the expected number of accidents for that segment, then the variance of accident counts on segments of that kind is $0[1+0/(\nu L)]$. The dimensions of ν and L must be complementary. That is, if in the course of model calibration ν is estimated per km, then L must be measured in kilometres. Note, ν estimated per km = $0.622 \times \nu$ estimated per mile. For intersections L is taken to be one. More detail and an explanation of the sources of overdispersion is in reference (*5*)

Many SPFs and overdispersion parameters have been estimated and the results can be found in the literature. Thus, e.g., Maycock and Hall (*6*) model accidents at roundabouts, Hauer et al.(*7*) model accidents at urban signalized intersections, Bonneson and McCoy (*8*) model accidents at stop-controlled rural intersections, Miaou (9) models truck accidents on rural roads; Vogt and Bared (*10*) model accidents on rural road segments and intersections, Persaud and Dzbik (*11*) model accidents on freeways.

In summary we defined:

μ — the number of accidents/(km-year) for expected on similar segments and accidents/year expected for similar intersections.

0 — the number of accidents during a specified period given by $\mu \times L \times Y$ expected for similar segments and $\mu \times Y$ expected for similar intersections. In this, L stands for segment length and Y for years.

ν — overdispersion parameter estimated per unit length for segments. Naturally, entities for which the accident frequency is not proportional to their length (e.g. intersections or rail-highway grade crossings) have an overdispersion parameter that is not estimated per unit length.

It is now possible to give the expression for the 'weight' used in equation 1. In general:

$$\text{weight} = \frac{1}{1+(\mu \times Y)/\varphi} \qquad \text{... 2}$$

where Y is the number of years of accident counts used. This expression for weight ensures that the variance of the estimate in equation 1 is as small as possible. For a full derivation and justification, see (*1*, pp. 193-194).

4. THE ABRIDGED EB PROCEDURE ILLUSTRATED.

To introduce the abridged procedure consider numerical examples of gradually increasing complexity:

Numerical Example 1: A Road segment with one year of accident counts.

A road segment is 1.8 km long, has an ADT of 4000, and recorded 12 accidents in the last year. The SPF for similar roads is $0.0224 \times ADT^{0.564}$ accidents/(km-year), with an overdispersion parameter ν=2.05/km. To estimate the safety of this road segment proceed as follows.

Step 1: Average for entities of this kind.
Roads such as this have $0.0224 \times 4000^{0.564} = 2.41$ accidents/(km-year), on average. Therefore segments that are 1.8 km long are expected to have 1.8×2.41=4.34 accidents in one year.

Step 2: Weight.
We need a 'weight' for joining the 12 accidents recorded on this road and the 4.34 accidents for an average road of this kind. For weight we use equation 2. Here μ=2.41 accidents/(km-year), Y=1 and the estimate of ν=2.05/km. Therefore: weight = 1/[1+(2.41×1)/2.05] =0.460. Note that both μ and ν are 'per unit length'.

Step 3: Estimate.
Using equation 1 the estimate of the expected accident frequency for the specific road segment at hand is: 0.460×4.34+0.540×12=8.48 accidents in one year. Note that 8.48 is between the average for similar sites (4.34) and the accident count for this site (12). The EB estimator pulls the accident count towards the mean and thereby accounts for the regression to mean bias. The standard deviation of the estimate of the expected accident frequency is given by:

$$\sigma(\text{estimate}) = \sqrt{(1-\text{weight}) \times \text{estimate}} \qquad \text{... 3}$$

Here, Φ=±/(0.54×8.48)=±2.14 accidents in one year.

Numerical Example 2: Three years of accident counts

Suppose now that for the same road segment we have three years of accident counts: 12, 7, 8, and that the ADT in each of those three years was 4000 vpd. To estimate the safety of the road segment:

Step 1: Average for entities of this kind.
As before, segments of this kind are expected to have 2.41 accidents/km-year. On 1.8 km in three years we expect 1.8×3×2.41=13.01 accidents.
Step 2: Weight.
The weight is 1/[1+(2.41×3)/2.05]=0.220. Note that with one year of accident data used the weight was 0.460. As more years of accident data as used, the weight (given to the number of accidents expected on similar entities) diminishes.
Step 3: Estimate.
Expected accidents=0.220×13.01 + 0.780×(12+7+8)=23.92 accidents in three years with Φ=±/(0.78×23.92)=±4.32 or 23.92/(3×1.8)±4.32/(3×1.8)=4.43±0.80 accidents/(km-year).

Numerical Example 3: Application of Accident Modification Functions (AMFs)

Suppose now that the SPF equation in Example 1 is for roads with 1.5 m shoulders while the road segment of interest has 1.2 m shoulders, and that a 0.3m decrease in shoulder width is known to increase accidents by, say, 4%.
Step 1: Average for entities of this kind.
Using the result from Example 1, segments of this kind are expected to have 1.04×2.41=2.51 accidents/km-year. On 1.8 km in three years we expect 1.8×3×2.51=13.55 accidents.
Step 2: Weight.
The weight is 1/[1+(2.51×3/2.05]=0.214.
Step 3: Estimate.
Expected accidents=0.214×13.55+0.786×(12+7+8)=24.12 ± /(0.786×24.12)=4.35 accidents in three years or [24.12±4.35]/(3×1.8)=4.47±0.81 accidents/(km-year).

Numerical Example 4: Subsections and Accident records.

Consider the road segment in Figure 1 that is made up of three subsections that differ in some traits (which determine the variable values of the SPF) and in the AMFs. However, the accident count is not available separately for each subsections, only for the entire 1.5 km segment on which 11 accidents were counted in the last two years.

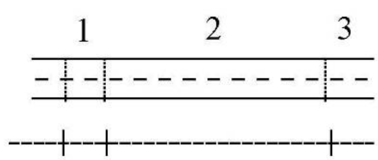


Figure 1

Step 1: Average for Entities of this kind.

The ADTs and AMFs differ amongst the subsections as shown in columns 2 and 4 of Table 1.

Table 1

Subsection	ADT	Length [km]	AMF	Accidents/(km-year)	Accidents
1	2000	0.1	.90	1.466	0.147
2	2300	1.2	.95	1.675	2.010
3	2300	0.2	1.05	1.851	0.370
Sum					2.527

Assume that, as in the earlier examples the SPF is $0.0224\times ADT^{0.564}$ accidents/(km-year) and ν=2.05/km. Thus, after correction for AMF, subsection 1 is expected to have $0.0224\times 2000^{0.564}\times 0.90 = 1.466$ accidents/(km-year) and therefore $1.466\times 0.1=0.147$ accidents/year. The three sub-sections together are expected to have $2.527\times 2=5.054$ accidents in two years or 2.527/1.5 =1.715 accidents/(km-year). From here on it is convenient to forget about the subsections and treat the 1.5 km segment as one entity.

Step 2: Weight.

The weight is $1/[1+(1.715\times 2)/2.05]=0.374$.

Step 3: Estimate.

Expected accidents for the 1.5 km long section in two years $=0.374\times 5.054+0.626\times 11=8.78$ $\pm/(0.626\times 8.78)=2.34$ accidents or $[8.78\pm 2.34)/(1.5\times 2)=2.93\pm 0.78$ accidents/(km-year).

Numerical Example 5: Accidents by severity.

Consider again the setting in numerical example 2 with the addition of the information in columns 1 and 2 of Table 2.

Step 1: Average for entities of this kind.

As in the earlier examples, segments of this kind are expected to have 2.41 total accidents/(km-year). Applying the typical proportions in column 2 of Table 2, we expect 0.046 fatal accidents, 0.128 A-injury accidents, . . ., as shown in column 3. On 1.8 km in three years we expect on roads of this kind $1.8\times 3\times 0.046=0.247$ fatal accidents as shown in column 4.

Table 2

Accident severity	Accidents in three years	Proportion on similar roads	Average Accidents/(km-year)	Average Accidents in three years	Weight	Expected Accidents this site
	1	2	3	4	5	6
Fatal (K)	1	0.019	0.046	0.247	0.937	0.295
Incapacitating injury (A)	2	0.053	0.128	0.690	0.843	0.896
Non-incapacitating injury (B)	2	0.151	0.364	1.965	0.653	1.977
Possible injury (C)	5	0.140	0.337	1.822	0.669	2.872
Property damage only	17	0.637	1.535	8.290	0.308	14.317
Total	27	1.000	2.410	13.014		20.357

Step 2: Weight.
The weight for fatal accidents is 1/(1+0.046×3/2.05)=0.937 as shown in column 5. The overdispersion parameter, ν remains 2.05/km for all severities because it can be shown that when the SPF is multiplied by a constant, the overdispersion parameter is unchanged. Note that the weight of the 'Average for entities of this kind' is large for the rare accident severities. It is the property of the EB procedure that estimates will not be dominated by the random occurrence of rare events.
Step 3: Estimates.
The estimate of expected fatal accidents=0.937×0.247 + 0.063×1=0.295±/(0.063×0.295) =0.136 accidents in three years. Note that the sum of expected accidents when estimated separately for each severity is 20.35. When the same has been estimated in example 2 using the total accidents without differentiation by severity, the estimate was 23.92 accidents. The discrepancy has two sources. First, it is appropriate that the specific accident severity of a site should be reflected in the estimates. Therefore, in principle, the two numbers should differ. However, there is a systematic reason for the discrepancy. It arises mainly because separation into severity classes inevitably results in smaller values of μ used in equation 2, and therefore in larger weights given to the expected accident frequency on similar entities. An ad-hoc correction could be to multiply each estimate by the ratio 23.92/20.35. The estimate of expected fatal accidents would then be 0.295×1.118=0.347. A correct way of removing the blemish would be to adopt procedures described by Flowers (*12*) or Heydecker (*13*). However, both require additional parameter estimates to be used and these are, at this

time, not easily available.

Numerical Example 6. An intersection.

For three-leg rural intersection in Minnesota Vogt and Bared (7) find that under nominal conditions μ is estimated by $6.54\times10^{-5}\times ADT_{mainline}\times ADT_{minor\ road}$ and the estimate of ν is 1.96. Consider such an intersection with $ADT_{mainline}$=4520, $ADT_{minor\ road}$=230, the AMF to account for differences from nominal conditions is1.27, and there were 7 accidents in three years.

Step 1: Average for entities of this kind.
Under the nominal conditions, intersections of this kind are expected to have $6.54\times10^{-5}\times4520^{0.82}\times230^{0.51}$=1.041 accidents/year. Under the real conditions of this intersection, using the AMFs, 1.27×1.041=1.322 accidents/year. In the three years for which accident counts are used, 3×1.322=3.966 accidents.
Step 2: Weight.
The weight is 1/[1+(1.322×3)/1.96]=0.331
Step 3: Estimate.
Expected accidents=0.331×3.966 + 0.669×7=6.00±/(0.669×6.00)=2.00 accidents in three years or [6.00±2.00]/3=2.00±0.67 accidents/year.

Numerical Example 7. Accidents allocated to a group of intersections .

Some data bases contain information about how many intersection (and intersection-related) accidents have occurred on a road segment without the ability to specify how many occurred on which intersection. Consider a road segment with two intersections for which we have estimates of μ_1 (2.6 accidents/year) , ν_1 (2.2) and of μ_2 (4.3 accidents/year), ν_2 (1.8). In three years, 11 accidents have occurred on these two intersections.

Step 1: Average for entities of this kind.
In the three years for which accident counts are available and on two similar intersections one should expect 3×2.6+3×4.3=7.8+12.9= 20.7 accidents.
Step 2: Weight.
Were one to use equation 2 directly, as if the two intersections were one, weight would be 1/(1+20.7/2)=0.088. In this the average overdispersion parameter was used. This is a bit of an oversimplification. Actually, when the accident count is available jointly for n entities with means $0_1, 0_2, \ldots, 0_n$ and overdispersion parameters $\nu_1, \nu_2, \ldots, \nu_n$ and when correlation coefficient between 0_i and 0_j is $\Delta_{i,j}$ then the weight should be computed by:

$$\textbf{weight} = \frac{1}{1+\dfrac{\sum_{i=1}^{n}\eta_i^2/\varphi_i + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n}\rho_{i,j}\sqrt{\dfrac{1}{\varphi_i\varphi_j}}\eta_i\eta_j}{\sum_{i=1}^{n}\eta_i}} \quad ..\ 4$$

But, it is at present not clear what correlation coefficient should be used and therefore the two extremes are of interest.

$$\text{When } \rho_{i,j}=0,\ \textbf{weight} = \frac{1}{1+\dfrac{\sum_{i=1}^{n}\eta_i^2/\varphi}{\sum_{i=1}^{n}\eta_i}} \quad ...\ 5$$

$$\text{When } \rho_{i,j}=1,\ \textbf{weight} = \frac{1}{1+\dfrac{\sum_{i=1}^{n}\sqrt{(\eta_i^2/\varphi)^2}}{\sum_{i=1}^{n}\eta_i}} \quad ...\ 6$$

In this example the weight is between $1/[1+(7.8^2/2.2+12.9^2/1.8)/20.7]=0.147$ and $1/\{1+[/(7.8^2/2.2)+/(12.9^2/1.8)]^2/20.7\}=0.085$.

Step 3: Estimate.
Using the simply-obtained weight of 0.088, Expected accidents$=0.088\times20.7+0.912\times11=11.94\pm/(0.912\times11.94)=3.30$ accidents in three years.

5. THE FULL PROCEDURE ILLUSTRATED.

So far we discussed the abridged EB procedure. The full procedure differs from the abridged procedure in that year to year changes in ADT and in other variables can be brought into estimation thereby allowing use of longer accident histories. The full EB procedure is illustrated by numerical examples.

August 2001

Numerical Example 8 - Accounting for changing ADTs

A road segment is 1.8 km long. It has remained physically unchanged during the past 9 years. The ADT estimates and accident counts for each year are given in rows 2 and 3 of Table 3. As in earlier examples, for this kind of road and nominal conditions μ is estimated by $0.0224 \times ADT^{0.564}$ accidents/(km-year) and the overdispersion parameter ν is 2.05. Assume further that to convert from nominal to real conditions, the product of all AMFs is, in this case, 0.95.To estimate the safety of this road section in each of the nine years proceed as follows:

Table 3

1	Year	1989	90	91	92	93	94	95	96	97	Sums
2	ADT	4500	4700	5100	5200	5600	5400	5300	5300	5400	
3	Accidents	12	5	9	8	14	8	5	7	6	74
4	μ_{year}, [accidents/(km-year)]	2.446	2.506	2.624	2.653	2.767	2.710	2.682	2.682	2.710	23.781
5	Expected accidents in year	4.402	4.511	4.724	4.776	4.980	4.879	4.828	4.828	4.879	42.806
6	Expected annual accident for segment	7.36	7.54	7.89	7.98	8.32	8.15	8.07	8.07	8.15	71.52

Step 1. Average for entities of this kind

Each year has an estimate of the expected number of accidents for roads of this kind. Thus, e.g., for 1989 and under nominal conditions, roads with ADT=4500 are estimated to have $0.0224 \times 4500^{0.564} = 2.574$ accidents/(km-year) and after adjustment to actual conditions $\mu_{1989} = 2.574 \times 0.95 = 2.446$ accidents/(km-year) as shown in row 4. Listed in row 5 are the expected accidents when segment length has been accounted for.

Step 2. Weight.

The formula for computing the weight is now:

$$\mathbf{weight} = \frac{1}{1 + \frac{\sum_{year=first\ year}^{year=last\ year} \mu_{year}}{\varphi}} \quad \ldots 7$$

Note that equations 2 and 7 are identical when all the μ's are the same. With $\nu=2.05$ and $\Gamma\mu_{year}= 23.781$, the weight = 1/(1+23.781/2.05) =0.0794.

Step 3. Estimates.

Now the expected number of accidents for the specific road section at hand and the period 1989-1997 is $0.0794\times42.846+0.9206\times74=71.52\pm\surd(0.9206\times71.52)=8.11$. Note that this estimate is based on the full nine-year accident history and this explains the small weight attached to what is expected at similar sites. The estimate for any specific year is now computed by multiplying the estimate for the entire period by the ratio $\mu_{year}/\Gamma\mu_{year}$. Thus, for 1997 the estimate is $[71.52\pm8.11]\times2.710/23.781=8.15\pm0.92$. These values are listed in row 6. In this manner, the evidence of the entire accident record of nine years is brought to bear on the estimate in any specific year.

Numerical Example 9 - Accounting for secular trend.

In the preceding example the underlying assumption was that while ADT changed over the years, other factors affecting the safety (weather, vehicles, drivers etc.) remained unchanged. However, most everything changes with time. This 'secular trend' can be expressed in multivariate models by 'yearly multipliers' which can be estimated together with all other regression coefficients. Such multipliers are listed in row 2a in Table 4. Thus, e.g., were the model $0.0224\times ADT^{0.564}$ applied to data from 1990, it would over-predict the total number of recorded accidents that occurred in 1990 by 1.6%; to bring the prediction and the accident count into agreement one has to multiply by 0.984 as shown in row 2a..The yearly multipliers alter the entries in row 5 and this, in turn, affects all other numerical results.

Table 4

1	Year	1989	90	91	92	93	94	95	96	97	Sums
2a	Yearly Multipliers	1	0.984	1.053	1.005	0.996	0.932	0.931	0.891	0.927	
2b	ADT	4500	4700	5100	5200	5600	5400	5300	5300	5400	
3	Accidents	12	5	9	8	14	8	5	7	6	74
4	μ_{year}, [accidents/(km-year)]	2.446	2.466	2.764	2.667	2.756	2.526	2.497	2.390	2.513	23.023
5	Expected accidents in year	4.402	4.439	4.974	4.800	4.960	4.547	4.495	4.301	4.523	41.441
6	Expected annual accident for segment	7.58	7.64	8.56	8.26	8.54	7.83	7.74	7.40	7.79	71.34

Numerical Example 10 - Projection.

The focus so far was on estimating what the expected accident frequency was for some year in the past. Occasionally one wishes to project what accident frequency should be expected at some time in the future. Projections of this kind are always necessary when one wishes compare what safety would have been had some intervention not been implemented to what safety was with the intervention in place. Suppose then that for the segment in numerical example 8 we wish to project the expected number of accidents in 2003 and 2004 when ADTs of 6000 and 6300 are expected and for when the yearly multiplier values of 0.9 and 0.92 are projected.

The starting point for the projection can be any of the values in Table 4. Thus, e.g., the value of 7.79 accidents in 1997 is for $AADT_{1997}=5400$ and the yearly multiplier of 0.927. Recall that the exponent of ADT in the model equation is 0.564. Thus, the projection ratio for 2003 is $(0.9\times6000^{0.564})/(0.927\times5400^{0.564})=1.030$ and for 2002 it is $(0.92\times6300^{0.564})/(0.927\times5400^{0.564})=1.083$. Therefore for 2003 we project $7.79\times1.030=8.02$ accidents and for 2002 we project $7.79\times1.083=8.44$ accidents.

6. SUMMARY.

The safety of entities is usually estimated from the history of its accident counts. The EB procedure for safety estimation combines accidents counts with knowledge about the safety of similar entities. Doing so has several advantages. Precision of estimation is enhanced when the accident record is sparse and the regression to mean bias is eliminated. As usually, improved precision requires added information. In this case one needs estimates of the Safety Performance Functions for similar entities and an estimate of the applicable overdispersion parameter. Since these are now more widely available, EB estimation of safety should be the preferred practice. The purpose of this paper is illustrate that what may seem to be a complex theory can be put into daily practice.

REFERENCES

1. Hauer, E. (1997). Observational before-after studies in road safety. Pergamon, Oxford, U.K.

2. Datta, T.K., Feber, D., Schattler, K., Datta, S., Effective safety improvements through low cost treatments. Transportation Research Record 1734. Pp. 1-6, 2000.

3. Abbess, C., Jarret, D., and Wright, C.C., Accidents at blackspots: estimating the effectiveness of remedial treatment, with special reference to the "regression-to-the-mean" effect. *Traffic Engineering and Control,* **22**, No. 10, 1981, pp. 535-542.

4. Harwood, D.W., F.M. Council, E. Hauer, W.E. Hughes and A Vogt, Prediction of expected safety performance on rural two-lane highways, Report No. FHWA-RD-99-207, Federal Highway Administration, 2000.

5.Hauer, E.,Overdispersion in modelling accidents on road sections and in Empirical Bayes estimation. *Accident Analysis and Prevention,* 33,799-808, 2001.

August 2001

6. Maycock, G. and Hall, R.D., (1984), Accidents at 4-arm roundabouts. Laboratory Report LR1120, Transport Research Laboratory, Crowthorne, Berkshire, UK.

7. Hauer, E., Ng, J. C. N., and Lovell, J.,(1989), Estimation of safety at signalized intersections. *Transportation Research Record.* **1185,** 48-61.

8. Bonneson, J. A. and McCoy, P. T.,(1993), Estimation of safety at two-way stop-controlled intersections on rural highways. *Transportation Research Record.* **1401,** 83-89.

9.Miaou, S-P.,(1996). Measuring the goodness of fit of accident prediction models. FHWA-RD-96-040. FHWA, McLean, VA.

10.Vogt, A. and Bared, J.,(1998), Accident models for two-lane rural segments and intersections. *Transportation Research Record.* **1635,** 18-29.

11. Persaud, B.N., and Dzbik, L.,(1993) Accident prediction models for freeways. *Transportation Research Record.* **1401,** 55-60.

12. Flowers, R. J.,(1981). A procedure for predicting future accident costs at specified locations. Texas Transportation Institute, Texas A&M University, TARE-53

13. Heydecker, B. G. and Wu, J. (1991) Using the information in road accident records. Proceedings of the 19th PTRC Summer Annual Meeting, Seminar K. PTRC, London.

APPENDIX D: PRESENTATION HANDOUTS

All of the presentations are attached.

AASHTO Vision for Highway Safety

Joel McCarroll, P.E.
AASHTO
Chicago, Illinois
July 28, 2009

AASHTO Safety Goal

- In May 2008, the AASHTO Board of Directors established a Towards Zero Death safety goal.
- The goal is to reduce fatalities by half in 20 years.

Outreach Efforts

- AASHTO has worked with other safety organizations to achieve a national consensus on the safety goal.
- The State Safety Partners (GHSA, IACP, AAMVA, and CVSA) have all adopted this goal or a similar goal.
- AASHTO is working to include the safety goal as a national safety goal in the new authorization.
- Development of a National Strategic Highway Safety Plan.

Authorization Proposals

- Increased Funding for Safety Efforts
- Commitment to the Strategic Highway Safety Plan Effort
- National Center for Safety Excellence
- Performance Management
- Flexibility
- Research

Internal Efforts

- Standing Committee on Highway Traffic Safety
- Subcommittee on Safety Management
- Subcommittee on Traffic Engineering (Safety Task Group)
- Subcommittee on System Operations and Management (VII, ITS)
- Standing Committee on Performance Management

Subcommittee on Safety Management

- The goal of the Subcommittee is to support the national goal of reducing fatalities by half in 20 years.
- Task Groups
  - Technical Information & Resources
  - Technical Safety Publication Oversight & Outreach
  - Oversight of National Strategic Highway Safety Plan
  - Safety Data Systems & Analysis and Workforce Development
  - Safety Informational Packages and Implementation of the SHSP
  - Research

Support for the HSM

- Completing the HSM and making it an AASHTO publication.
- Identifying data gaps and other user concerns for future editions of the HSM.
- Safety Analyst – AASHTOware

Support for the HSM (Cont.)

- www.highwaysafetymanual.org will become an AASHTO maintained website.
- Research Support
  - Keeping AMF/CRF's up to date
  - Developing new AMF/CRF's where none exist today
  - International and Domestic Scans to Identify New or Cutting Edge Solutions

Other Safety Activities

- Updating the Series 500 Guides
- Promoting networking and information sharing:
  - Standing Committees and Subcommittees
  - Safety Leadership Forums
  - http://safety.transportation.org

AASHTO Contacts for Safety and the Highway Safety Manual

Kelly Hardy
khardy@aashto.org

Ken Kobetsky
kenk@aashto.org

Jim McDonnell
jimm@aashto.org

Session 2
History

How did SPF come into being and why is it here to stay?

Geni Bahar, P.E.
NAVIGATS Inc.

Outline

- Overview of two issues
  - Variability of crash occurrence and regression to the mean (RTM)
  - Misleading meaning of crash rate
- Estimation method & safety performance functions (SPFs)
- Applications
- References
- Next steps

July 29 and 30, 2009 2

Once upon a time...

- Before-after safety evaluation studies
  - Based on crash counts before and after the implementation of a treatment
  - The difference between these counts was considered the safety effect of the given treatment
  - Example: 3years of data
    - Before: 12 crashes; After: 8 crashes
    - Thus: [(12-8)/12] x 100= 34% decrease in crashes

July 29 and 30, 2009 3

And then...

- We noticed that at similar locations, not treated and with the same before-crash records, also showed a decrease in crashes
- Question?? Is it true that 34% decrease in crashes is due to the treatment or were there other factors?

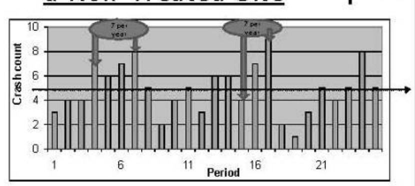
July 29 and 30, 2009 4

We also noted that...

- The sites selected and treated had very high crash occurrence
- The crash occurrence varied greatly; crashes were rare and random
- Let's see a few examples

July 29 and 30, 2009 5

25-Period Crash Counts on a Non-Treated Site



Poisson-distributed counts- Average of 4.23 crashes/period

July 29 and 30, 2009 6

July 29 and 30, 2009
Chicago, Illinois

the national SPF SUMMIT 2009

California Rural Stop-controlled Untreated Intersections

Intersections with given number of crashes in 1994-96	Crashes/ intersection in 1994-96	Crashes/ intersection per year in 1994-96	Crashes/ intersection per year in 1997-99	Percent Change
110	0	0.00	0.32	Large increase
136	1	0.33	0.55	65.4%
101	2	0.67	0.88	32.2%
101	3	1.00	0.99	-1.3%
67	4	1.33	1.23	-7.5%
44	5	1.67	1.54	-7.7%
37	6	2.00	1.63	-18.5%
26	7	2.33	2.00	-14.3%
21	8	2.67	2.38	-10.7%
28	9	3.00	3.30	9.9%
16	10	3.33	2.85	-14.4%
10	11	3.67	2.93	-20.0%
45	12	5.26	5.04	-4.1%

Source: ASIB Data by Dr. Persaud

July 29 and 30, 2009 7

Issue 1:Regression to the Mean (RTM)

- Counts above or below will move toward an average value; thus above normal crash counts at a site will be followed by a reduced count even if the site is unchanged
- Thus, selecting sites for improvement with high number of crashes / a short time periods will indeed
  - Lead to an over-estimation of the treatment effect
  - Lead to selecting sites not necessarily the ones that the treatment is most effective

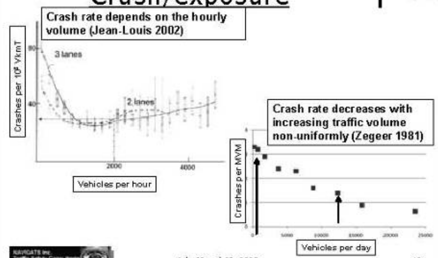
July 29 and 30, 2009 8

Introducing Traffic Volumes

- Traditionally, we use crash rates to take into account the difference in exposure
- Crash rate = average crash frequency / exposure

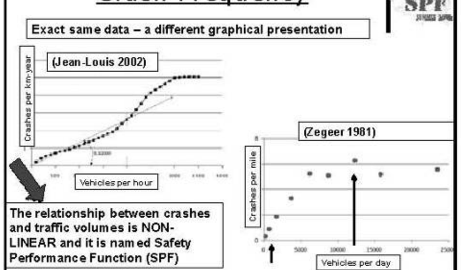
July 29 and 30, 2009 9

Crash Rate= Crash/exposure



July 29 and 30, 2009 10

Crash Frequency



July 29 and 30, 2009 11

Issue 2: Crash Rate

- Crash rate is not linear; the SPF is a curve with diminishing slope, not a straight line through the origin
- Crash rate does not separate the safety effect from change in traffic flow
- Differences in traffic volumes cannot be accounted for by crash rates

July 29 and 30, 2009 12

July 29 and 30, 2009
Chicago, Illinois

In Conclusion, We Need an Estimation Method

- That would account for regression to the mean when:
  - Selecting sites for treatment
  - Evaluating the safety effect of treatment
- That would estimate the safety of a site
  - With greater precision than direct counts for a short period of time
- That would incorporate exposure

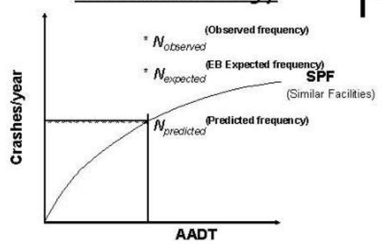
July 29 and 30, 2009 13

Methodology

- Empirical Bayes (EB) method meets these conditions
- EB in highway safety was studied in-depth for more than 30 years
- EB uses two "clues"
  - the historical crash counts of a single site
  - the average crash estimate of similar sites (same category and same traffic volume) represented by the SPF

July 29 and 30, 2009 14

EB Methodology



July 29 and 30, 2009 15

Safety Performance Function Development

- "Fits a curve" to observed crash data
  - Provides equation so y (=crash) value may be predicted from x (=AADT) value
  - Distinct curves for injury and non-injury
- The statistical "base" modeling process generates regression parameters and provide a "weight" to correct a RTM bias and increase precision

July 29 and 30, 2009 16

Typical SPFs

- SPFs are available for several facilities and crash severity types
  - Signalized and stop-controlled intersections
  - Roundabouts
  - Two-lane and multi-lane roadways
  - Freeways
  - Urban and rural environments
- SPFs are representative of the jurisdiction data used for their development

July 29 and 30, 2009 17

Some Applications

- What is the expected number and severity of crashes for a site with one year or more years of observed crash data?
- What is the predicted number and severity of crashes with an increase of traffic volume and/or design or operational change?
- What is the difference in future crashes after the implementation of either of two optional treatments?

July 29 and 30, 2009 18

In Conclusion, We Need an Estimation Method

- That would account for regression to the mean when:
  - Selecting sites for treatment
  - Evaluating the safety effect of treatment
- That would estimate the safety of a site
  - With greater precision than direct counts for a short period of time
- That would incorporate exposure

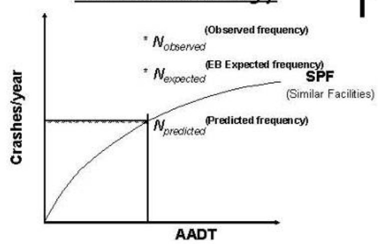
July 29 and 30, 2009 13

Methodology

- Empirical Bayes (EB) method meets these conditions
- EB in highway safety was studied in-depth for more than 30 years
- EB uses two "clues"
  - the historical crash counts of a single site
  - the average crash estimate of similar sites (same category and same traffic volume) represented by the SPF

July 29 and 30, 2009 14

EB Methodology



July 29 and 30, 2009 15

Safety Performance Function Development

- "Fits a curve" to observed crash data
  - Provides equation so y (=crash) value may be predicted from x (=AADT) value
  - Distinct curves for injury and non-injury
- The statistical "base" modeling process generates regression parameters and provide a "weight" to correct a RTM bias and increase precision

July 29 and 30, 2009 16

Typical SPFs

- SPFs are available for several facilities and crash severity types
  - Signalized and stop-controlled intersections
  - Roundabouts
  - Two-lane and multi-lane roadways
  - Freeways
  - Urban and rural environments
- SPFs are representative of the jurisdiction data used for their development

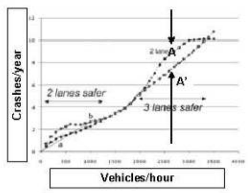
July 29 and 30, 2009 17

Some Applications

- What is the expected number and severity of crashes for a site with one year or more years of observed crash data?
- What is the predicted number and severity of crashes with an increase of traffic volume and/or design or operational change?
- What is the difference in future crashes after the implementation of either of two optional treatments?

July 29 and 30, 2009 18

Comparison between sites and highway facility types



July 29 and 30, 2009 19

Some References

- "Estimating Safety by the Empirical Bayes Method: A Tutorial" by Hauer et al (2002) (in your folder)
- -"Observational Before-After Studies in Road Safety" by Hauer (1997)
- "Highway Safety Manual" (2010)

July 29 and 30, 2009 20

Where are we now?

- Preparing data
- Developing own jurisdictional SPFs
- Calibrating base SPFs for each jurisdiction using calibration process (HSM Part C)
- Using own applications and/or national tools such as:IHSDM; SafetyAnalyst, and HSM
- Developing and deploying training

July 29 and 30, 2009 21

Where are we going?

- EB method will become the standard of professional practice in the estimation of road safety
  - Estimating the safety of a location
  - Prioritizing potential sites for improvement
  - Evaluating safety effects of treatments
  - Assessing potential safety savings due to site improvements

July 29 and 30, 2009 22

Thank you

genibahar@navigats.com

July 29 and 30, 2009 23

July 29 and 30, 2009
Chicago, Illinois

Role of Safety Performance Functions in the

Highway Safety Manual

July 29, 2009

Presentation Overview

- SPF Application in Part C: Predictive Method
- SPF Application in Part B: Roadway Safety Management Process

Safety Performance Functions in

Part C – Predictive Method

SPFs in Part C – Predictive Method

HSM Chapter	Undivided Roadway Segments	Divided Roadway Segments	Intersections			
			Stop Control on Minor Leg(s)		Signalized	
			3-Leg	4-Leg	3-Leg	4-Leg
10— Rural Two-Lane Roads	✔	–	✔	✔	–	✔
11— Rural Multi-Lane Highways	✔	✔	✔	✔	–	✔
12— Urban and Suburban Arterial Highways	✔	✔	✔	✔	✔	✔

Summary Data Needs for SPF Application

- SPF for specific facility type
- AADT
- Length
- Site characteristics to adjust with AMFs
  - Roadway
  - Intersection
- Local Calibration Factor
- Crash data for EB Method application

Application of SPFs in Part C

- 1.5-mi rural two-lane
- Tangent roadway segment
- 10,000 veh/day
- 0% grade
- Local calibration factor = 1.10
- 6 driveways per mi
- 10-ft lane width
- 4-ft gravel shoulder
- Roadside hazard rating = 4
- $N_{observed}$ = 10 crashes/year

- **Objective:**
  - Calculate predicted average crash frequency ($N_{predicted}$)

the national SPF SUMMIT 2009

Predictive Method Sample Application

Step 1 - Base Conditions Estimate (N_{spf})

$$N_{spfrs} = AADT \times L \times 365 \times 10^{6} \times e^{-0.312}$$
$$= 10{,}000 \times 1.5 \times 365 \times 10^{-6} \times e^{(-0.312)}$$
≈ 4 Crashes/year

Step 2 – Estimate Predicted Average Crash Frequency

$$AMF_{COMB} = AMF_{Lane Width} \times AMF_{Shoulder Width/Type} \times AMF_{Driveway Density} \times AMF_{Roadside Design}$$
$$= 1.38$$

$$N_{predicted} = 1.38 \times 4 \times 1.10$$
≈ 6 Crashes/year

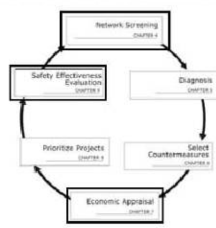
Kittelson & Associates, Inc.

Safety Performance Functions in

Part B – Roadway Safety Management

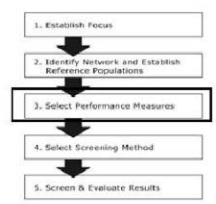
Kittelson & Associates, Inc.

SPFs and Part B – Roadway Safety Management



Kittelson & Associates, Inc.

Chapter 4 – Network Screening



Kittelson & Associates, Inc.

Chapter 4 – Network Screening

Performance Measure	Accounts for RTM Bias	Method Estimates a Performance Threshold
Average Crash Frequency	No	No
Crash Rate	No	No
Equivalent Property Damage Only (EPDO) Average Crash Frequency	No	No
Relative Severity Index	No	Yes
Critical Rate	Considers data variance but does not account for RTM Bias	Yes
[illegible]	[illegible]	[illegible]
Level of Service of Safety	Considers data variance but does not account for RTM Bias	Expected average crash frequency plus/minus 1.5 standard deviations
[illegible]	[illegible]	[illegible]
Probability of Specific Crash Types Exceeding Threshold Proportion	Considers data variance; not effected by RTM Bias	Yes
Excess Proportions of Specific Crash Types	Considers data variance; not effected by RTM Bias	Yes
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Kittelson & Associates, Inc.

Chapter 4 – Network Screening

- Excess Predicted Average Crash Frequency Using SPFs

Intersection	Observed Average Crash Frequency	Predicted Average Crash Frequency from an SPF	Excess Predicted Average Crash Frequency
2	11.7	1.7	10.0
3	7.7	2.2	5.5
7	11.3	2.6	8.7
10	5.7	2.2	3.5
15	5.7	2.3	3.4
17	4.3	2.6	1.7
19	3.7	2.5	1.2

Intersection	Excess Predicted Average Crash Frequency
2	10.0
7	8.7
3	5.5
10	3.5
15	3.4
17	1.7
19	1.2

Kittelson & Associates, Inc.

Chapter 7 – Economic Appraisal

- Estimate Crash Reduction on Suburban Arterial Intersection

Kittelson & Associates, Inc.

Estimate Crash Reduction

- Predicted Crashes - INTERSECTION
  - Predict Future Crash Frequency with SPF

    Data needs: SPFs, Future AADT, Length
  - Apply AMFs and Calibration Factor to Account for Local Conditions

    Data needs: AMFs for existing condition, local calibration factor
- Predicted Crashes - ROUNDABOUT
  - Apply AMF to Account for Alternate Conditions (Roundabout)

    Data needs: AMFs for alternate condition

Kittelson & Associates, Inc.

Estimate Monetary Benefit

- Convert crash difference to monetary benefits and estimate annual savings of improvement

Crash Severity	Comprehensive Crash Costs
Fatality (K)	$4,008,900
Disabling Injury (A)	$216,000
Evident Injury (B)	$79,000
Fatal/Injury (K/A/B)	$158,200
Possible Injury (C)	$44,900
PDO (O)	$7,400

Kittelson & Associates, Inc.

Summary of Data Needs for SPF Application

- Applicable SPF
- AADT
- Length
- Local Geometric/Operational Conditions and Corresponding AMFs
- Local Calibration Factors
- Historical crash data for EB Method Application

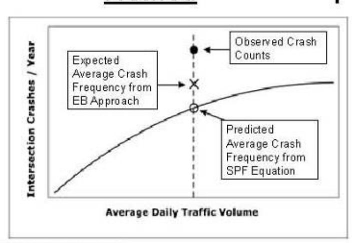
Kittelson & Associates, Inc.

- Thank you!

www.highwaysafetymanual.org

Kittelson & Associates, Inc.

SPFs in Part C – Predictive Method



Kittelson & Associates, Inc.

July 29 and 30, 2009
Chicago, Illinois

the national SPF SUMMIT 2009

Predictive Method Sample Application

- Step 3 – Estimate Expected Average Crash Frequency

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed}$$

$$N_{expected} = 0.507 \times 6.084 + (1 - 0.507) \times 10$$

≈ 8 Crashes/year

Kittelson & Associates, Inc.

Chapter 9 - Safety Effectiveness Evaluation

Data Needs and Inputs	Safety Evaluation Method: EB Before/After	Before/After with Comparison Group	Before/After Shift in Proportion	Cross-Sectional
10 to 20 treatment sites	✓	✓	✓	✓
10 to 20 comparable non-treatment sites		✓		✓
A minimum of 650 aggregate crashes in non-treatment sites		✓		
3 to 5 years of crash and volume "before" data	✓	✓	✓	
3 to 5 years of crash and volume "after" data	✓	✓	✓	✓
SPF for treatment site types	✓	✓		
SPF for non-treatment site types		✓		
Target crash type			✓	

Kittelson & Associates, Inc.

July 29 and 30, 2009
Chicago, Illinois

Role of SPFs in the Interactive Highway Safety Design Model (IHSDM)

Mike Dimaiuta
LENDIS Corporation

Safe Roads for a Safer Future

What is IHSDM?

- A product of FHWA's Safety Research and Development Program
- A suite of software tools that support project-level geometric design decisions by providing quantitative information on the expected safety and operational performance

IHSDM

What Benefits does IHSDM Provide?

- IHSDM results help project developers make design decisions that improve the expected safety performance of designs
- IHSDM helps project planners, designers, and reviewers justify and defend geometric design decisions

IHSDM

Evaluation Modules (2008 Public Release)

- Policy Review
- Crash Prediction
- Design Consistency
- Intersection Review
- Traffic Analysis
- Driver/Vehicle

IHSDM

Crash Prediction Module Scope

- Estimates expected crash frequency based upon roadway geometry and traffic volumes

IHSDM

What Highway Types can the 2009 CPM Beta Release Evaluate?

- Crash prediction capabilities matching the Highway Safety Manual, Draft 3.1
- Facility types:
  - Two-lane rural highways
  - Multilane rural highways
  - Urban & suburban arterials
- Existing and proposed alternative highway geometric designs

IHSDM

Relationship between IHSDM and the HSM

A. Introduction and Fundamentals
B. Roadway Safety Management Process
C. **Predictive Methods (IHSDM CPM)**
   Chapter 10: Rural, Two-Lane Roads
   Chapter 11: Rural Multilane Highways
   Chapter 12: Urban/Suburban Arterials
D. Accident Modification Factors

Relationship between IHSDM and the HSM

- FHWA intends IHSDM CPM to be a faithful implementation of HSM Part C methodology
- FHWA implemented new models and revised 2-lane rural model based on HSM Draft 3.1 (April 2009)

CPM Model Components

$$N_{predicted} = N_{spf\,x} \times (AMF_{1x} \times AMF_{2x} \times \ldots \times AMF_{yx}) \times C_x$$

- SPFs (Base Models)
- AMFs
- Calibration Factors
- Empirical Bayes (using crash history data)

CPM SPFs are a function of…

- For Highway Segments:
  - AADT
  - Length of segment
- For Intersections:
  - AADT of major road
  - AADT of minor road

SPFs – Highway Types

Highway Segments	2R	MR	U/SA
2-lane undivided (2U)	X		X
2-lane divided (2D)			
3-lane w/TWLTL (3T)	X		X
4-lane undivided (4U)		X	X
4-lane divided (4D)		X	X
5-lane arterial w/TWLTL (5T)			X

SPFs – Collision Types

Highway Segments	2R	MR	U/SA
Total (all collision types)	X	X	
Multi-vehicle, non-driveway			X
Single-vehicle			X
Multi-veh., driveway-related			X
Vehicle-pedestrian[1]			X
Vehicle-bicycle[1]			X

[1] Adjustment factor only

July 29 and 30, 2009
Chicago, Illinois

SPFs – Crash Severities

Highway Segments	2R	MR	U/SA
Total	X	X	X[1]
FI		X	X[2]
FI (no "C")		X	
PDO			X[2]

[1]Multi-Vehicle (non-driveway), Single Vehicle, Multi-Vehicle (driveway-related)

[2]Multi-Vehicle, Single Vehicle

IHSDM

SPFs – Intersection Types

Intersections	2R	MR	U/SA
3-leg STOP-control on minor	X	X	X
3-leg Signalized			X
4-leg STOP-control on minor	X	X	X
4-leg Signalized	X	X[1]	X

[1]No specific base conditions and no AMFs; only applicable for generalized predictions

IHSDM

SPFs – Collision Types

Intersections	2R	MR	U/SA
Total (all collision types)	X	X	
Multi-vehicle			X
Single-vehicle			X
Vehicle-pedestrian[1]			X
Vehicle-bicycle[2]			X

[1]SPF for signalized intersections; adjustment factor for stop-controlled

[2]Adjustment factor only

IHSDM

SPFs – Crash Severities

Intersections	2R	MR	U/SA
Total	X	X	X[1,2]
FI		X	X[1]
FI (no "C")		X	
PDO			X[1]

[1]Multi-Vehicle, Single Vehicle (all intersection types)

[2]Pedestrian-related (3SG and 4SG only)

IHSDM

CPM Data Needs

- Vary by highway type
  - rural 2-lane
  - rural multilane
  - urban/suburban arterials
- Highway Segment Data and Intersection Data

IHSDM

CPM Data Needs - Segments

ALIGNMENTS	2R	MR	U/SA
Horizontal			
– Complete	X		
– Length (curves not needed)		X	X
Vertical			
- Grades (VC's not needed)	X		
- Tangent		X	X

IHSDM

CPM Data Needs - Segments

GENERAL	2R	MR	U/SA
Design Speed	X		
AADT	X	X	X
Area Type	X	X	X
Speed Designation			X
Functional Class			X

CPM Data Needs - Segments

CROSS-SECTION	2R	MR	U/SA
Cross Slope (S.E.)	X		
Through Lane	X	X	X
Auxiliary Lanes •Turn lanes (2R, MR, U/SA) •Passing/climbing lanes (2R)	X	X	X
Shoulders	X	X	
TWLTL	X	X	X
Median		X	X

CPM Data Needs - Segments

ROADSIDE	2R	MR	U/SA
Driveway Density	X		
Driveway Locations/Types			X
Roadside Hazard Rating	X		
Side Slopes		X	
On-Street Parking			X
Roadside Fixed Object Density			X

CPM Data Needs - Segments

OTHER	2R	MR	U/SA
Lighting	X	X	X
Automated Speed Enforcement	X	X	X
Centerline Rumble Strip	X		

CPM Data Needs - Intersections

	2R	MR	U/SA
Number of legs	X	X	X
AADT's for Maj/Min Roads	X	X	X
Type of traffic control	X	X	X
Approach leg type (major/minor)	X	X	X
Skew angle	X	X	
Approaches with exclusive left/right turn lanes	X	X	X
Lighting	X	X	X

CPM Data Needs - Intersections

	2R	MR	U/SA
RTOR (approaches prohibited)			X
Left-Turn Signal Phasing			X
Presence of Red Light Camera			X
Pedestrian Volume (all legs)			X
Max. Lanes Crossed by Peds			X
Bus Stops w/in 1000'			X
School w/in 1000'			X
Alcohol Sales Estab. w/in 1000'			X

CPM Data Needs - Crash History

CRASH HISTORY DATA (Optional)	2R	MR	U/SA
Segment-related Crashes	X	X	X
Intersection-related Crashes	X	X	X

IHSDM

2009 CPM Beta Release

- May be downloaded free-of-charge at: http://www.ihsdm.org
- Technical support:
  - E-mail: IHSDM.Support@fhwa.dot.gov
  - Phone: (202)-493-3407

IHSDM

Future Plans

- Next Public Release in conjunction with the HSM 1st Edition (2010)

IHSDM

Questions?

For additional information:
www.tfhrc.gov/safety/ihsdm/ihsdm.htm

IHSDM Technical Support:
IHSDM.Support@fhwa.dot.gov; (202)-493-3407

To download IHSDM software: www.ihsdm.org

Shyuan-Ren (Clayton) Chen
Clayton.Chen@fhwa.dot.gov; (202)-493-3054

IHSDM

Role of SPFs in SafetyAnalyst

Ray Krammes
Federal Highway Administration

FHWA Tools Supporting Implementation of the HSM

HSM Part	*Supporting Tool*
B: Roadway Safety Management Process	*SafetyAnalyst*
C: Predictive Methods	*IHSDM*
D: Accident Modification Factors	*CRF/AMF Clearinghouse*

July 29 and 30, 2009 2

Relationship among HSM, SafetyAnalyst and IHSDM

HSM	Level of Analysis	Tool
Part B – Roadway Safety Management Process	System-Wide (Network-Level)	SafetyAnalyst
Part C – Predictive Methods	Specific Roadway (Project-Level)	IHSDM

July 29 and 30, 2009 3

SafetyAnalyst

- Analytical tool to support safety management decision making by State and local highway agencies
- Automates many of the best statistical approaches described in the Highway Safety Manual (Part B)
- Integrates all parts of the safety management process in a single, modular software package

July 29 and 30, 2009 4

Relationship between the HSM and SafetyAnalyst

HSM Chapter		SafetyAnalyst Module	
4	Network Screening	1	Network Screening
5	Diagnosis	2	Diagnosis and Countermeasure Selection
6	Select Countermeasures		
7	Economic Appraisal	3	Economic Appraisal and Priority Ranking
8	Prioritize Projects		
9	Safety Effectiveness Evaluation	4	Countermeasure Evaluation

July 29 and 30, 2009 5

Use of SPFs in SafetyAnalyst

- SafetyAnalyst methods are based on expected accident frequency at sites
- Expected accident frequency at a site is a weighted average of observed and predicted accident frequencies
- Weights based on Empirical-Bayes methods
- Predicted accident frequencies are based on SPFs

6

July 29 and 30, 2009
Chicago, Illinois

SPFs in SafetyAnalyst

- Negative Binomial Regression models
- SPFs for 45 site subtypes:
  - 17 subtypes of roadway segments
  - 12 subtypes of intersections
  - 16 subtypes of ramps
- Based on HSIS data from 4 States
  - Default SPFs are a function of ADT only
  - Developed for Total and F & I accidents
  - Calibration procedures available to account for local conditions
  - User-defined SPFs may be input

7

Roadway Segment SPFs in SafetyAnalyst

RURAL
- Two-lane
- Multilane
  - undivided
  - divided
- Freeways:
  - Within interchange area
    - 4 lanes
    - 6+ lanes
  - Between interchanges
    - 4 lanes
    - 6+ lanes

URBAN
- Arterials
  - Two-lane
  - Multilane
    - undivided
    - divided
  - One-way
- Freeways:
  - Within interchange area
    - 4 lanes
    - 6 lanes
    - 8+ lanes
  - Between interchanges
    - 4 lanes
    - 6 lanes
    - 8+ lanes

8

Intersection SPFs in SafetyAnalyst

RURAL
- 3-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control
- 4-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control

URBAN
- 3-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control
- 4-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control

9

Ramp SPFs in SafetyAnalyst

RURAL
- Diamond
  - off-ramp
  - on-ramp
- Parclo loop
  - off-ramp
  - on-ramp
- Free-flow loop
  - off-ramp
  - on-ramp
- Free-flow outer connection
- Direct or semidirect connection

URBAN
- Diamond
  - off-ramp
  - on-ramp
- Parclo loop
  - off-ramp
  - on-ramp
- Free-flow loop
  - off-ramp
  - on-ramp
- Free-flow outer connection
- Direct or semidirect connection

10

SafetyAnalyst Data Requirements

- Site characteristics (i.e., inventory data)
  - Roadway segments
  - Intersections
  - Ramps
- Accidents

11

Roadway Segment Inventory Data

- Segment number
- Segment location (linkable to accident data)
- Segment length (mi)
- Area type (rural/urban)
- Number of through traffic lanes (by direction)
- Presence of median (divided/undivided)
- Direction of travel (for divided highways if each direction is treated as a separate segment)
- Access control (freeway/nonfreeway)
- ADT (veh/day)
- Within interchange area? (freeways only)

12

July 29 and 30, 2009
Chicago, Illinois

Intersection Inventory Data

- Intersection number
- Intersection location (linkable to accident data)
- Intersection location data (minor road)
- Area type (rural/urban)
- Number of intersection legs
- Type of traffic control
- Major-road ADT (veh/day)
- Minor-road ADT (veh/day)

SafetyAnalyst 13

Ramp Inventory Data

- Ramp number
- Ramp location (linkable to accident data)
- Ramp length (mi)
- Area type (rural/urban)
- Ramp type (off-ramp/on-ramp/ freeway-to-freeway ramp)
- Ramp configuration (diamond/loop/etc.)
- Ramp ADT (veh/day)

SafetyAnalyst 14

Accident Data

ACCIDENT-LEVEL DATA
- Accident case number
- Accident location (linkable to site data)
- Accident date (day/month/year)
- Relationship to junction
- Accident type and manner of collision
- Accident severity level
- Roadway segment, intersection, or ramp number
- Divided highway (side of road indicator)

VEHICLE-LEVEL DATA
- Initial direction of travel
- Vehicle maneuver/action

SafetyAnalyst 15

For More Information about SafetyAnalyst

- Go to:
  www.safetyanalyst.org
  www.aashtoware.org
- Contact:
  - Ray Krammes @ Ray.Krammes@dot.gov, (202) 493-3312
  - Vicki Schofield @ vschofield@aashto.org, (202) 624-XXXX

SafetyAnalyst 16

SafetyAnalyst Modules

Module 1 – Network Screening
Module 2 – Diagnosis and Countermeasure Selection
Module 3 – Economic Appraisal and Priority Ranking
Module 4 – Countermeasure Evaluation

SafetyAnalyst 17

Module 1 – Network Screening

- Review highway network (or any portion of the network) to identify sites with potential for safety improvement
- Identify sites that are candidates for further investigation
  - Identification does not necessarily imply that the site has an existing safety problem or has more accidents than expected

SafetyAnalyst 18

Module 1
Types of Network Screening

- Basic network screening for sites with high accident frequencies (total accidents or specific severity levels or collision types):
  - with *peak searching* on roadway segments
  - with *sliding window* on roadway segments
- High proportion of specific accident type
- Sudden increase in mean accident frequency
- Steady increase in mean accident frequency
- Corridor screening (extended roadway sections)

SafetyAnalyst 19

Module 2 – Diagnosis and Countermeasure Selection

- Guide user in the diagnosis of safety problems at specific sites
- Suggest array of countermeasures that address identified accident patterns
- User selects recommended countermeasures for further economic evaluation in Module 3

SafetyAnalyst 20

Module 2
Diagnosis Tools

- Collision diagrams
  - Provides simple collision diagram capabilities
  - Third-party software can be linked
- Accident summary statistics
  - Generates table, bar-charts, and/or pie-charts for range of accident data elements
- Statistical tests
  - Test for minimum accident frequencies
  - Test for high proportions of accidents
- Diagnosis review questions

SafetyAnalyst 21

Module 3 - Economic Appraisal & Priority Ranking

- Perform economic analysis of alternative countermeasures for a specific site
- Perform economic analysis of countermeasures across selected sites
- Develop priority ranking of alternative improvements
- Select an optimal mix of sites and countermeasures

SafetyAnalyst 22

Module 3
Appraisal & Ranking Measures

- Cost effectiveness
- EPDO-based cost effectiveness
- Benefit-cost ratio
- Net benefits
- Construction costs
- Safety benefits
- Number of total accidents reduced
- Number of FI accidents reduced
- Number of FS accidents reduced

SafetyAnalyst 23

Module 4 – Countermeasure Evaluation

- Determine safety effectiveness (percent reduction in crashes) for specific implemented countermeasures
- Conduct before-after evaluation of crash frequencies using the Empirical Bayes (EB) approach
- Conduct before-after evaluation of shifts in crash type proportions
- Reliable results require multiple sites and multiple years of before and after data for each site

SafetyAnalyst 24

the national SPF SUMMIT 2009

Calibration of SPFs in the HSM, IHSDM, and *SafetyAnalyst*

Doug Harwood
Midwest Research Institute

Purpose of Calibration

- To enable SPFs or safety prediction methods developed with data from one jurisdiction to be applied in another jurisdiction

What Differences Between Jurisdictions Does Calibration Account For?

- Climate
- Driver behavior
- Animal populations
- Crash reporting thresholds
- Crash reporting system procedures

How is the Calibration Factor Used?

Typical SPF with Calibration Factor:

$$N = \exp(a + b \times \ln(AADT))\ C$$

How is the Value of the Calibration Factor Determined?

Steps in Calibration:

1. Select facility types and SPFs
2. Select calibration sites
3. Obtain data:
   - site characteristics
   - observed crash data
4. Apply SPF or predictive method to each site
5. Compute calibration factor

How is the Value of the Calibration Factor Determined?

$$C = \frac{\text{Sum of observed crashes}}{\text{Sum of predicted crashes}}$$

July 29 and 30, 2009
Chicago, Illinois

Calibration in *SafetyAnalyst*

- The SPF for each individual facility type (i.e., site subtype) is calibrated separately for each calendar year
- All available sites for each site subtype of interest are used
- Calibration is done automatically by the software whenever new data are loaded – no user intervention is required

How is the Calibration Factor Used?

SafetyAnalyst SPF with calibration factor:

N = exp(a + b x ln(AADT)) C

Data Needs for Calibration of *SafetyAnalyst*

- Site characteristics
- Crash frequencies
- All needed data are mandatory variables in the *SafetyAnalyst* data set

Calibration in HSM Part C

- The entire predictive method for a given facility type is calibrated, rather than individual SPFs

$$N_{predicted} = N_{spf\ x} \times (AMF_{1x} \times AMF_{2x} \times \ldots \times AMF_{yx}) \times C_x$$

Calibration in HSM Part C

- Calibration procedures are presented in the Appendix to Part C
- Guidance is provided on:
  - data elements needed for calibration (listed in Exhibit A-2 in Appendix to HSM Part C)
  - All input variables to HSM Part C methods are either required or desirable data
  - minimum samples sizes

Calibration in HSM Part C

- A calibration data set must be assembled for each facility type
- Minimum sample size for calibration:
  - 30 to 50 sites that collectively experience at least 100 crashes per year
- The same calibration sites can be used with new crash data (and updated traffic volumes) to calibrate for future years

Calibration in IHSDM
• There is no formal calibration method built into the software
• Calibration factors determined outside the software may be entered by the user
• Calibration factors developed for the HSM or *SafetyAnalyst* can be used in IHSDM

Questions?

SPF Development in Illinois

Yanfeng Ouyang
Department of Civil & Environmental Engineering
University of Illinois at Urbana-Champaign

ILLINOIS July 29 and 30, 2009

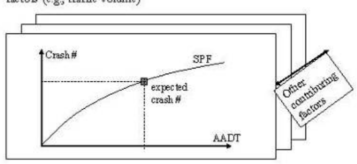
Outline

- Background
  - Methodology review
- SPF Development In Illinois
  - Data preparation
  - SPFs development
- SPF Applications
  - (Kim Kolody, Session 4)
- Uses of SPF and PSI Values
  - (David Piper, Session 9)

ILLINOIS July 29 and 30, 2009

Background

- Safety performance functions (SPFs)
  - Descriptive statistical relationships between crash counts and contributing factors (e.g., traffic volume)



- Developing SPFs helps
  - identify high-potential candidate locations for safety improvement
  - prepare for implementation of various safety tools

Model Specifications

- Lognormal Regression Models
  - log(crash count) follows normal distribution
  - Ordinary least-squares estimation
- Loglinear Regression Models
  - Poisson models
    - Describes discrete, rare events
    - Poisson distribution (variance = mean)
  - Negative binomial models
    - Negative binomial distribution
    - Overdispersion parameter, k
  - Maximum likelihood estimation

ILLINOIS July 29 and 30, 2009

Explanatory Variables

- Quantitative
  - Values that represent a condition, characteristic, or quantity
  - Can be directly entered into SPF
  - E.g., AADT, lane width, # lanes, etc.
- Categorical
  - Non-numerical variables to describe a situation
  - Use binary 'dummies', or define "peer groups"
  - E.g., median type, shoulder type, terrain type, etc.

ILLINOIS July 29 and 30, 2009

SPF Types

- Level-I SPF
  - Determine crash count based only on traffic volumes (AADT)
  - From past studies, AADT has the largest impacts on crashes

$$E[y_i] = (Seg\ Length)_i \cdot \alpha_0 \cdot (AADT_i)^{\alpha_1}$$
$$E[y_i] = e^{\beta_0} \cdot (AADT_{Major,i})^{\beta_1} \cdot (AADT_{Minor,i})^{\beta_2}$$

- Level-II SPF
  - Multivariate analysis that explicitly includes other variables
  - Can be used for education and enforcement purposes

$$E[y_i] = (Seg\ Length)_i \cdot \alpha_0 \cdot (AADT_i)^{\alpha_1} \cdot X_{2i}^{\alpha_2} \cdots$$
$$E[y_i] = e^{\beta_0} \cdot (AADT_{Major,i})^{\beta_1} \cdot (AADT_{Minor,i})^{\beta_2} \cdot \exp(\beta_3 X_{3i} + \beta_4 X_{4i} + \cdots)$$

ILLINOIS July 29 and 30, 2009

July 29 and 30, 2009
Chicago, Illinois

Development

- Segment Length Selection
  - Entire homogeneous segment with variable lengths
  - Break segments into small sections
  - Sliding window approach
- Intersection Crashes
  - Crashes that are
    - "at an intersection"
    - "intersection related, but not at an intersection"
    - "not intersection related"
  - Crashes within 250 feet of an intersection (*SafetyAnalyst*)

ILLINOIS July 29 and 30, 2009

The Illinois Experience

- Illinois is committed to reducing fatalities and severe injuries on roadways
  - Focus on crashes with fatality and severe injuries (Ks, As, Bs)
- Roadway site types
  - Roadway segments (homogeneous segments)
  - Intersections
- Model specification
  - Type-I SPFs
  - Negative binomial model

ILLINOIS July 29 and 30, 2009

Overview of Datasets

- Five years of crash data (2001-2005) on U.S. and state marked and unmarked routes
- Roadway data from Illinois Roadway Inventory System (IRIS)
  - 60,240 segments (16421 miles)
  - 54,880 intersections (state-state, state-local)
- Crash data
  - 2,826 records of K (fatal)
  - 26,768 records of A (disabling injury)
  - 65,654 records of B (evident injury)
- Intersection treatment
  - Consider crashes within 250 feet of an intersection (*SafetyAnalyst*)
  - Cross roads often lack roadway data
    - Local cross roads, use Average AADT in each county for various area types (provided by IDOT)
    - State-maintained minor cross roads, use the average AADT of the minor route for the County and Township near the intersection

ILLINOIS July 29 and 30, 2009

Peer Groups

Roadway Segment Mileage Analyzed by Peer Group

Roadway Segment Peer Groups	Mileage Analyzed By Peer Group
1. Rural 2-Lane Highway	9,586
2. Rural Multilane Undivided Highway	40
3. Rural Multilane Divided Highway	341
4. Rural Freeway, 4-Lanes	1,429
5. Rural Freeway, 6+ Lanes	32
6. Urban 2-Lane Highway	2,000
7. Urban One-Way Arterial	187
8. Urban Multilane Undivided Highway	771
9. Urban Multilane Divided Highway	1,247
10. Urban Freeway, 4-Lanes	441
11. Urban Freeway, 6-Lanes	282
12. Urban Freeway8+ Lanes	64
Total	16,421

Number of Intersections Analyzed by Peer Group

Intersection Peer Groups	Number of Intersections Analyzed by Peer Group
1. Rural Minor Leg Stop Control	16,498
2. Rural All-Way Stop Control	369
3. Rural Signalized Intersection	202
4. Rural Undetermined Intersection	7,361
5. Urban Minor Leg Stop Control	17,737
6. Urban All-Way Stop Control	242
7. Urban Signalized Intersection	6,057
8. Urban Undetermined Intersection	6,414
Total	54,880

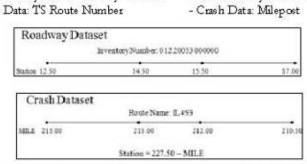
(Adapted from Illinois Five Percent Report, 2008)

ILLINOIS July 29 and 30, 2009

Data Preparation

Roadway Site Definition
- GIS Roadway Data: Inventory Number
- Crash Data: TS Route Number

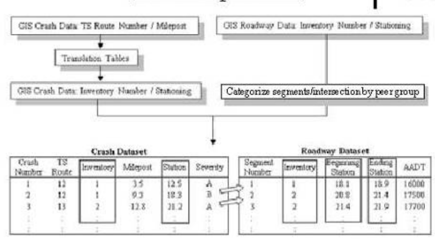
Positioning System
- GIS Roadway Data: Station
- Crash Data: Milepost



- IDOT provides a translation table to convert the TS Route and Milepost into Key Route Number and Station, for each year

ILLINOIS July 29 and 30, 2009

Data Preparation

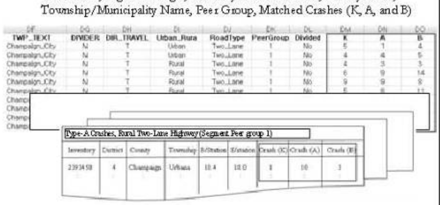


ILLINOIS July 29 and 30, 2009

the national SPF SUMMIT 2009

Data Preparation

- Required Fields in the Input Data
  - Inventory Number, Beginning Station, Ending Station, AADT, AADT Year, Road Name, Segment Length, Roadway Functional Class, County Name, Township/Municipality Name, Peer Group, Matched Crashes (K, A, and B)



SPF Development Example

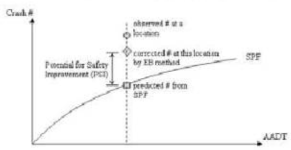
- Segment
  - Functional form: $E[y_i] = (Seg\ Length)_i \cdot e^a \cdot (AADT_i)^b$
  - Maximum Likelihood Estimation (MLE) in SAS
  - Estimation for 12 peer groups and four severity types (K, A, B and K+A+B)

Peer Group - Severity A	Regression Coefficients		Dispersion Parameter Per Mile
	Intercept(a)	Log(AADT(b))	
PeerGroup 1 - Rural Two-Lane Highway	-94.544	0.133	0.001
PeerGroup 2 - Rural Multilane Undivided Highway	-96.998	8.449	5.774
PeerGroup 3 - Rural Multilane Divided Highway	-4.734	0.637	0.944
PeerGroup 4 - Rural Freeway, 4 Lanes	13.943	-1.528	0.001
PeerGroup 5 - Rural Freeway, 6+ Lanes	-9.485	-102.400	0.001
PeerGroup 6 - Urban Two-Lane Highway	-324.688	34.217	0.001
PeerGroup 7 - Urban One-way Arterial	-7.052	0.984	1.211
PeerGroup 8 - Urban Multilane Undivided Highway	-11.283	-102.400	0.001
PeerGroup 9 - Urban Multilane Divided Highway	-8.260	0.731	2.790
PeerGroup 10 - Urban Freeway, 4 Lanes	6.324	-58.897	0.001
PeerGroup 11 - Urban Freeway, 6 Lanes	-5.036	0.406	0.001
PeerGroup 12 - Urban Freeway, 8+ Lanes	-130.496	10.872	0.001

ILLINOIS July 29 and 30, 2009

PSI Calculation

- Weighted PSI (Potential for Safety Improvements)
  - PSI – how much a site's safety performance exceeds the expectation
  - Empirical Bayesian (EB) Method: Find a weighted average of the predicted and observed numbers of crashes
  - Default values of weights: Fatal-K (25), Injury-A (5), and Injury-B (1)



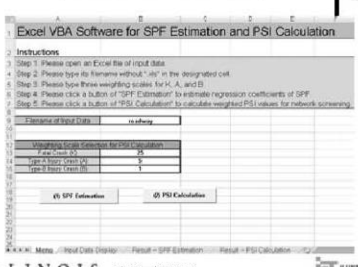
PSI Calculation Example

- Network Screening with Weighted PSI
  - Each road segment has a weighted PSI value per segment length
  - List road segments in descending order of weighted PSI values

Inventory	Route	Beginning Station	Ending Station	AADT	# of Lanes	Length (Mi)	Fatalities	A-Injuries	B-Injuries	Total PSI
X047903790000000	IL126	1.91	4.67	5900	2	2.76	5	12	6	57.6
X099100550000000	I055	24.85	27.46	93000	4	2.61	4	23	28	34.4
X089203010000000	US020	2.04	4.56	6200	2	2.52	3	2	2	16.6
X010207090000000	US136	18.23	20.27	5000	2	2.04	3	0	3	14.1
X016203390000000	IL058	19.83	20.67	35100	4	0.84	3	2	8	11.4
X025100570000000	I057	16.76	19.26	16300	4	2.5	3	2	1	10.8

ILLINOIS July 29 and 30, 2009

Process Automation



ILLINOIS July 29 and 30, 2009

Other Related Work

- Multivariate SPF development
- Implementation the SPFs in local safety tools
- Utilization and applications of SPFs
  - (Kim Kolody, Session 4)
  - (David Piper, Session 9)

ILLINOIS July 29 and 30, 2009

July 29 and 30, 2009
Chicago, Illinois

SPF Development and Data Needs

Washington State Department of Transportation

John Milton Ph.D., P.E.,
Washington State Department of Transportation

July 29th, 2009
Chicago, Illinois
National Safety Performance Function Summit

Overview

- Why SPFs?
- Model Development (Frequency vs. Severity)
- Data Collection
- Model Specification Issues
  - Homoskedasticity
  - Regression to the Mean
  - Omitted Variable Bias
- Transferability
  - East Versus West

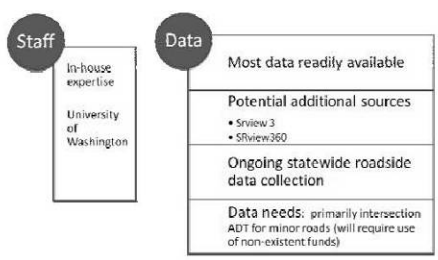
Why SPFs?

- Early 1990s recognition that Federal Dollars were not going to last, and efficiency of expenditures had to increase
- Wrote in to law that state had to address both historic and risk of a crash
- Doing it already, just not using what might be considered "available science"

Frequency vs Severity

- Frequency based
- Poisson/Negative Binomial
- Bayes (Hierarchical)
- Nested and Mixed Logit

Key Data Components Necessary



Data in Washington

- Geometric
  - Horizontal/Vertical Curve/angle point radius, length, PC/PVI/PT
  - Lane and Shoulder width
- Pavement type and condition
- Accident data
  - by severity, type, weather, contributing factors, actions etc.
- Traffic
  - ADT, PHF, Truck %, etc

Development of SPFs in WA State

- Homogenous vs non-homogeneous sections
  - New section based on changes in section
- Categorical versus Continuous variable
  - E.g., Shoulders width greater than 5' versus actual shoulders width
  - The greater the use of continuous the more data needed
  - Chose homogeneous sections with a preference towards continuous variables

Development of SPFs in WA State Statistical Issues

- Chose Homogenous sections to reduce heteroskedasticity (unequal variance) in models
- Could use continuous data more readily
- Prefer well specified, local models to ADT only models because of omitted variable bias in models, and low goodness of fit.

Development of SPFs in WA State Statistical Issues

- Concern about transferability across state
  - Functional class
  - East/west
- Intersection data greatest challenge because of minor street ADT

Development of SPFs in WA State Statistical Issues

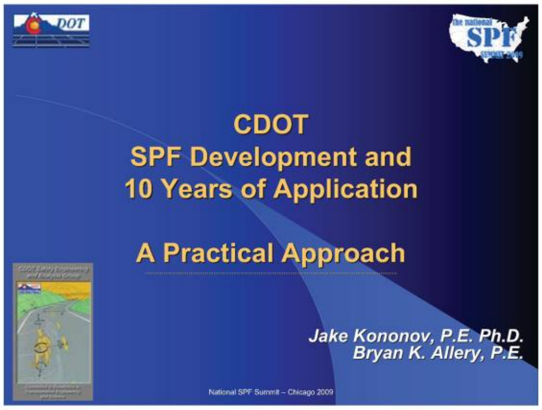
- Severity Models
  - Roadside information necessary
  - By Severity Type
    - Some severity levels may be grouped

Lessons from Past Experience

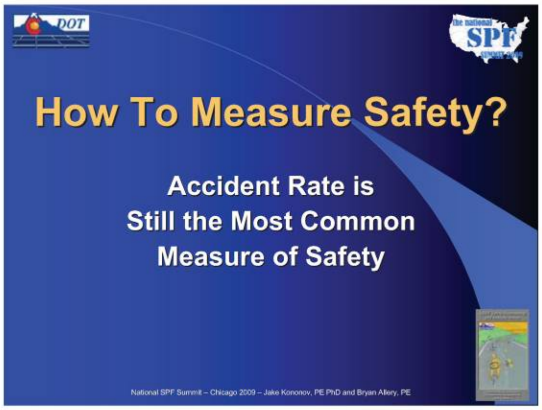
1. The more complex the model is to the user the more challenges will occur.
2. Models will be evaluated and question for deviations from current observations
3. Models benefit from good data and concerns for specification errors, not just RTM!
4. Self developed models can be under or over specified
5. Training is a necessity

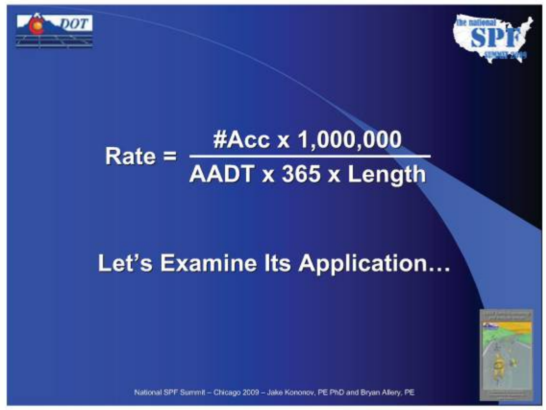
Summary

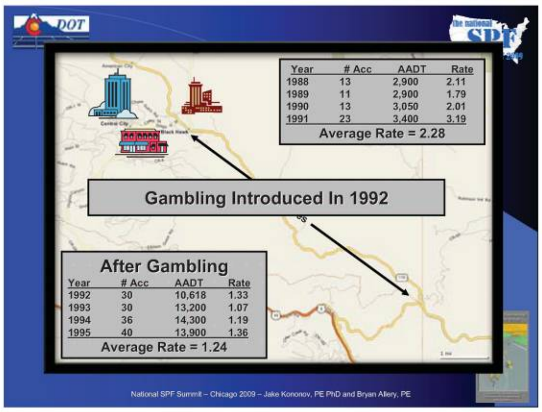
- Develop Data collection plan consistent with states capability and desires
- It is ok to start slow and add as you go along
- It is not necessary to develop your own SPFs. There are benefits and disadvantages to doing this in terms of cost, data resources and upkeep
- Training is necessary


DOT
CDOT
SPF Development and
10 Years of Application
A Practical Approach
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009


DOT
In Order to Manage Safety Effectively,
We Need to be Able to Measure it
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
How To Measure Safety?
Accident Rate is
Still the Most Common
Measure of Safety
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
$$\text{Rate} = \frac{\#\text{Acc} \times 1{,}000{,}000}{\text{AADT} \times 365 \times \text{Length}}$$
Let's Examine Its Application…
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

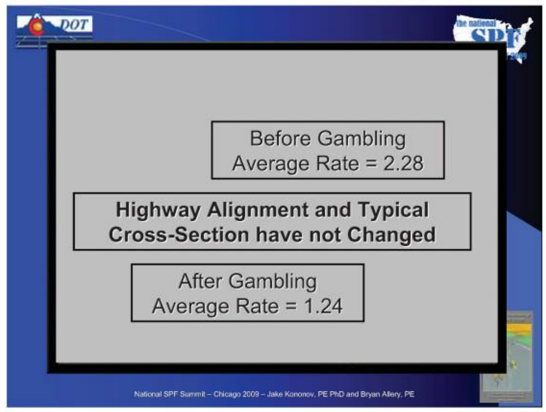

DOT

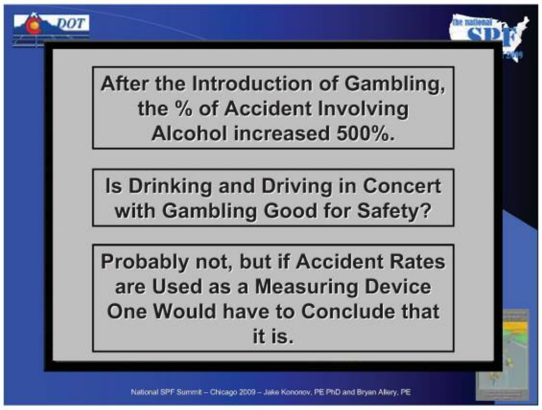
Year	# Acc	AADT	Rate
1988	13	2,900	2.11
1989	11	2,900	1.79
1990	13	3,050	2.01
1991	23	3,400	3.19

Average Rate = 2.28
Gambling Introduced In 1992
After Gambling

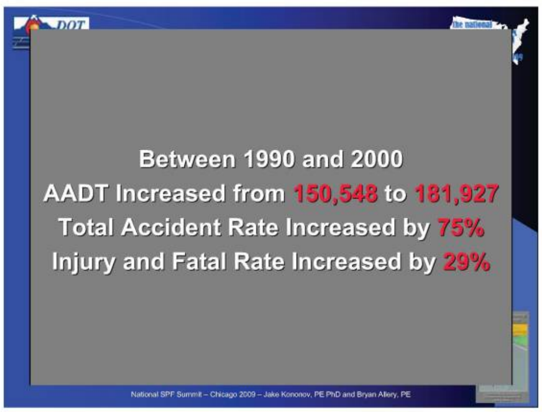
Year	# Acc	AADT	Rate
1992	30	10,618	1.33
1993	30	13,200	1.07
1994	36	14,300	1.19
1995	40	13,900	1.36

Average Rate = 1.24
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
Before Gambling
Average Rate = 2.28
Highway Alignment and Typical
Cross-Section have not Changed
After Gambling
Average Rate = 1.24
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


After the Introduction of Gambling, the % of Accident Involving Alcohol increased 500%.
Is Drinking and Driving in Concert with Gambling Good for Safety?
Probably not, but if Accident Rates are Used as a Measuring Device One Would have to Conclude that it is.
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Colfax Ave
MP 210.31
2000
1,692 Crashes
181,927 AADT
1990
805 Crashes
150,548 AADT
Accident Rates
Arapahoe Road
MP 197.19
I-25
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Between 1990 and 2000
AADT Increased from 150,548 to 181,927
Total Accident Rate Increased by 75%
Injury and Fatal Rate Increased by 29%
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

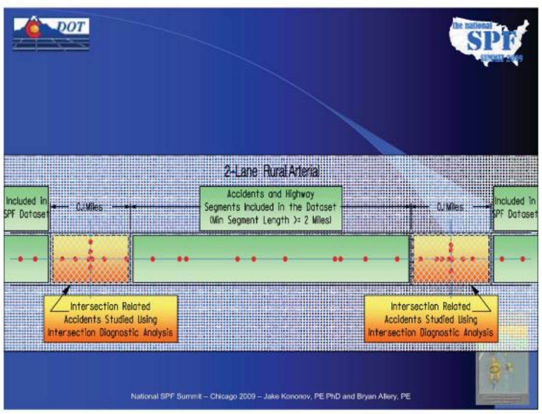

C-470
Platte Canyon
MP 15.44
I-25
MP 26.21
1990
58 Crashes
36,011 AADT
2004
308 Crashes
77,680 AADT
Accident Rates
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

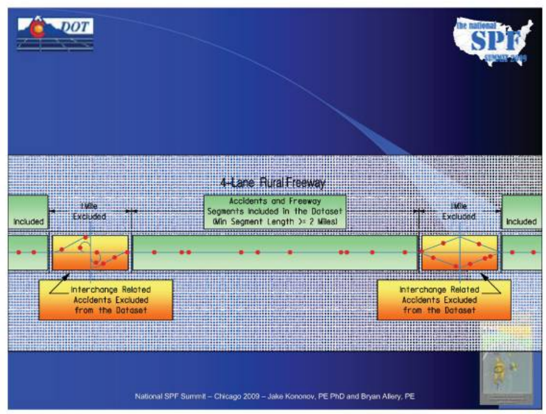

Between 1990 and 2004
AADT Increased from 36,011 to 77,680
Total Accident Rate Increased by 146%
Injury and Fatal Rate Increased by 60%
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

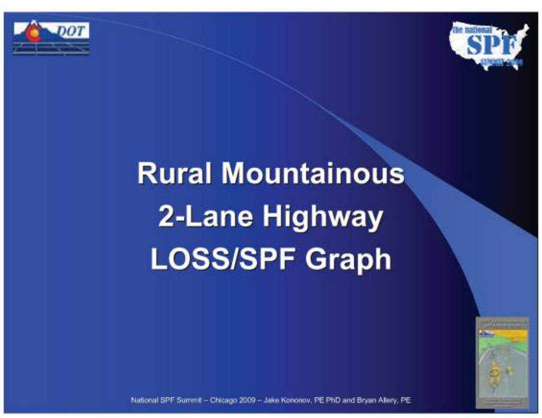

Clearly the Rate is Changing with AADT
In Order to Understand how the Crash Rate is Changing, We need to Develop a Relationship between Safety and Traffic Exposure
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

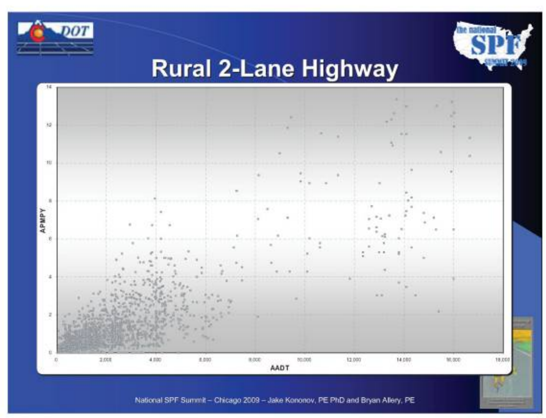

This Relationship is Reflected by, Safety Performance Function (SPF)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

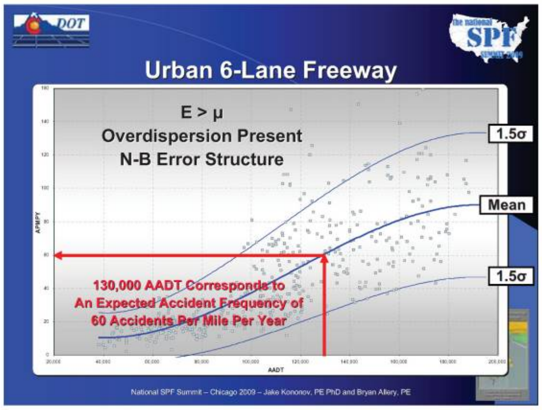

Calibration of Safety Performance Functions in Rural and Urban Environments
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

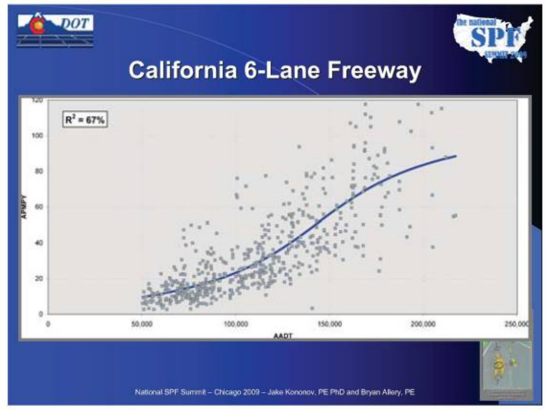

2-Lane Rural Arterial
Accidents and Highway Segments Included in the Dataset (Min Segment Length >= 2 Miles)
Intersection Related Accidents Studied Using Intersection Diagnostic Analysis
Intersection Related Accidents Studied Using Intersection Diagnostic Analysis
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

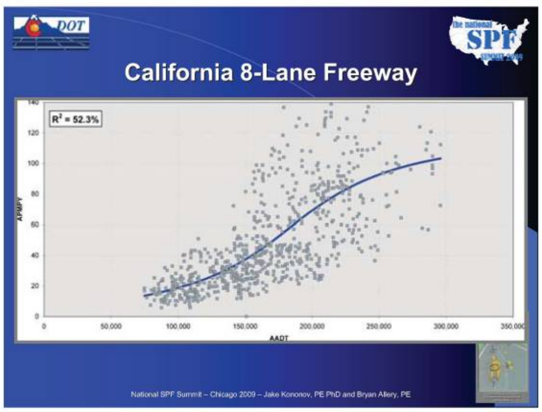

4-Lane Rural Freeway
Included
Excluded
Accidents and Freeway Segments Included in the Dataset (Min Segment Length >= 2 Miles)
Excluded
Included
Interchange Related Accidents Excluded from the Dataset
Interchange Related Accidents Excluded from the Dataset
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

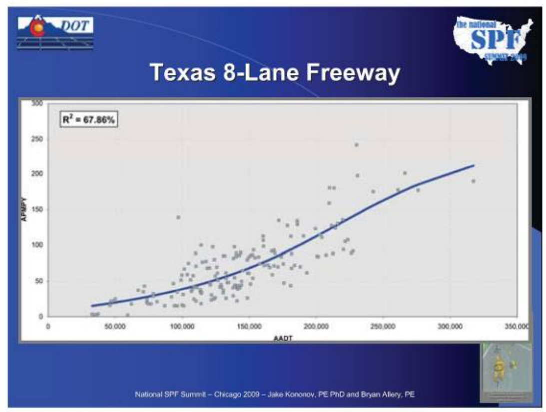

Rural Mountainous 2-Lane Highway LOSS/SPF Graph
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

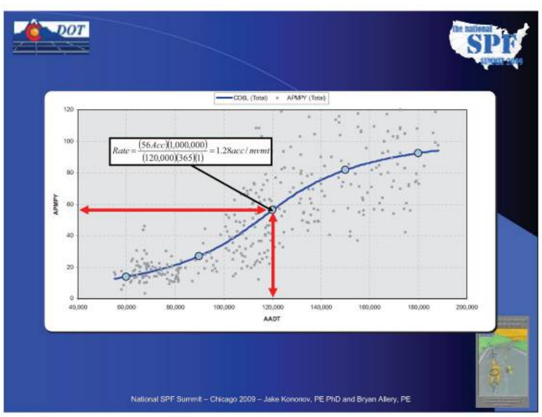

Rural 2-Lane Highway
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

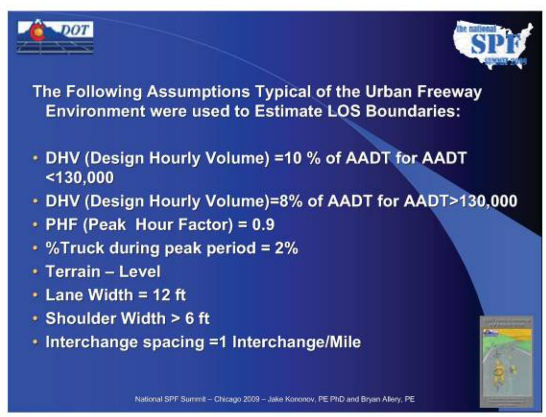

Urban 6-Lane Freeway
E > μ
Overdispersion Present
N-B Error Structure
1.5σ
Mean
1.5σ
130,000 AADT Corresponds to
An Expected Accident Frequency of
60 Accidents Per Mile Per Year
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

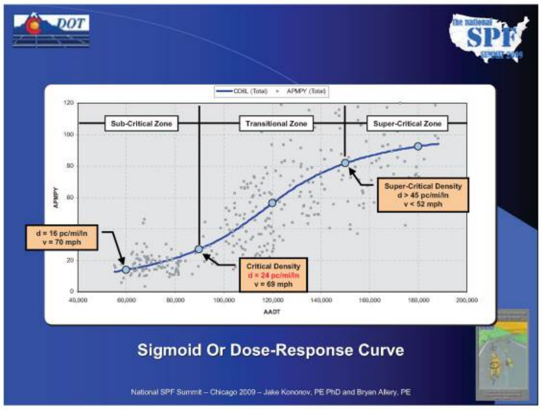

California 6-Lane Freeway
R² = 67%
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

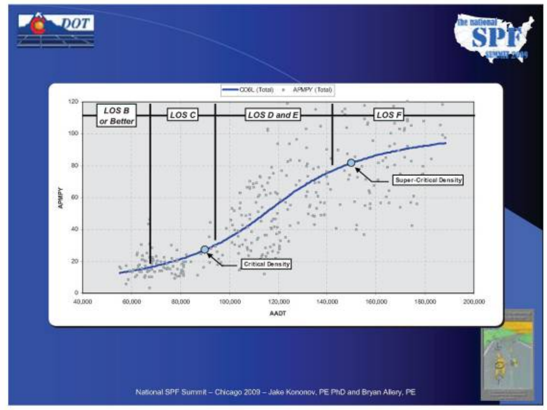

California 8-Lane Freeway
R² = 52.3%
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

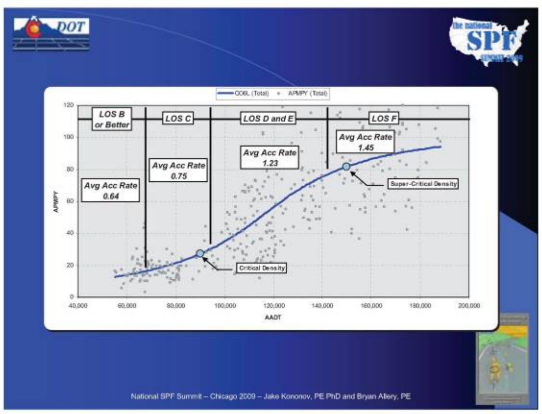

Texas 8-Lane Freeway
R² = 67.86%
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

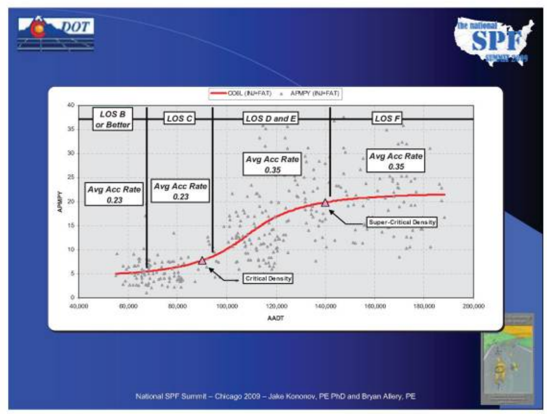

Rate = (56.4acc)(1,000,000) / (120,000)(365)(1) = 1.28acc / mvmt
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

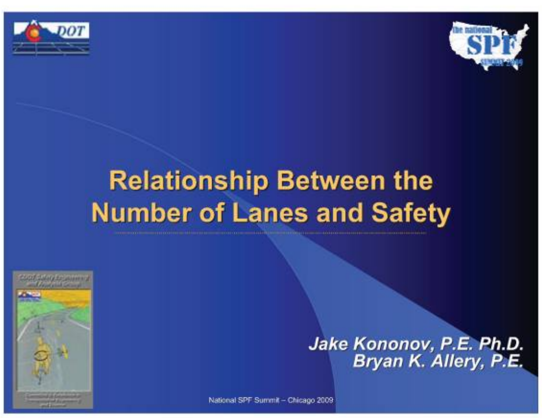

The Following Assumptions Typical of the Urban Freeway Environment were used to Estimate LOS Boundaries:
• DHV (Design Hourly Volume) =10 % of AADT for AADT <130,000
• DHV (Design Hourly Volume)=8% of AADT for AADT>130,000
• PHF (Peak Hour Factor) = 0.9
• %Truck during peak period = 2%
• Terrain – Level
• Lane Width = 12 ft
• Shoulder Width > 6 ft
• Interchange spacing =1 Interchange/Mile
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

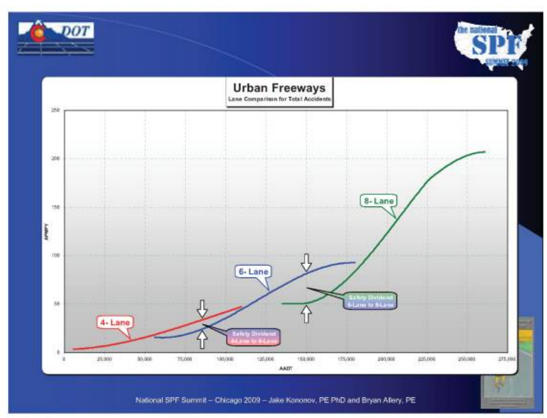

Sub-Critical Zone
Transitional Zone
Super-Critical Zone
d = 16 pc/mi/ln
v = 70 mph
Critical Density
d = 24 pc/mi/ln
v = 69 mph
Super-Critical Density
d > 45 pc/mi/ln
v < 52 mph
APMPY
AADT
Sigmoid Or Dose-Response Curve
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

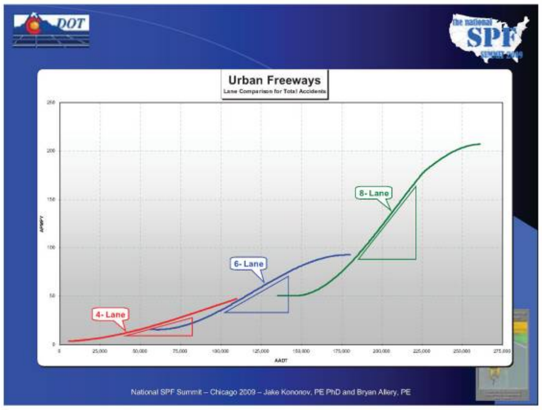

LOS B
or Better
LOS C
LOS D and E
LOS F
Super-Critical Density
Critical Density
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

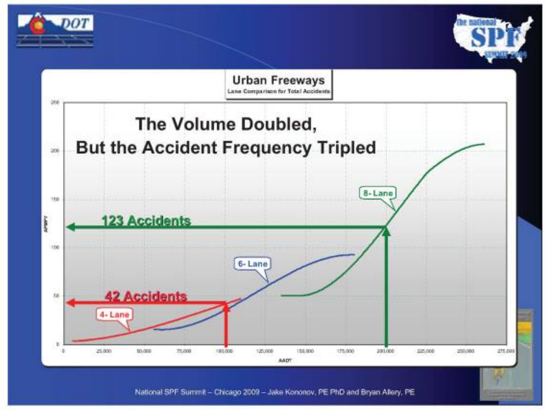

LOS B
or Better
LOS C
LOS D and E
LOS F
Avg Acc Rate
0.64
Avg Acc Rate
0.75
Avg Acc Rate
1.23
Avg Acc Rate
1.45
Super-Critical Density
Critical Density
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

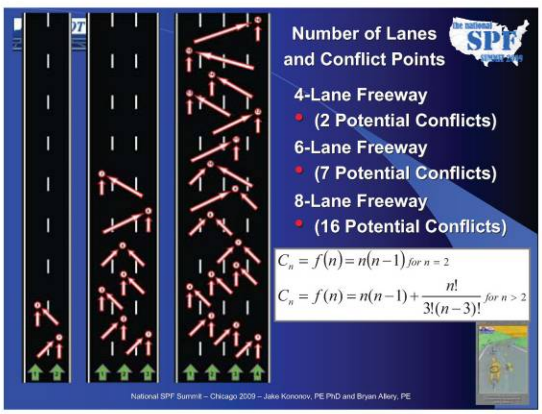

LOS B
or Better
LOS C
LOS D and E
LOS F
Avg Acc Rate
0.23
Avg Acc Rate
0.23
Avg Acc Rate
0.35
Avg Acc Rate
0.35
Super-Critical Density
Critical Density
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

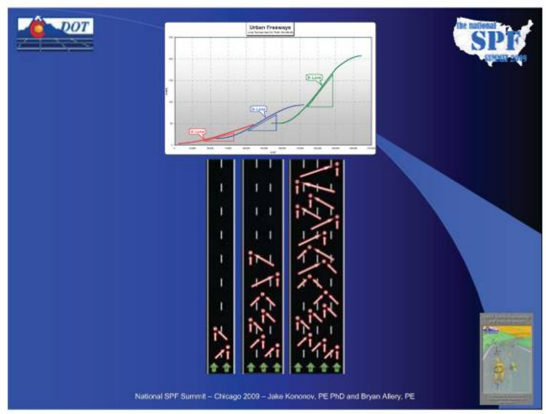

Relationship Between the
Number of Lanes and Safety
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009


Urban Freeways
4- Lane
6- Lane
8- Lane
Safety Dividend
4-Lane to 6-Lane
Safety Dividend
6-Lane to 8-Lane
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

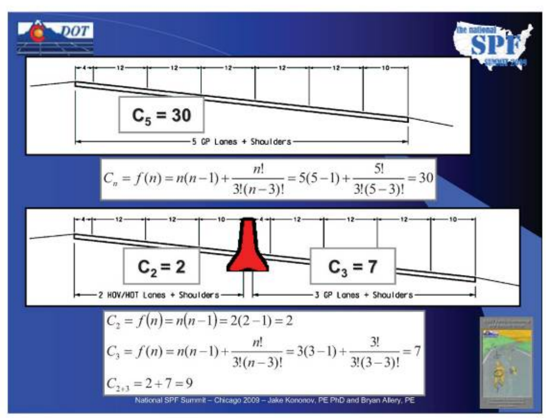

DOT
the national SPF
Urban Freeways
Lane Comparison for Total Accidents
8- Lane
6- Lane
4- Lane
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

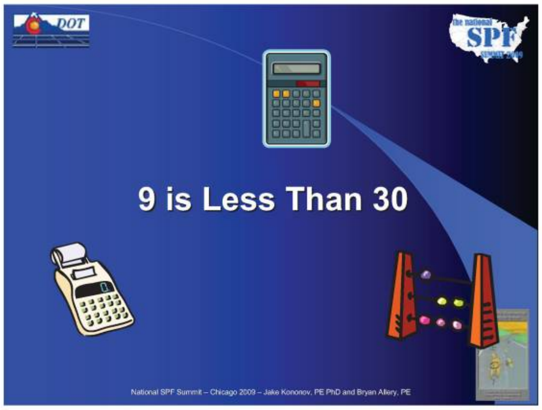

DOT
the national SPF
Urban Freeways
Lane Comparison for Total Accidents
The Volume Doubled,
But the Accident Frequency Tripled
123 Accidents
42 Accidents
8- Lane
6- Lane
4- Lane
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Number of Lanes
and Conflict Points
4-Lane Freeway
(2 Potential Conflicts)
6-Lane Freeway
(7 Potential Conflicts)
8-Lane Freeway
(16 Potential Conflicts)
$C_n = f(n) = n(n-1)$ for $n = 2$
$C_n = f(n) = n(n-1) + \frac{n!}{3!(n-3)!}$ for $n > 2$
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

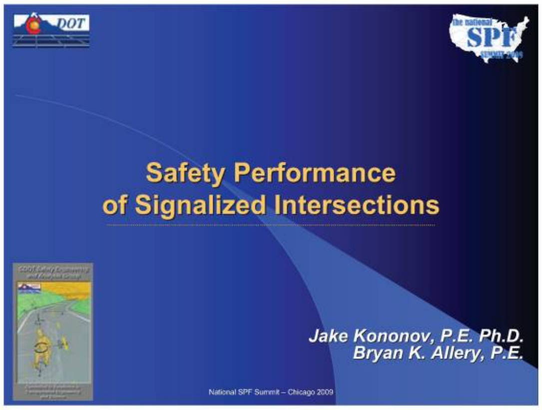

DOT
the national SPF
Urban Freeways
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
the national SPF
As the Number of Lanes Increases,
the Degree of Freedom for Things
to go Wrong also Increases
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

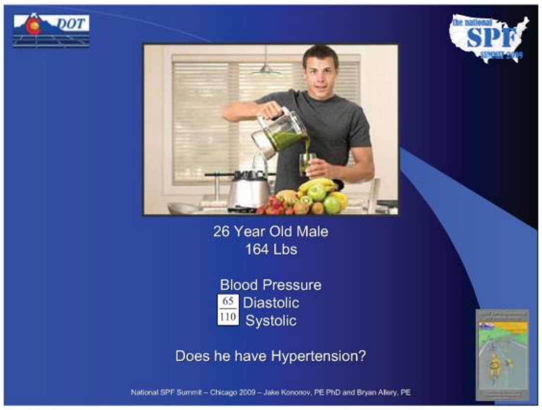

DOT
the national SPF
$C_5 = 30$
5 GP Lanes + Shoulders
$C_n = f(n) = n(n-1) + \frac{n!}{3!(n-3)!} = 5(5-1) + \frac{5!}{3!(5-3)!} = 30$
$C_2 = 2$
$C_3 = 7$
2 HOV/HOT Lanes + Shoulders
3 GP Lanes + Shoulders
$C_2 = f(n) = n(n-1) = 2(2-1) = 2$
$C_3 = f(n) = n(n-1) + \frac{n!}{3!(n-3)!} = 3(3-1) + \frac{3!}{3!(3-3)!} = 7$
$C_{2+3} = 2 + 7 = 9$
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE



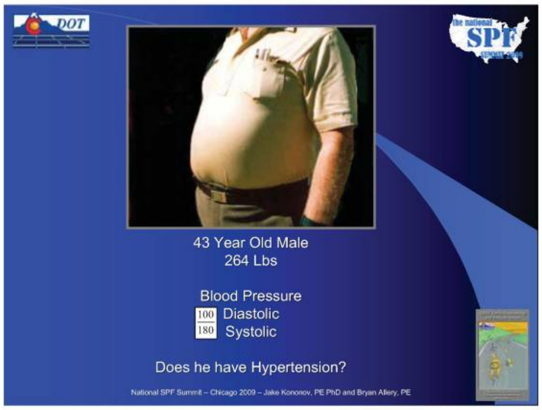
9 is Less Than 30
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE



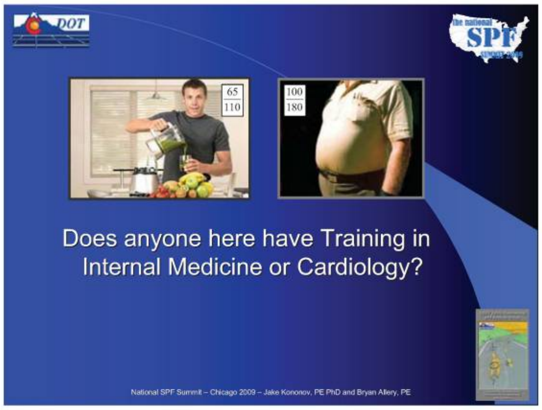
Safety Performance
of Signalized Intersections
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009



26 Year Old Male
164 Lbs
Blood Pressure
65 Diastolic
110 Systolic
Does he have Hypertension?
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE



43 Year Old Male
264 Lbs
Blood Pressure
100 Diastolic
180 Systolic
Does he have Hypertension?
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE



65
110
100
180
Does anyone here have Training in Internal Medicine or Cardiology?
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

Urban
4 Leg
6-Lane
Signalized
Fully Actuated
Mast Arm Signal Layout
Lighted
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

Virginia Department of Transportation

Virginia's Safety Modeling Story

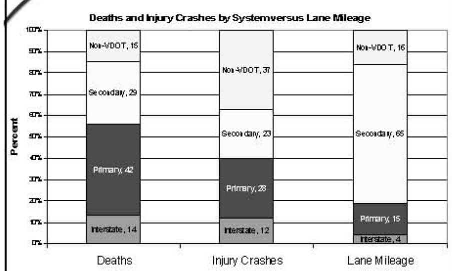
Stephen W. Read P.E., P.Eng.
Highway Safety Improvement Programs

Virginia's Safety Modeling Story

Outline

1. Past Initiatives
   – SHSP driven causal studies & regional issues
2. Present Initiatives
   – HSM and SafetyAnalyst preparation
3. Future Efforts
   – SPF modeling refinements and comparisons

SHSP and Action Planning



Previous SPF Development: Regional Issues & SHSP

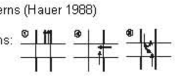
Safety Evaluation Procedure for
Signalized Intersections in NoVA District

Purpose and Data

- Traffic Control – phasing of protected vs. permitted
- Choose 4 leg intersections
- Collected data on 43 intersections from three sources:
  – Synchro files (traffic volume by vehicle movement and left-turn signal type)
  – MIST files (signal phase changing plan and time of day)
  – Crash DB (crash and vehicle data)
- 43 sites – approaches were 14% prot; 21% perm; 5% combined; 12% split

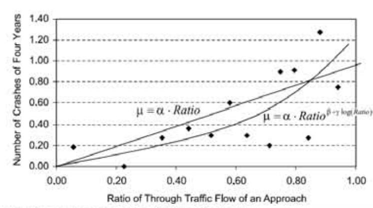
4-Way Signalized SPF Models

- Started with 16 Crash patterns (Hauer 1988)
- Focused on 3 crash patterns:



- Considered 4 times of day (AM peak, PM peak, mid-day & evening off-peak)
- Created 9 subtypes based on 3 crash patterns & 4 TOD

Intersection SPF Development



The final Poisson mean model (or SPF) is written as:

$$\hat{\mu}_i = \hat{E}(\kappa_i) = \exp\begin{pmatrix} -6.8155 + 0.7736 \log Flow_{through,i} - 0.0013 Flow_{through,i} \\ +0.3212 \log Flow_{left-turn,i} + 0.7209 PmPt_{left-turn,i} \end{pmatrix}$$

VDOT Virginia Department of Transportation

Virginia's Safety Modeling Story

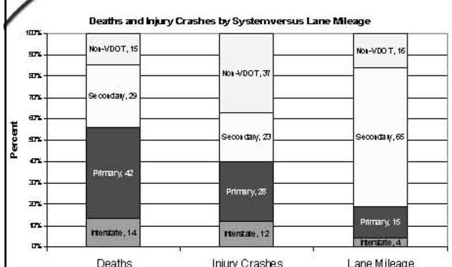
Stephen W. Read P.E., P.Eng.
Highway Safety Improvement Programs

Virginia's Safety Modeling Story

Outline

1. Past Initiatives
   – SHSP driven causal studies & regional issues
2. Present Initiatives
   – HSM and SafetyAnalyst preparation
3. Future Efforts
   – SPF modeling refinements and comparisons

SHSP and Action Planning



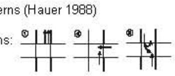
Previous SPF Development: Regional Issues & SHSP

Safety Evaluation Procedure for
Signalized Intersections in NoVA District

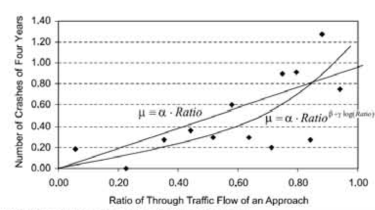
Purpose and Data

- Traffic Control – phasing of protected vs. permitted
- Choose 4 leg intersections
- Collected data on 43 intersections from three sources:
  - Synchro files (traffic volume by vehicle movement and left-turn signal type)
  - MIST files (signal phase changing plan and time of day)
  - Crash DB (crash and vehicle data)
- 43 sites – approaches were 14% prot; 21% perm; 5% combined; 12% split

4-Way Signalized SPF Models

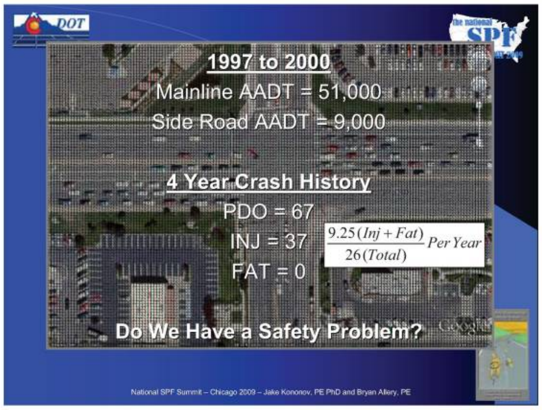
- Started with 16 Crash patterns (Hauer 1988)
- Focused on 3 crash patterns: 
- Considered 4 times of day (AM peak, PM peak, mid-day & evening off-peak)
- Created 9 subtypes based on 3 crash patterns & 4 TOD

Intersection SPF Development

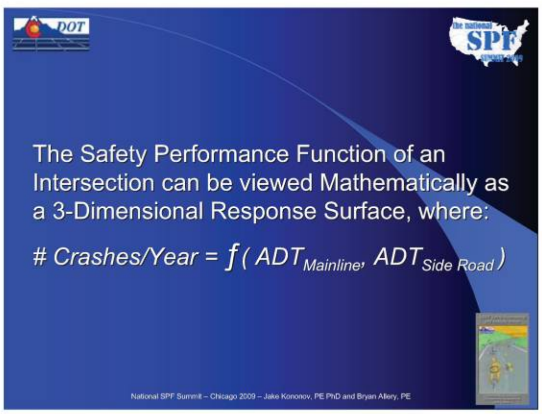


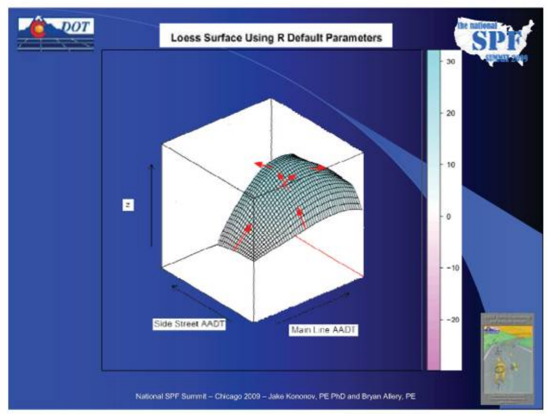
The final Poisson mean model (or SPF) is written as:

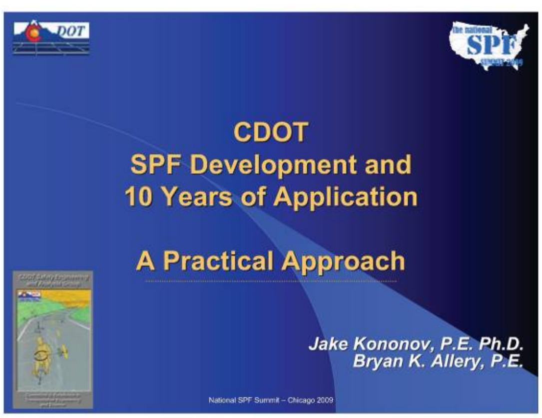
$$\hat{\mu}_i = \hat{E}(\kappa_i) = \exp\begin{pmatrix} -6.8155 + 0.7736 \log Flow_{through,i} - 0.0013 Flow_{through,i} \\ +0.3212 \log Flow_{left-turn,i} + 0.7209 PmPt_{left-turn,i} \end{pmatrix}$$


1997 to 2000
Mainline AADT = 51,000
Side Road AADT = 9,000
4 Year Crash History
PDO = 67
INJ = 37
FAT = 0
9.25 (Inj + Fat) / 26 (Total) Per Year
Do We Have a Safety Problem?
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


2001 to 2004
Mainline AADT = 63,000
Side Road AADT = 12,000
4 Year Crash History
PDO = 50
INJ = 17
FAT = 0
4.25 (Inj + Fat) / 16.75 (Total) Per Year
Do We Have a Safety Problem?
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


The Safety Performance Function of an Intersection can be viewed Mathematically as a 3-Dimensional Response Surface, where:
Crashes/Year = ƒ(ADT Mainline, ADT Side Road)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Loess Surface Using R Default Parameters
Side Street AADT
Main Line AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


CDOT
SPF Development and
10 Years of Application
A Practical Approach
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009

Virginia's Safety Modeling Story

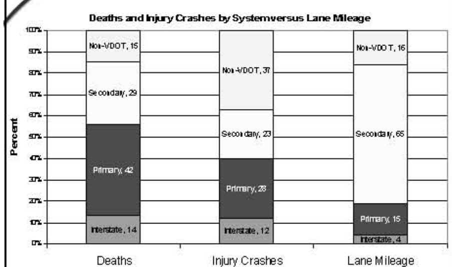
Stephen W. Read P.E., P.Eng.
Highway Safety Improvement Programs

Virginia's Safety Modeling Story

Outline

1. Past Initiatives
   – SHSP driven causal studies & regional issues
2. Present Initiatives
   – HSM and SafetyAnalyst preparation
3. Future Efforts
   – SPF modeling refinements and comparisons

SHSP and Action Planning



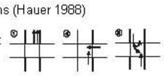
Previous SPF Development: Regional Issues & SHSP

Safety Evaluation Procedure for
Signalized Intersections in NoVA District

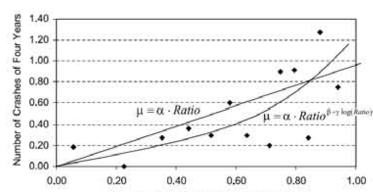
Purpose and Data

- Traffic Control – phasing of protected vs. permitted
- Choose 4 leg intersections
- Collected data on 43 intersections from three sources:
  – Synchro files (traffic volume by vehicle movement and left-turn signal type)
  – MIST files (signal phase changing plan and time of day)
  – Crash DB (crash and vehicle data)
- 43 sites – approaches were 14% prot; 21% perm; 5% combined; 12% split

4-Way Signalized SPF Models

- Started with 16 Crash patterns (Hauer 1988)
- Focused on 3 crash patterns: 
- Considered 4 times of day (AM peak, PM peak, mid-day & evening off-peak)
- Created 9 subtypes based on 3 crash patterns & 4 TOD

Intersection SPF Development



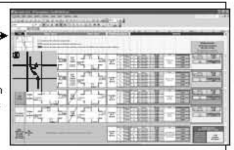
The final Poisson mean model (or SPF) is written as:

$$\hat{\mu}_i = \hat{E}(\kappa_i) = \exp\begin{pmatrix} -6.8155 + 0.7736 \log Flow_{through,i} - 0.0013 Flow_{through,i} \\ + 0.3212 \log Flow_{left-turn,i} + 0.7209 PmPt_{left-turn,i} \end{pmatrix}$$

1

Intersection Analysis

- Deliverables:
  - EB spreadsheet
  - User's guide



- Issues:
  - Matching directions between crash files and Synchro files
  - Small sample sizes
  - Manual inputting into the spreadsheet
- Potentials: When signal database containing Synchro files is coordinated with crash database, all of the above issues would be resolved.

Young-Jun.Kweon@VDOT.Virginia.gov
http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=08-R1

SHSP Driven Safety Action Plans

Crash Causal Factors for High Risk Two-lane Hwys

Purpose and Data

- Predominant factors on high crash segments
- From 200 (8 to 10 mi) sites choose 144 to collect detailed crash, traffic and geometric data
  - Excluded signalized intersection crashes
  - Total and Truck AADT (4 year period)
  - Traffic Speed
  - Horz/Vert alignment
  - Driveways Etc..

Two-Lane SPF Models

- First conducted fault tree analysis for primary factors
- Developed GLM – NB models for urban and rural primary and secondary routes
  - Total crashes (4 year period)
  - By collision type
- Issues
  - Minimal sites; only higher crash density
  - Requires detailed data not inventoried

Two-lane SPFs

Urban Primary

$$\text{Total Crashes} = \exp(4.4527 + 0.0006 * \text{AADT} + 1.784 * \textit{Length} - 1.2843 * \text{Passing Allowed} - 349.989 * \text{Grade})$$

Urban Primary

$$\text{Total Crashes} = \exp(4.4527 + 0.0006 * \text{AADT} + 1.784 * \textit{Length} - 1.2843 * \text{Passing Allowed} - 349.989 * \text{Grade})$$

Urban Secondary

$$\text{Total Crashes} = \exp(-0.0441 + 0.0409 * \textit{OperationalSpeed} + 0.0002 * \textit{AADT} + 0.3888 * \textit{Length} + 0.2517 * \textit{CrossStreetDensity} + 0.0409 * \textit{Truck} - 0.0029 * \textit{Curvature})$$

Nicholas.Garber@VDOT.Virginia.gov
http://www.virginiadot.org/vtrc/main/online_reports/pdf/09-r1.pdf

SHSP Driven Safety Action Plans

Crash Causal Factors for High Risk Multi-lane Primary Highways

Purpose and Data

- Predominant factors on high crash segments
- From 365 (1 to 2 mi) sites to collect detailed crash, traffic and geometric data
  - •Excluded signalized intersection crashes (unsig included)
  - •Total and Truck AADT (4 year period)
  - •Traffic Speed
  - •Horz/Vert alignment
  - •Driveways
  - •Etc..

Multi-lane SPF Models

- First conducted fault tree analysis for primary factors
- Developed GLM – NB models for urban and rural primary routes for divided, undivided and traversable
  - Total crashes (4 year period)
  - By collision type
- Issues
  - Minimal sites; only higher crash density
  - Requires detailed data not inventoried

2

Multi-lane SPFs

Urban Divided Injury

$$\text{Rear End Crashes} = \exp(0.1799 + 0.0415 \times \textit{CommercialEntrances} + 0.00006 \times \textit{AADT})$$

$$\text{Total Crashes} = \exp(1.2075 + 0.00003 \times \textit{AADT} + 0.0396 \times \textit{Commercial Entrances})$$

Urban Divided PDO

$$\text{Rear End Crashes} = \exp(0.2765 + 0.1354 \times \textit{Signals} + 0.0356 \times \textit{Commercial Entrances} + 0.00006 \times \textit{AADT})$$

$$\text{Total Crashes} = \exp(1.0312 + 0.0843 \times \textit{Cross Routes} + 0.0272 \times \textit{Commercial Entrances} + 0.00006 \times \textit{AADT})$$

Urban Divided Injury + PDO

$$\text{Angle Crashes} = \exp(1.8164 + 0.000008 \times \textit{AADT} - 0.1927 \times \textit{Shoulder Width} + 0.0655 \times \textit{Median Crossovers})$$

$$\text{Rear End Crashes} = \exp(0.9460 + 0.00006 \times \textit{AADT} + 0.0481 \times \textit{Commercial Entrances})$$

$$\text{Total Crashes} = \exp(1.9806 + 0.0440 \times \textit{Commercial Entrances} + 0.00004 \times \textit{AADT})$$

Urban Undivided Injury + PDO

$$\text{Total Crashes} = \exp(2.1827 + 0.00005 \times \textit{AADT} + 0.0980 * \text{Cross Routes})$$

Multi-lane SPFs

Table 8. R^2 Values for Developed Models

Highway Type	Severity	Collision Type	R^2 Correlation Based
Rural Divided	Injury	Rear end	0.34
	PDO	Rear end	0.27
		Total	0.36
	Injury + PDO	Rear end	0.47
		Total	0.35
Urban Divided	Injury	Rear end	0.48
		Total	0.39
	PDO	Rear end	0.60
		Total	0.58
	Injury + PDO	Angle	0.36
		Rear end	0.62
		Total	0.55
Urban Undivided	Injury + PDO	Total	0.14
Urban Traversable Median	Injury	Rear end	0.35
		Total	0.35
	PDO	Rear end	0.49
		Total	0.54
	Injury + PDO	Angle	0.53
		Rear end	0.53
		Total	0.46

Nicholas.Garber@VDOT.Virginia.gov
Young-Jun.Kweon@VDOT.Virginia.gov
http://www.virginiadot.org/vtrc/main/online_reports/pdf/09-r15.pdf

Present Initiatives: Developing SPFs compatible with HSM and SafetyAnalyst

Intersection Related Crash Models Subtypes -

- Urban 4-Leg Signalized
  - 568 Sites
- Urban 4-Leg with Minor Stop Control
  - 1239 Sites
- Urban 3-Leg Signalized
  - 836 Sites
- Urban 3-Leg with Minor Stop Control
  - 5367 Sites
- Rural 4-Leg Signalized
  - 182 Sites
- Rural 4-Leg with Minor Stop Control
  - 1570 Sites
- Rural 3-Leg Signalized
  - 183 Sites
- Rural 3-Leg with Minor Stop control
  - 8411 Sites

Functional Form for Intersection SPFs:

$Acc = e^{a} \times AADT^{b}_{maj} \times AADT^{c}_{min}$

Intersection SPF Models

- Developing GLM – NB models for urban and rural routes based on Major and Minor AADT for:
  - Total Crashes
  - F+I
- Difficulties
  - Defining TCD
    - Poor inventory – impute from crash report for signals, 2 and 4 way stops
    - Insufficient 4-way stop sites for model
    - Tracking change in TCD by crash report
  - Determining "Urban" or "Rural"
    - Based on Functional Classification
    - Mixed approach leg classes were excluded
  - Defining Major versus Minor Approach Volumes
    - SA and HSM not clear - important since the functional form of the model relies on a certain parameter being matched to the natural log of the major and minor AADT.
    - Model 1 = SA volume based definition
    - Possible Model 2= Volume and functional class definition

Intersection Model Comparison

	R^2 Freeman Tukey (%)			
	TOTAL CRASH		FATAL&INJURY CRASH	
	VA	MN	VA	MN
Urban 4-Legged Signalzied	56.04	33.58	40.59	32.42
Rural 4-Legged Signalized	81.69	80.84	64.53	19.49
Urban 4-Legged Minor Stop Control	31.29	21.55	19.28	7.97
Rural 4-Legged Minor Stop Control	16.90	13.43	10.00	9.98
Urban 3-Legged Signalized	37.01	30.86	26.01	26.20
Urban 3-Legged Minor Stop Control	22.97	10.38	13.38	9.77

Two-Lane Highway SPF Models

Purpose and Data

- AADT based for SA categories
- Rural and Urban based on Functional Class
- Approx 12,000 miles with Traffic Volumes and Roadway Inventory for years 2003-07
- Sites segmented at all:
  - Intersections (none internal to site)
  - geometric changes
  - speed zones

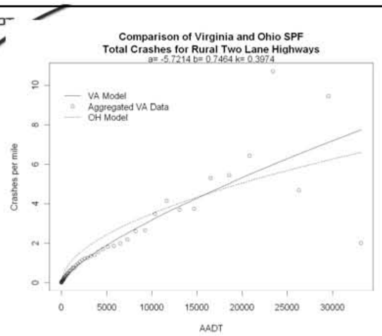
Two-Lane Highway Data

AREA	# OF SEGMENT	LENGTH (Miles)	REGION	# OF SEGMENT	LENGTH (Miles)
Urban	57605	6949.8	Northern	30685	3398.0
			Northwest and Southwest	9142	1431.5
			Central and Eastern	17778	2120.3
Rural	82030	42837.5	Northern	8186	3932.8
			Northwest and Southwest	49737	27169.6
			Central and Eastern	24107	11735.1

Two-Lane Highway SPF Models

$$crashes = e^{a} \cdot AADT^{b} \cdot segmentlength$$

		a	b	k	R^2_{ft}	$R^2_{ft(OH)}$
Total	Urban	-6.158	0.811	1.140	35.6%	32.5%
	Rural	-5.721	0.746	0.397	34.5%	10.0%
Fatal + Injury	Urban	-6.191	0.814	1.128	35.5%	32.1%
	Rural	-5.694	0.742	0.401	34.0%	9.2%



Two-Lane Highway SPF Models

- Developed GLM – NB models based on four years average AADT for:
  - Total Crashes
  - F+I
- Issues
  - Defining Traffic Volumes
    - Secondaries counted every 5 years
  - Understanding of Roadway Inventory for systematic definition of intersections, cross-section and traffic volume by LRS segments
  - Attempting regional level models (results TBD)

Planning Level SPFs

- A key focus of the VA Strategic Highway Safety Plan is the treatment of corridors with high numbers of crashes
- Virginia is developing a new approach that applies planning-level SPFs to 2-3 mile sections of road

Planning Level SPFs

- Project Goals:
  - Develop SPFs to identify 2-3 mile long sections of road for more detailed analysis
  - Help to identify longer sections where a safety assessment (audit) or coordinated set of improvements may be beneficial
- Summary of Approach:
  - SPFs will aggregate intersections and segments together (no separate intersection and segment SPFs)
  - Using data from 2003 to 2007 on Virginia's primary system to develop SPFs as a test case
  - 7339 miles of road and almost 160,000 total crashes
  - Different models for distinct regions of the state – DC suburbs, western mountains, and central/eastern urbanized area

4

Planning Level SPFs

$$Crashes = e^{\alpha}\left(ADT\right)^{\beta}\left(Length\right)$$

- SPF breakdown:
  - Use same model form as SafetyAnalyst
  - SPFs for all crashes and fatal/injury
  - SPFs for rural/urban
  - Geometric categories:
    - 2 lane roads
    - Multilane undivided
    - Multilane divided – not access controlled
    - Multilane divided – access controlled

Overview of Data for Planning SPFs

SPF Category	Centerline Miles	Links	Crashes
Rural Two-Lane	4582.1	11591	39302
Rural Multilane Divided	1377.57	4119	26268
Rural Multilane Undivided	256.01	1039	4176
Rural Limited Access	130.23	312	1605
Urban Two-Lane	261.66	1572	8005
Urban Multilane Divided	447.94	3543	60688
Urban Multilane Undivided	105.51	901	12039
Urban Limited Access	178.21	693	7381
Totals	7,339.23	23,770	159,464

Planning Level SPFs

- **Issues encountered:**
  - Inconsistencies between roadway inventory and crash data coding
  - Fluctuations in ADT values
  - Tradeoffs between losing 0 crash counts due to data aggregation and decrease in segment homogeneity
- **SPF development is just beginning**
- **Next steps:**
  - Evaluate quality of planning level SPFs
  - Compare to current critical rate-based screening approach for safety corridors

Michael.Fontaine@VDOT.Virginia.gov

Future Initiatives:
SPF Refinements

- In Virginia, we can identify same segments or intersections over years. Thus, we can form panel or longitudinal data.
- We can convert panel data to seemingly single-year data (cross-sectional data) by collapsing data over years.

2003

ID	Crash	AADT1	AADT2
10012	4	7,680	1,230

2004

ID	Crash	AADT1	AADT2
10012	2	8,490	998
10013	7	13,880	3,435
:	:	:	:

2007

ID	Crash	AADT1	AADT2
10012	8	9,015	1,450
10013	15	17,630	5,578
:	:	:	:

2003-2007

ID	ΣCrash	$\overline{AADT1}$	$\overline{AADT2}$
10012	22	8,895	1,230
10013	34	13,880	3,435
:	:	:	:

- Two model types are available: panel models vs. cross-sectional models. Which one should we use?

Testing SPF Model Types

- Currently conducting a study on model types using 3 criteria: estimation performance, prediction performance & dispersion.
- Preliminary findings:
  - In estimation and prediction performance, no difference between panel and cross-sectional models were found.
  - In dispersion parameter, cross-sectional models for some subtypes significantly underestimated dispersions..

Sub-category SPF Model Differences

- Urban 4-Legged Two-Way Stop Intersections
  - Panel Model: k=0.428
  - Cross-Sectional Model: k=0.252
- EB Formula:
  - E(Crash)EB = w x E(Crash) + (1 - w) x Crash
  - where w = 1 / { 1 + k x E(Crash) }

	Panel Model	Cross-Sectional Model
Crash	5	
E(Crash)	8.5	
k	0.428	0.252
w	1/(1+0.425x8.5) =0.216	1/(1+0.252x8.5) =0.318
$E(Crash)_{EB}$	0.216x8.5+(1-0.216)x5=5.755	0.318x8.5+(1-0.318)x5=6.114

5

SPF Application
"Down the Road"

- Presently loading data into SafetyAnalyst in "test" counties to investigate results with national models
- Plan to use VA statewide and regional models to compare with SA

6

SPF Applications for Safety Analysis in Illinois

Kim Kolody, P.E.
CH2M HILL Inc. for the Illinois Department of Transportation

CH2MHILL

Illinois SPF Experience

- SPF development and data needs
  - Yanfeng Ouyang, U of Illinois (Wed. Morn.)
- SPF applications
  - Kim Kolody, CH2M Hill (Wed. afternoon)
    - 100 Percent List, Five Percent List and Tools
    - Highway Safety Implementation Program applications
    - Education, Enforcement
- Use of SPF tools
  - Dave Piper, Illinois DOT (Thurs. morning)

CH2MHILL July 29 and 30, 2009 2

Timeline to SPFs

2005 2006 2007 2008 2009

- 2005: All crashes to determine high priorities
- 1st Year for Five Percent Report
- Weighted crashes/mi and weighted crash/MEV by peer group to determine high priorities
- SPF Weighted PSI to determine high priorities
- SPF Weighted PSI to determine high priorities and **all** state route locations

CH2MHILL July 29 and 30, 2009 3

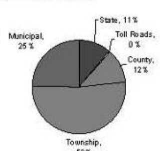
Implementing SPFs

- Evolving to the latest procedure accomplished the following:
  - Provided a rigorous analytical approach
  - Provided an objective approach
  - Provided a consistent approach
  - Shifted the focus to severe crashes
  - Shifted the focus to various roadway types

CH2MHILL July 29 and 30, 2009 4

State System Performance

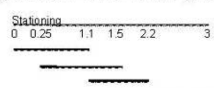
- Intersections - 8 peer groups
  - Over 47,000 intersections analyzed
- Segments - 12 peer groups
  - Over 89,000 analysis segments total (16,077 miles)
  - More complicated process



CH2MHILL July 29 and 30, 2009 5

System Segments

- Original SPF was calculated based on the Illinois Roadway Inventory System segments
- Combined segments in sliding window process
  - Rural: 1 mile (min), Urban: 0.25 miles (min)
  - Multiple values for segments

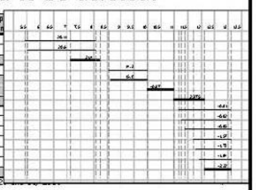


CH2MHILL July 29 and 30, 2009 6

Unique PSI Values: Segments

- Step 1: Sliding window segments with highest PSI values are selected, overlaps flagged to be deleted.

Inventory	Begin Station	End Station	PSI / mile	Selected Segments	Overlapping Segments
025 20328 000000	5.48	8.12	20.11		x
025 20328 000000	5.51	8.12	20.62		x
025 20328 000000	7.18	8.30	21.40	x	x
025 20328 000000	8.6	10	14.31		x
025 20328 000000	8.66	10	14.95	x	x
025 20328 000000	10	11	-0.87	x	x
025 20328 000000	11	12.12	2.98	x	x
025 20328 000000	11.19	13.12	-0.81		x
025 20328 000000	11.22	13.12	-0.82		x
025 20328 000000	11.3	13.12	-0.85		x
025 20328 000000	11.73	13.12	-1.56		x
025 20328 000000	11.9	13.12	-1.73		x
025 20328 000000	11.97	13.12	-1.84		x
025 20328 000000	12.12	13.12	-2.22	x	x

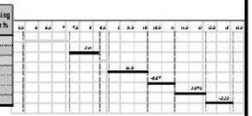


CH2MHILL July 29 and 30, 2009

Unique PSI Values: Segments

- Step 2: Gaps between are assigned the highest overlapping PSI value or the highest adjacent PSI value if small (<0.1 urban or <0.25 rural).

Inventory	Begin Station	End Station	PSI / mile	Selected Segments	Overlapping Segments
025 20328 000000	5.48	7.18	20.62	xx	x
025 20328 000000	7.18	8.30	21.40	x	x
025 20328 000000	8.30	8.66	14.31	xx	x
025 20328 000000	8.66	10	14.95	x	x
025 20328 000000	10	11	-0.87	x	x
025 20328 000000	11	12.12	2.98	x	x
025 20328 000000	12.12	13.12	-2.22	x	x



CH2MHILL

100 Percent List

- Intersection/Segment PSI
  - Excel Tables – all, each district
  - GIS layers – point and line files

IRIS Definition						Location Description					Crashes by Severity		
Inventory Number	Beg Station	End Station	Length	Peer Group	PrGrp Name	Dist.	County Name	Route Name	Total Crashes	PSI	K	A	B
[illegible]	0	[illegible]	[illegible]	9	Urban Multilane Undivided Hwy	8	ST. CLAIR	KING BRIDGE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	9	Urban Multilane Divided Hwy	1	COOK	LAKESHORE DR	[illegible]	213.44	1	[illegible]	[illegible]
[illegible]	17.51	17.55	[illegible]	11	Urban Freeway, 6-Lanes	1	COOK	W LEO DAN RYAN	[illegible]	205.72			
[illegible]	17.55	17.78	[illegible]	11	Urban Freeway, 6-Lanes	1	COOK	W LEO DAN RYAN	[illegible]	205.72	[illegible]	9	[illegible]
[illegible]	0	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	8	ST. CLAIR		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	DAN RYAN EXPWY	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	9	Urban Multilane Divided Hwy	1	COOK	LAKESHORE DR	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	12	Urban Freeway, 8+ Lanes	1	COOK	KENNEDY EXPWY	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	11	Urban Freeway, 6-Lanes	1	COOK	STEVENSON EXPWY	[illegible]	[illegible]	1	[illegible]	[illegible]

CH2MHILL July 29 and 30, 2009 9

100 Percent > FIVE PERCENT

- The FHWA Five Percent report guidelines state

"As part of the new HSIP, States are required to submit an annual report describing not less than 5 percent of their highway locations exhibiting the most severe safety needs [Section 148(c)(1)(D)]. "

CH2MHILL July 29 and 30, 2009 10

FIVE PERCENT Segments

- All segments were ranked from highest to lowest PSI values.
- Five percent accumulated mileage was selected for each peer group.
  - 16,000 miles analyzed
  - 855 miles included in FIVE PERCENT

CH2MHILL

FIVE PERCENT Segments

Class.	PeerGroup	Total Analyzed Mileage	5% Selected Locations Segments	5% Selected Locations Mileage	Class.	Total Analyzed K, A, B Crashes	Total Analyzed Crashes Per Mile	5% Selected Locations K, A, B Crashes	5% Selected Locations Crashes Per Mile	5% Selected Locations % of Total
1	Rural 2-Lane	9,292	438	461	1	8,197	0.88	1,099	2.4	13.4
2	Rural Multilane Undivided	44	2	3	2	45	1.02	11	3.8	24.4
3	Rural Multilane Divided	321	21	16	3	598	1.86	47	2.9	7.9
4	Rural Freeway, 4 Lanes	1,265	69	68	4	3,314	2.62	370	5.4	11.2
5	Rural Freeway, 6+ Lanes	24	2	1	5	70	2.92	3	2	4.3
6	Urban 2-Lane	2,141	271	115	6	4,716	2.2	814	7.1	17.3
7	Urban One-Way Arterial	181	36	8	7	282	1.56	91	10.8	32.3
8	Urban Multilane Undivided	825	166	60	8	3,303	4	646	10.8	19.6
9	Urban Multilane Divided	1,288	282	86	9	8,284	6.43	1,996	23.3	24.1
10	Urban Freeway, 4 Lanes	461	41	30	10	3,221	6.99	505	16.6	15.7
11	Urban Freeway, 6 Lanes	194	49	12	11	4,027	20.76	815	70.1	20.2
12	Urban Freeway, 8+ Lanes	41	17	3	12	2,509	61.2	468	142.7	18.7
		16,077	1,394	855		38,565		6,865		17.8

- FIVE PERCENT accounts for 18% of fatal, A-injury, and B-injury crashes

CH2MHILL

FIVE PERCENT Segments

Class.	Peer Group	Head-On and Opposite Direction Sideswipe		Fixed Object and Overturned		Angle and Turning		Rear End and Same Direction Sideswipe	
		Analyzed	5%	Analyzed	5%	Analyzed	5%	Analyzed	5%
1	Rural 2-Lane	11%	19%	62%	62%	10%	10%	11%	7%
2	Rural Multilane U	7%	18%	66%	65%	16%	9%	18%	18%

Class.	Peer Group	Younger Driver (16-20)		Older Driver (65+)		Impaired Driver		Restraint Not Used/Used		Driving Too Fast for Conditions	
		Analyzed	5%	Analyzed	5%	Analyzed	5%	Analyzed	5%	Analyzed	5%
1	Rural 2-Lane	26%	24%	13%	13%	20%	26%	18%	27%	19%	24%
2	Rural Multilane	18%	27%	9%	9%	22%	27%	11%	0%	24%	27%

Peer Group 1–Rural Two-Lane Highway

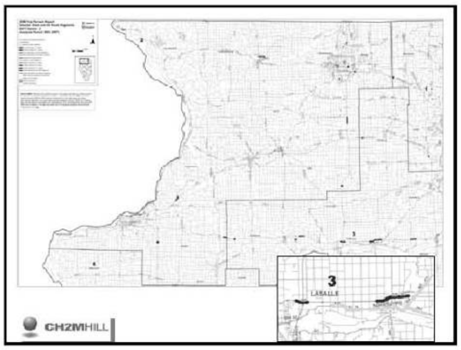
IRIS Definition						Location Description						Crashes by Severity				
Inventory Number	Beg Station	End Station	Length	Peer Group	Prop Name	District	County	County Name	Route Name	Total Crashes	PSI	K	A	B	*Gap	Beg-I
065 2003+000000	16.25	16.38	0.13	1	Rural 2-Lane Hwy	6	65	Menard		0	66.0211				xx	I-6-000
065 2003+000000	16.38	17.78	1.4	1	Rural 2-Lane Hwy	6	65	Menard		8	66.0211	4	1	3	x	I-6-000
042 307+7000000	4.23	5.29	1.06	1	Rural 2-Lane Hwy	8	42	Jersey	McClusky	7	54.3339	2	4	1	x	I-8-000
028 32882000000	3.29	4.64	1.35	1	Rural 2-Lane Hwy	9	28	Franklin		5	50.7985	3	1	1	x	I-9-000

CH2MHILL

FIVE PERCENT Segments

- Tables contain (peer group and location)
  - Identification Number
  - Location information: IRIS, description
  - Number crashes (K, A, B), PSI value
  - Number and percent of crashes
    - Crash type
    - Younger driver (16-20)
    - Older driver (65+)
    - Impaired driver
    - Use of Restraint
    - Driving too fast

CH2MHILL



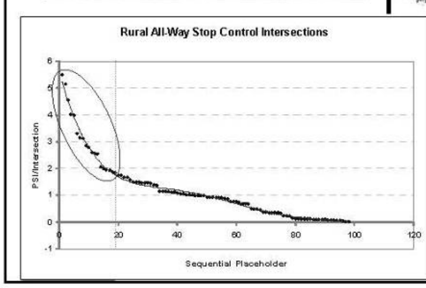
CH2MHILL

FIVE PERCENT Intersections

- All intersections were ranked from highest to lowest PSI values.
- Five percent of the total intersections was over 2300 intersections ≈ not manageable for evaluation.
- Knee of the curve approach for selecting high risk locations.

CH2MHILL

FIVE PERCENT Intersections



FIVE PERCENT Intersections

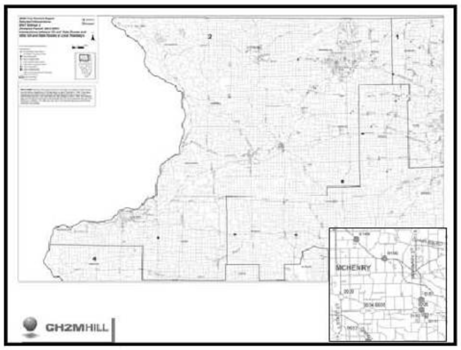
Class.	Peer Group	Number of Intersections Analyzed	Number of 5% Selected Locations	Percent of Inter.
1	Rural Minor Leg Stop Control	16,239	82	0.50%
2	Rural All-Way Stop Control	215	14	6.50%
3	Rural Signalized	121	8	6.60%
4	Rural Undetermined	3,657	48	1.30%
5	Urban Minor Leg Stop Control	17,653	160	0.90%
6	Urban All-Way Stop Control	380	20	5.30%
7	Urban Signalized	5,070	55	1.10%
8	Urban Undetermined	4,353	45	1.00%
		47,688	432	0.90%

Class.	Peer Group	Crashes Analyzed in All Sites				Crashes Analyzed in 5% Locations				
		Fatal	A-type Inj	B-type Inj	Total	Fatal	A-type Inj	B-type Inj	Total	% of Total
1	Rural Minor Leg Stop Control	290	2,047	3,530	5,867	16	267	265	548	9%
2	Rural All-Way Stop Control	5	71	135	211	2	26	34	62	29%
3	Rural Signalized	13	88	208	309	4	27	49	80	26%
4	Rural Undetermined	66	451	787	1,304	9	120	122	251	19%
5	Urban Minor Leg Stop Control	454	6,231	16,451	23,136	30	634	1,325	1,989	9%
6	Urban All-Way Stop Control	10	136	423	569	2	31	140	173	30%
7	Urban Signalized	377	8,262	23,467	32,106	27	593	1,329	1,949	6%
8	Urban Undetermined	164	2,423	7,027	9,614	16	328	869	1,213	13%
TOTAL		1,379	19,709	52,028	73,116	106	2,026	4,133	6,265	9%

FIVE PERCENT Intersections

- Tables contain (peer group and location)
  - Identification Number
  - Location information: IRIS, description
  - Number crashes (K, A, B), PSI value
  - Number and percent of crashes
    - Crash type
    - Younger driver (16-20)
    - Older driver (65+)
    - Impaired driver
    - Use of Restraint
    - Driving too fast

CH2MHILL



CH2MHILL

FIVE PERCENT REPORT

- Describes the methodology
- Identifies Five Percent locations
  - Maps for each district
  - Tables of crash stats, crash caseIDs
  - Comparisons to the prior year
- Corridors of interest
- Countywide analyses
- Responses from the Districts

CH2MHILL July 29 and 30, 2009 21

Seg. ID	Safety Observations	Potential Countermeasures	Estimated Costs	Implem. Impediments	Comments
1 D?-0007	Intersection fatality at 170th Street (1000 ADT) in town of Preemption. Narrow shoulders, miscellaneous typical sections, vertical and horizontal curvature w/ poor sight distance at cemetery. Request speed study through town. Stop sign currently doubled up at 170th.	low cost improvements: chevrons, entrance warning signage for the cemetery; Intermediate improvements - 5' HMA shoulder, rumble strip; long term improvements - culvert extensions, earthwork for better sight distance around horizontal, vertical curves, and entrances			Request Districtwide HSIP to place Chevrons and monitor the crash data and follow up with other improvements if needed.
6 D?-0009	Severe accidents are westbound run off the road in a horizontal curve.	low cost improvement - Chevrons, striping	Low cost - $10,000		Request Districtwide HSIP to place Chevrons and monitor the crash data and follow up with other improvements if needed.

Seg. ID	Safety Observations	Potential Countermeasures	Estimated Costs	Implem. Impediments	Comments
[illegible]	11' travel lanes, no paved shoulder, rolling vertical alignment, tight horizontal alignment, narrow existing ROW with steep foreslopes & backslopes & narrow ditches. overpoles offset fairly close to travel lane.	3R type improvement. Speed appears to be an issue - localized enforcement could be an option.	$750,000 per mile plus ROW costs.	Relatively low ADT for this high cost project.	This segment also appeared on the 2007 5% report. Due to low volume, a high type improvement does not seem justifiable. Will suggest speed enforcement to ISP & continue to monitor.
[illegible]	High volume urban 5 lane highway with numerous commercial entrances.	Consolidation of commercial entrances.		Lack of support from City of Jacksonville & local businesses.	Will propose access management study be conducted & will continue to monitor segment.

July 29 and 30, 2009 22

FIVE PERCENT REPORT

- Used by the IDOT districts, the Illinois State Police and local agencies
  - Provides a platform for educating safety professionals
  - Focuses the safety partners on severe crashes and the most hazardous locations
  - Identify locations for focused enforcement
  - Determine the type of enforcement needed i.e. speed, alcohol, seatbelt

CH2MHILL July 29 and 30, 2009 23

Users Response to SPFs

- The process has been validated by field reviews and responses from the districts
- Provided a consistent and objective approach
- Focus on different types of roadways, not just high volume roadways
- Improved data
- Coordinated effort among 4 Es

CH2MHILL July 29 and 30, 2009 24

SPF Applications for Safety Analysis in Illinois

- SPFs have facilitated a culture change from all crashes to severe crashes
- SPFs have allowed a proactive approach to addressing fatal and severe crashes
- SPFs are used to describe the safety performance of all state routes and intersections

CH2MHILL July 29 and 30, 2009 25

SPF Applications for Safety Analysis in Illinois

- SPFs are used to determine the most hazardous locations
- SPFs are an initial step in determining HSIP potential projects
- SPFs are used to evaluate
  - Individual sites
  - Corridors
  - Systematic issues

CH2MHILL July 29 and 30, 2009 26

Thank you

Kim.Kolody@ch2m.com
773-693-3800x245

CH2MHILL July 29 and 30, 2009 27

SPFs Applications by State DOTs

Washington State Department of Transportation

John Milton Ph.D., P.E.,
Washington State Department of Transportation

July 29th, 2009
Chicago, Illinois

National Safety Performance Function Summit

Overview

- Washington State Applications
  - Rural Two Lane Highways
  - Interstates
  - Signals and Channelization
- Ongoing Development
  - Rural Multilane Highways
- Present Uses

Effective Expenditure of Dollars

- Bottom line is to maximize potential for return on investment
- Approaches range from standards based solutions to focused solutions
- Return on investments decisions are critical
- 90% Federal Investment no longer
- Suggest the need for optimized decision making

Effective Expenditure of Dollars

- In standards based solutions one requires a long return.
- Focused solutions require a strong ability to determine the expected safety picture.
- Anecdotal is not acceptable, nor is a low probability of a return
  - Rate based or methods that don't control for specification error will not optimize return

Development of SPFs in WA State

- WSDOT chose to move toward development of local SPFs
  - Developed for all highways excluding interstate
  - Believe that statistical issues related to rate based or short term frequency estimations need to be considered in program development and these elements phased out over time
  - Prefer well specified, local models to ADT only models

Development of SPFs in WA State

- Use SPFs for planning and programming in the prevention sub-program for both corridors and intersections
- Models were developed independently for each element
- Modifications were made in Design Manual to account for changes, and the particular focus of the program

Development of SPFs in WA State

- Over time WSDOT moved from a focus on all severity collision to fatal and serious
- With interstate development use Data Envelopment Analysis to allow for modifications of policies within program needs

Development of SPFs in WA State

- Rural two lane highways early development in 1994
- Previously used critical rate solely
  - Used negative binomial estimation
  - Homogenous sections
  - Entire rural highway systems for collectors, minor arterials and principle arterials with East/West split.

Development of SPFs in WA State

- Rural two lane highways
  - Large Data Set
    - Geometric
    - Traffic
    - Crash
  - Analyst wanted to use to determine before and after even when told not to do so.

Development of SPFs in WA State

- Interstate highways
  - Large Data Set
    - Geometric
    - Traffic
    - Crash
    - Weather
  - Hierarchical Bayes
  - Used to analyze entire network
  - Data Envelopment Analysis to allow for flexibility in policy

Development of SPFs in WA State

- Rural Multilane
- Refinement of two-lane models

Development of Severity SPFs in WA State

- Multilane divided highways
- Using multinomial, nested and mixed logit estimation
- Mixed Logit offered flexibility
- Allows for estimation of coefficients and variance
- Developed utility functions (SPFs) for PDO, Minor and Major Injury
- Future to incorporate full roadside database

Future Relationships to HSM, *SafetyAnalyst* and IHSDM

- WSDOT intends to adopt the tools consistent with current WSDOT Policy that prefers SPFs
- WSDOT will encourage
  - use in *Developer Review*, *Local Agency Evaluations* and *EA/EIS Statements*
  - continued growth in methods and procedures, with flexibility to use local SPFs as an important element
- Severity Models using Roadside Features will occur

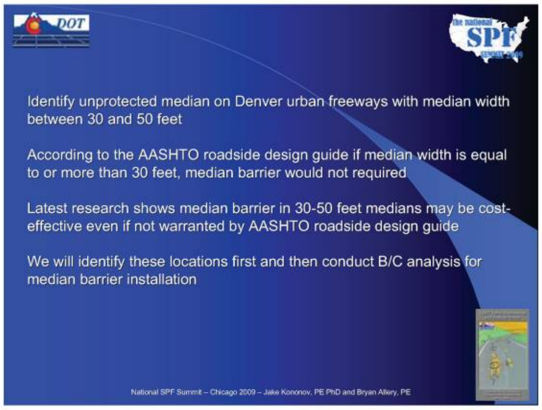
Lessons from Past Experience

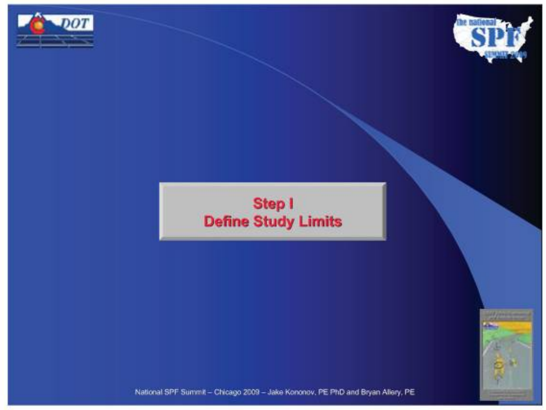
1. SPFs can improve efficiency of expenditures
2. SPFs are currently available with HSM, SafetyAnalyst, and IHSDM and useable
3. SPFs can be developed relatively easily if data is available
4. SPFs have multiple uses in the project development context
5. Training is a necessity

Summary

- It is ok to start slow and add as you go along
- Depending on the use of the tools, data collection may not be as expansive as once thought
- Training is necessary
- Think outside the box and be willing to move towards safety as more than an anecdotal consideration

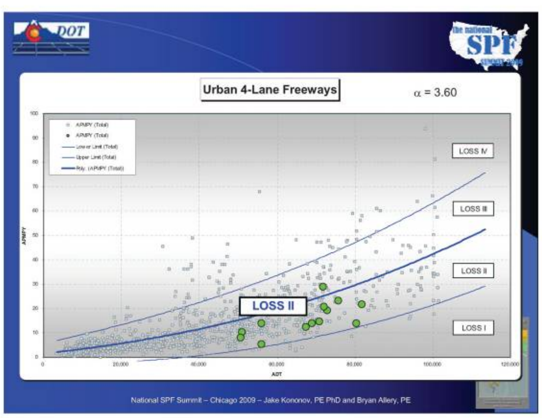
THE END


Identify unprotected median on Denver urban freeways with median width between 30 and 50 feet
According to the AASHTO roadside design guide if median width is equal to or more than 30 feet, median barrier would not required
Latest research shows median barrier in 30-50 feet medians may be cost-effective even if not warranted by AASHTO roadside design guide
We will identify these locations first and then conduct B/C analysis for median barrier installation
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

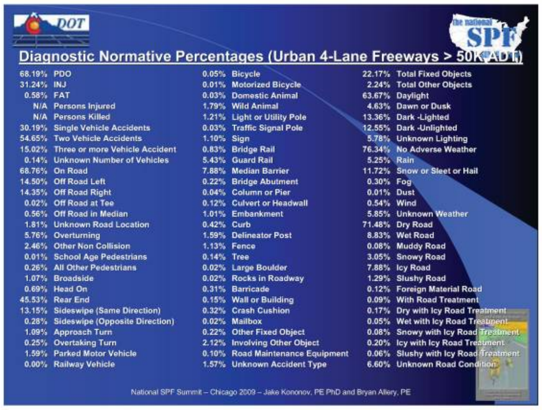

Step I
Define Study Limits
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


SH470A LOSS and Pattern Recognition Analysis
Begin MP 0
End MP 26
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

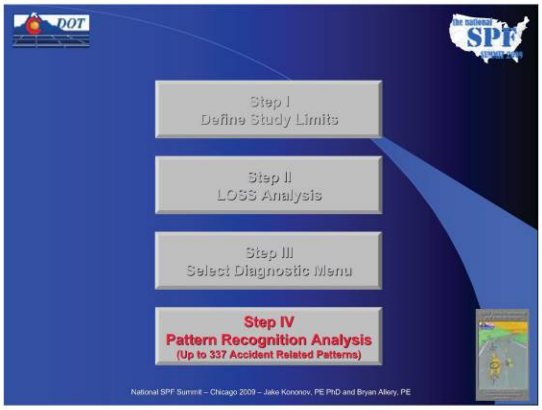

Step I
Define Study Limits
Step II
LOSS Analysis
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Urban 4-Lane Freeways
α = 3.60
LOSS IV
LOSS III
LOSS II
LOSS I
LOSS II
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

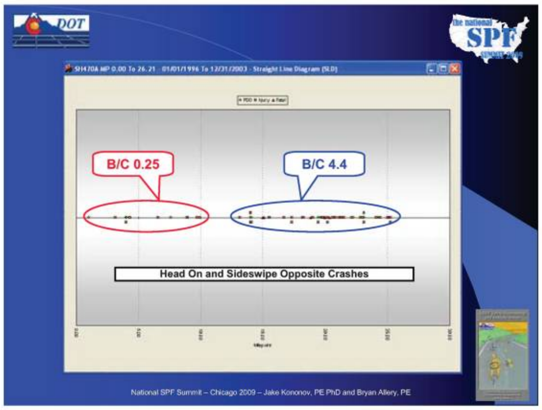

Step I
Define Study Limits
Step II
LOSS Analysis
Step III
Select Diagnostic Menu
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE



Diagnostic Normative Percentages (Urban 4-Lane Freeways > 50K ADT)
68.19% PDO
31.24% INJ
0.58% FAT
N/A Persons Injured
N/A Persons Killed
30.19% Single Vehicle Accidents
54.65% Two Vehicle Accidents
15.02% Three or more Vehicle Accident
0.14% Unknown Number of Vehicles
68.76% On Road
14.50% Off Road Left
14.35% Off Road Right
0.02% Off Road at Tee
0.56% Off Road in Median
1.81% Unknown Road Location
5.76% Overturning
2.46% Other Non Collision
0.01% School Age Pedestrians
0.26% All Other Pedestrians
1.07% Broadside
0.69% Head On
45.53% Rear End
13.15% Sideswipe (Same Direction)
0.28% Sideswipe (Opposite Direction)
1.09% Approach Turn
0.25% Overtaking Turn
1.59% Parked Motor Vehicle
0.00% Railway Vehicle
0.05% Bicycle
0.01% Motorized Bicycle
0.03% Domestic Animal
1.79% Wild Animal
1.21% Light or Utility Pole
0.03% Traffic Signal Pole
1.10% Sign
0.83% Bridge Rail
5.43% Guard Rail
7.88% Median Barrier
0.22% Bridge Abutment
0.04% Column or Pier
0.12% Culvert or Headwall
1.01% Embankment
0.42% Curb
1.59% Delineator Post
1.13% Fence
0.14% Tree
0.02% Large Boulder
0.02% Rocks in Roadway
0.31% Barricade
0.15% Wall or Building
0.32% Crash Cushion
0.02% Mailbox
0.22% Other Fixed Object
2.12% Involving Other Object
0.10% Road Maintenance Equipment
1.57% Unknown Accident Type
22.17% Total Fixed Objects
2.24% Total Other Objects
63.67% Daylight
4.63% Dawn or Dusk
13.36% Dark -Lighted
12.55% Dark -Unlighted
5.78% Unknown Lighting
76.34% No Adverse Weather
5.25% Rain
11.72% Snow or Sleet or Hail
0.30% Fog
0.01% Dust
0.54% Wind
5.85% Unknown Weather
71.48% Dry Road
8.83% Wet Road
0.08% Muddy Road
3.05% Snowy Road
7.88% Icy Road
1.29% Slushy Road
0.12% Foreign Material Road
0.09% With Road Treatment
0.17% Dry with Icy Road Treatment
0.05% Wet with Icy Road Treatment
0.08% Snowy with Icy Road Treatment
0.20% Icy with Icy Road Treatment
0.06% Slushy with Icy Road Treatment
6.60% Unknown Road Condition
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

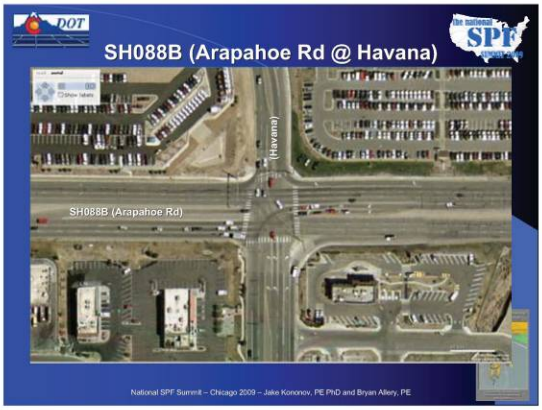


Step I
Define Study Limits
Step II
LOSS Analysis
Step III
Select Diagnostic Menu
Step IV
Pattern Recognition Analysis
(Up to 337 Accident Related Patterns)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

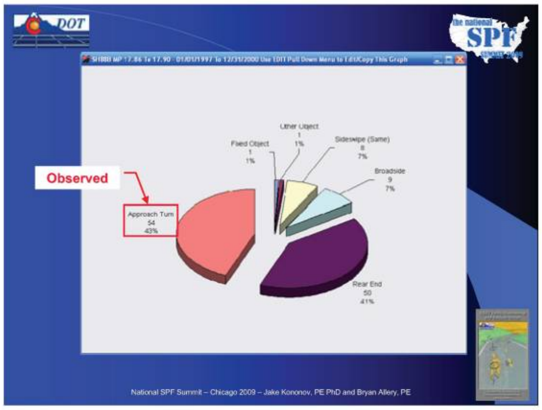


B/C 0.25
B/C 4.4
Head On and Sideswipe Opposite Crashes
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

Direct Diagnostics
Example #1
State Highway 88
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

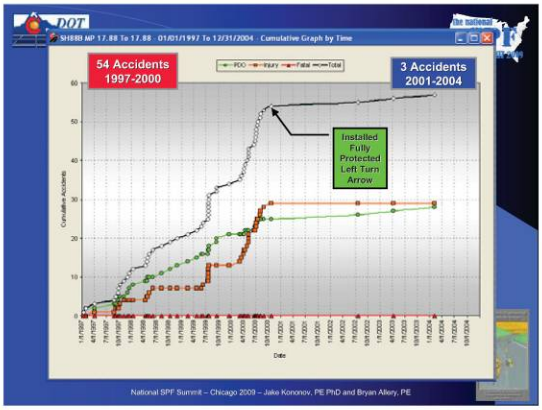


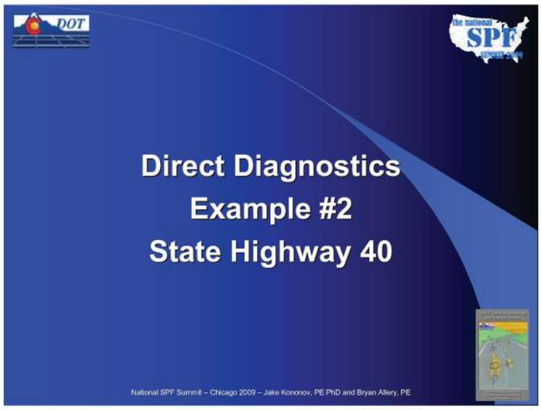
SH088B (Arapahoe Rd @ Havana)
(Havana)
SH088B (Arapahoe Rd)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

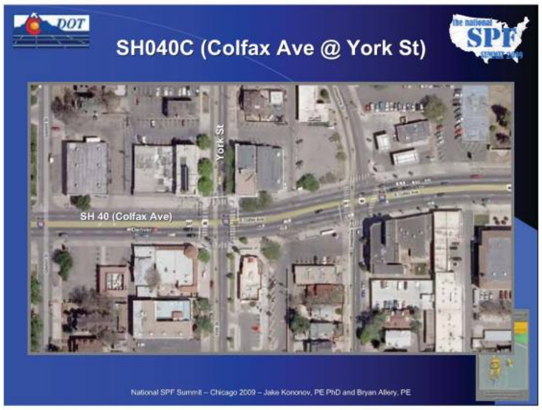


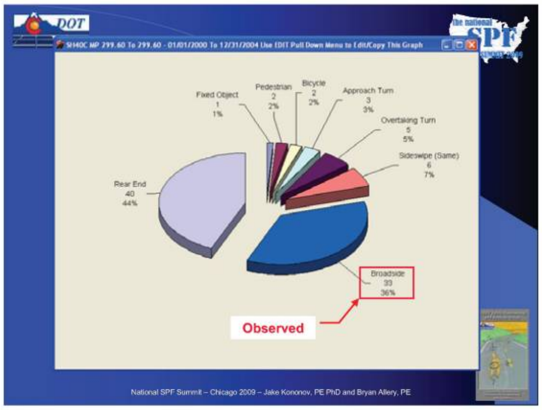
Observed
Approach Turn
54
43%
Fixed Object
1
1%
Other Object
1
1%
Sideswipe (Same)
8
7%
Broadside
9
7%
Rear End
50
41%
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

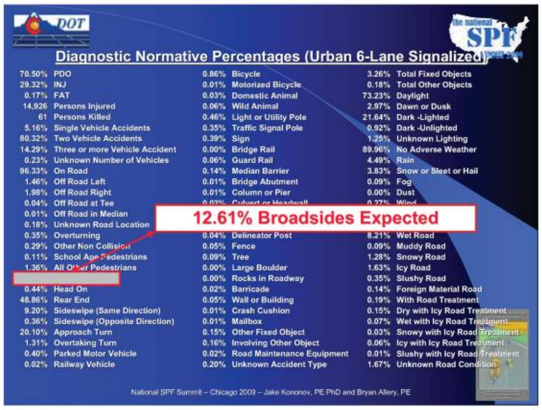

DOT
Diagnostic Normative Percentages (Urban 6-Lane Signalized)
70.50% PDO
29.32% INJ
0.17% FAT
14,926 Persons Injured
61 Persons Killed
5.16% Single Vehicle Accidents
80.32% Two Vehicle Accidents
14.29% Three or more Vehicle Accident
0.23% Unknown Number of Vehicles
96.33% On Road
1.46% Off Road Left
1.98% Off Road Right
0.04% Off Road at Tee
0.01% Off Road in Median
0.18% Unknown Road Location
0.35% Overturning
0.29% Other Non Collision
0.11% School Age Pedestrians
1.36% All Other Pedestrians
12.61% Broadside
0.44% Head On
48.86% Rear End
9.20% Sideswipe (Same Direction)
0.36% Sideswipe (Opposite Direction)
1.31% Overtaking Turn
0.40% Parked Motor Vehicle
0.02% Railway Vehicle
0.86% Bicycle
0.01% Motorized Bicycle
0.03% Domestic Animal
0.06% Wild Animal
0.46% Light or Utility Pole
0.35% Traffic Signal Pole
0.39% Sign
0.00% Bridge Rail
0.06% Guard Rail
0.14% Median Barrier
0.01% Bridge Abutment
0.01% Column or Pier
0.04% Delineator Post
0.05% Fence
0.09% Tree
0.00% Large Boulder
0.00% Rocks in Roadway
0.02% Barricade
0.05% Wall or Building
0.01% Crash Cushion
0.01% Mailbox
0.15% Other Fixed Object
0.16% Involving Other Object
0.02% Road Maintenance Equipment
0.20% Unknown Accident Type
3.26% Total Fixed Objects
0.18% Total Other Objects
73.23% Daylight
2.97% Dawn or Dusk
21.64% Dark -Lighted
0.92% Dark -Unlighted
1.25% Unknown Lighting
89.96% No Adverse Weather
4.49% Rain
3.83% Snow or Sleet or Hail
0.09% Fog
0.00% Dust
8.21% Wet Road
0.09% Muddy Road
1.28% Snowy Road
1.63% Icy Road
0.35% Slushy Road
0.14% Foreign Material Road
0.19% With Road Treatment
0.15% Dry with Icy Road Treatment
0.07% Wet with Icy Road Treatment
0.03% Snowy with Icy Road Treatment
0.06% Icy with Icy Road Treatment
0.01% Slushy with Icy Road Treatment
1.67% Unknown Road Condition
20.10% Approach Turn Expected
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

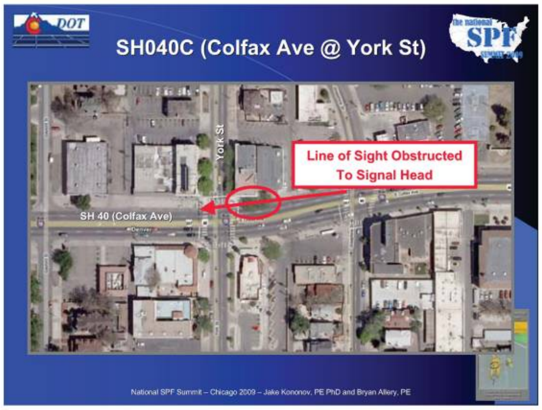

DOT
54 Accidents
1997-2000
3 Accidents
2001-2004
Installed
Fully
Protected
Left Turn
Arrow
Cumulative Accidents
Date
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
Direct Diagnostics
Example #2
State Highway 40
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

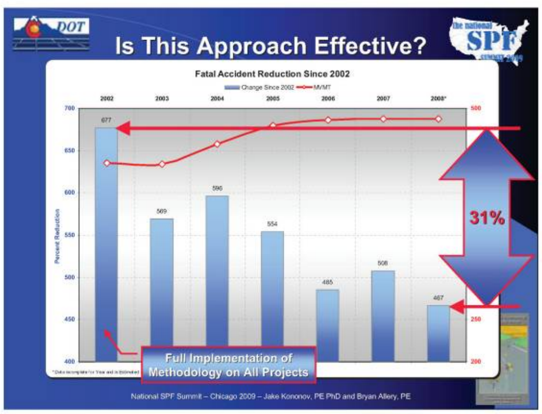

DOT
SH040C (Colfax Ave @ York St)
York St
SH 40 (Colfax Ave)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

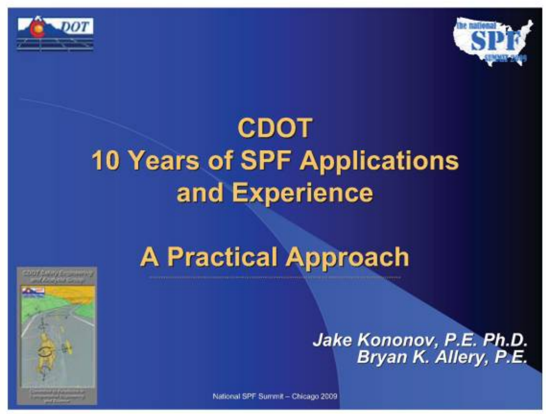

DOT
Fixed Object
1
1%
Pedestrian
2
2%
Bicycle
2
2%
Approach Turn
3
3%
Overtaking Turn
5
5%
Sideswipe (Same)
6
7%
Rear End
40
44%
Broadside
33
36%
Observed
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
Diagnostic Normative Percentages (Urban 6-Lane Signalized)
70.50% PDO
29.32% INJ
0.17% FAT
14,926 Persons Injured
61 Persons Killed
5.16% Single Vehicle Accidents
80.32% Two Vehicle Accidents
14.29% Three or more Vehicle Accident
0.23% Unknown Number of Vehicles
96.33% On Road
1.46% Off Road Left
1.98% Off Road Right
0.04% Off Road at Tee
0.01% Off Road in Median
0.18% Unknown Road Location
0.35% Overturning
0.29% Other Non Collision
0.11% School Age Pedestrians
1.36% All Other Pedestrians
0.44% Head On
48.86% Rear End
9.20% Sideswipe (Same Direction)
0.36% Sideswipe (Opposite Direction)
20.10% Approach Turn
1.31% Overtaking Turn
0.40% Parked Motor Vehicle
0.02% Railway Vehicle
0.86% Bicycle
0.01% Motorized Bicycle
0.03% Domestic Animal
0.06% Wild Animal
0.46% Light or Utility Pole
0.35% Traffic Signal Pole
0.39% Sign
0.00% Bridge Rail
0.06% Guard Rail
0.14% Median Barrier
0.01% Bridge Abutment
0.01% Column or Pier
0.04% Delineator Post
0.05% Fence
0.09% Tree
0.00% Large Boulder
0.00% Rocks in Roadway
0.02% Barricade
0.05% Wall or Building
0.01% Crash Cushion
0.01% Mailbox
0.15% Other Fixed Object
0.16% Involving Other Object
0.02% Road Maintenance Equipment
0.20% Unknown Accident Type
3.26% Total Fixed Objects
0.18% Total Other Objects
73.23% Daylight
2.97% Dawn or Dusk
21.64% Dark -Lighted
0.92% Dark -Unlighted
1.25% Unknown Lighting
89.96% No Adverse Weather
4.49% Rain
3.83% Snow or Sleet or Hail
0.09% Fog
0.00% Dust
8.21% Wet Road
0.09% Muddy Road
1.28% Snowy Road
1.63% Icy Road
0.35% Slushy Road
0.14% Foreign Material Road
0.19% With Road Treatment
0.15% Dry with Icy Road Treatment
0.07% Wet with Icy Road Treatment
0.03% Snowy with Icy Road Treatment
0.06% Icy with Icy Road Treatment
0.01% Slushy with Icy Road Treatment
1.67% Unknown Road Condition
12.61% Broadsides Expected
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


SH040C (Colfax Ave @ York St)
York St
Line of Sight Obstructed
To Signal Head
SH 40 (Colfax Ave)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


ADD WEB
SAFETY ASSESSMENTS
HERE
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Is This Approach Effective?
Fatal Accident Reduction Since 2002
Change Since 2002
MVMT
2002
2003
2004
2005
2006
2007
2008*
677
569
596
554
485
508
467
Percent Reduction
31%
Full Implementation of
Methodology on All Projects
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


CDOT
10 Years of SPF Applications
and Experience
A Practical Approach
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009

Quantitative Safety Information and Project Development

Session 8
Policy Level Issues Related to Safety
Timothy Neuman, PE
Chief Highway Engineer
CH2M HILL

Presentation Overview

- How will the availability of system-wide quantitative safety information influence agency project development processes?
- What types of policies are envisioned to be most affected?
- What organizational and educational barriers need to be overcome?

July 29 and 30, 2009 2

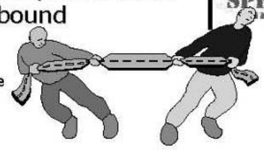
Transportation Agency Responsibilities

- Programming and Prioritization
- *Project Development*
- Operations and Maintenance

Project Development Process

Problem Definition → Decision and Evaluation Framework → Design Studies (Alternatives) → Screening and selection of preferred → Preliminary and Final Design

Project Development Risks Abound



- Some stakeholder opposition must be assumed for essentially every project
- Purpose and need must be defensible
- Recommended solutions must be effective and defensible (per proven solutions or industry best practices)
- Costs and impacts must be justified to be acceptable to regulatory agencies (assuming adversarial interests or resource conflicts exist)

July 29 and 30, 2009

Safety Information and Project Development

Is safety truly part of the problem or not? If so, what is the specific safety problem? If not, then what is the problem?

How important is safety relative to other factors in developing and screening alternatives?

Problem Definition → Decision and Evaluation Framework → Design Studies (Alternatives) → Screening and selection of preferred → Preliminary and Final Design

If the problem is truly a safety one, then what solutions make sense? If it is a congestion or other problem the universe of solutions is different.

Are design exceptions acceptable or not? If so, what types? Where? Under what circumstances?

July 29 and 30, 2009
Chicago, Illinois

the national SPF SUMMIT 2009

Project Development Issues

- Defining Purpose and Need (problem statement)
- Project Type and Safety Information
  - New Construction
  - Reconstruction
  - 3R
- Alternatives development, analysis and decision-making
- Agency liability and risk management

Project 'purpose and need' drives the environmental decision-making process

Replacement of infrastructure in disrepair

Congestion or traffic operational problems

Safety (crash prevention and/or severity mitigation)

The way things are today

- Not every project is driven by safety…
- But most purpose and need statements assert safety as a driver
- Solutions may or may not specifically deal with safety (other 'drivers' generally prevail)
- Challenges to EISs and EAs are the primary means of stalling or halting otherwise good projects

SPIs (and other tools) offer objective, defensible means of characterizing safety problems

Project Type Definitions

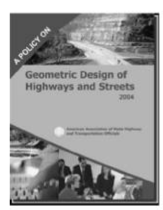
- New construction (projects on new alignment)
- Reconstruction of existing facility

- Resurfacing, restoration or rehabilitation ('3R')

The Green Book encourages 3R designation where it is appropriate

'Specific site investigations and crash history analysis often indicate that the existing design features are performing in a satisfactory manner. *The cost of full reconstruction for these facilities, particularly where major realignment is not needed, will often not be justified.*'

Green Book Foreword, pg xliii



July 29 and 30, 2009
Chicago, Illinois

The way things are today – Nominal safety drives project type decisions

- *Nominal Safety* is examined in reference to compliance with standards, warrants, guidelines and sanctioned design procedures

- *Substantive Safety* is the expected or actual crash frequency and severity for a highway or roadway

* Ezra Hauer, ITE Traffic Safety Toolbox Introduction, 1999

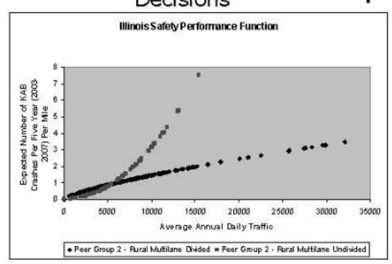
Project Development Process

Problem Definition → Decision and Evaluation Framework → Design Studies (Alternatives) → Screening and selection of preferred → Preliminary and Final Design

Designers have many choices to make

- Number and type of lanes; shoulders
- Presence, type and width of medians
- Accommodation of bicyclists and pedestrians
- Accommodation of transit vehicles
- Traffic control strategies
- Design level of service
- Intersection types
- Access control

Objective Safety Information Supports Project Evaluations and Decisions



Objective safety information informs and improves decisions

- Type of facility
- Effect of varying cross section dimensions
- Effect of alignment
- Access control policies and solutions
- Roadside design policies
- Intersection design solutions
- Traffic control strategies
- etc.

Project Development Process

Problem Definition → Decision and Evaluation Framework → Design Studies (Alternatives) → Screening and selection of preferred → Preliminary and Final Design

Design Exceptions are part of project development

- Understand objective operational and safety effects of potential design exceptions
- Employ proven, safety-effective mitigation strategies
- Fully document the design exception and mitigation approach

Potential project development policy changes

- 3R design criteria
- Identifying safety as a key 'purpose and need' element
- Revisions to agency standard design solutions
- New tasks or reports integrated with other technical work (e.g., design study reports, interchange justification reports, design exceptions requests)

Potential programming policy changes

- Project scoping (3R vs. reconstruction) to incorporate quantitative safety up front
- Criteria for considering conversion of two-lane highway to multi-lane facility; or other basic capacity improvements
- Allocation of funding for safety-driven projects vs. other priorities based on confidence in information and demonstrated paybacks

Policy Level Data Issues

- Acquisition and Maintenance of Safety Data
  - Not just crashes
  - Traffic counts (more, intersections)
  - Geometric (including roadside)
  - Traffic control
- Substantive Safety Based Policies

Cultural and Educational Barriers to Overcome

- Exploding the 'Safety always comes first' myth
- Balancing safety against other values is not only ok, it is what we should have been doing all along
- Recognizing 'safety' as a continuum and not an absolute
- Coming to grips with the fact that some things we do are 'less safe' than the alternative that we don't like for other reasons
- Understanding design decisions as discretionary in nature

Organizational Barriers to Overcome

- Scientific safety information is too important to be relegated to just your safety program
- Safety Divisions/Bureaus have roles to play in essentially all projects at all levels
- Safety asset acquisition and management needs to become a priority (across Divisions/offices)
- Project development teams must include safety expertise
- Designers and other problem solvers must enhance their basic understanding of safety science

A View to the Future

- Decisions based on objective information are better decisions; we ought to do a better job
- Resources spent in the name of safety will actually produce measurable safety benefits
- Proven successes will lead to re-allocation of limited resources
- Design standards and criteria will evolve to more closely reflect the science of safety
- Performance based design processes may eventually supplant standards based approaches

Questions and Discussion

Policy Level Issues related to Safety in the Project & Program Development Stages

the national SPF SUMMIT 2009

Washington State Department of Transportation

John Milton Ph.D., P.E.,
Washington State Department of Transportation

July 29th, 2009
Chicago, Illinois

National Safety Performance Function Summit

Overview

- Uses in strategic Planning to Maintenance and Operations
- Guidelines, Standards, Policy and Procedures

Planning → Programming → Design → Maintenance and Operation

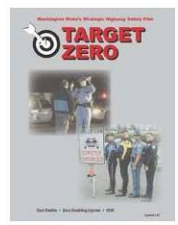
- Who, What, Where, Why, When and How?

Determining the Scope of Use

- SPFs have uses throughout the Project and Program Development Stages
  - Each Step in the process will require a review of policies
    - For instance, SPFs could be used as a network screening tool for local issues, corridors or for the System.
    - One or all can be chosen
    - Clear Intent

Determining the Scope of Use

- A *Specific Strategic Objective* should drive the policy
  - WSDOT "Target Zero" Strategic Highway Safety:
    - All Crashes or Specific Types
    - All Severity or only the most severe
  - Local versus system solutions



Determining the Scope of Use

Programming?	• Priority Ranking
Planning?	• Potential countermeasure or solution development
Project Development?	• Design Exception/Solutions/Environmental Analysis
Maintenance and Operations?	• Low cost enhancements • Developer Evaluations

Guidelines, Standards, Policies & Procedures

- Specific Guidelines, Standards, Policies and Procedures in each stage:

Planning → Programming → Design → Maintenance and Operation

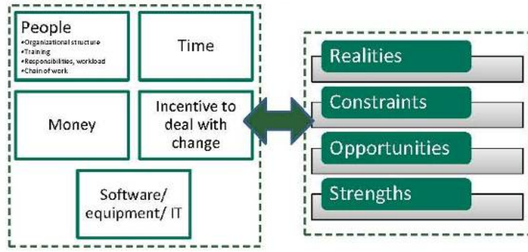
- Manuals & guidance documents will need to be assessed for gaps and opportunities

Guidelines, Standards, Policies & Procedures

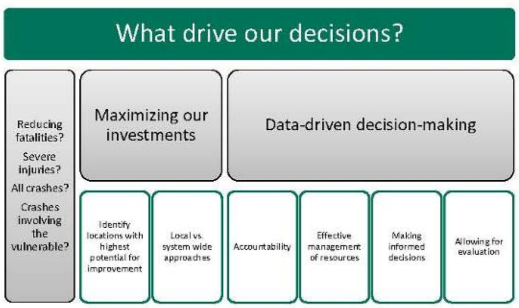
- Policy directive necessary for successful implementation
  - Funding needs/allocation: budget restraints
  - Personnel training
  - IT/computing resources
  - Integration & effective use of available data (plan & budget & execute data collection plans)

Guidelines, Standards, Policies & Procedures

- Within WSDOT: Making the linkage to support successful implementation



Guidelines, Standards, Policies & Procedures



Guidelines, Standards, Policies & Procedures

- Use of multiple AMFs
  - Implementation of combination of countermeasures at site/on corridor
- Setting standards for evaluation
  - Sample sizes
  - Analysis methodology (SE, RTM, etc.)
- Integration with existing systems, processes, and standards

Guidelines, Standards, Policies & Procedures

- Example
  - Previous Interstate Standards Solutions Going to only Few Projects
  - Little Benefit in terms of Projects Benefits
  - Using SPF to determine highest potential benefit across system

Guidelines, Standards, Policies & Procedures

- Result
  - Safety Dollars will go to higher benefit locations with greater return on investment.

Who, What, Why, Where, When & How?

- Washington experience indicates:
  - You'll need to answer these fundamental questions as part of the policy development
  - These questions will come from the executive and elected officials
  - Lack of clarity will result in outcomes will very across regional boundaries

Summary

- Use of SPFs are far ranging within the organization
  - Policy should address & indicate organizational use and need
- As the use of SPF varies, so will the need for review of current policy documents
  - Assessment of gaps and opportunities is critical
  - Think outside the box
- Answer the fundamental questions of *Who, What, Where, Why, When* and *How*?
- Training is necessary!

THE END

Tort Liability Issues Related to Safety in Project & Program Development Stages

Washington State Department of Transportation

John Milton Ph.D., P.E.,
Washington State Department of Transportation

July 29th, 2009
Chicago, Illinois

National Safety Performance Function Summit

Overview

- Reality of Tort
- Important Legal Concepts
- Risk Mitigation
- Anecdotal Decisions versus Science Based
  - Public Perception (e.g., Jury Perception)
- Issues of Fact

THREE ABSOLUTES

Life	Death	Tort

Three Absolutes: Life, Death and Tort Liability

- 100% of getting sued unless sovereign immunity still exists in the jurisdiction
- Failure to provide a reasonably safe roadway for ordinary travel
- Suits will most often be negligence in design, operation, or maintenance
- Some will occur on a failure to follow programmatic procedures

IMPORTANT LEGAL CONCEPTS

- Notice of Condition or Reasonably Foreseeable
- Failure of Duty
- Proximate Cause of Injury

Risk Mitigation

- Tort Liability should not be a reason not to do something that is felt to be a means to optimize the reduction crash frequency and severity

GOAL

Reduction in the frequency and severity of collisions

Anecdotal Decisions versus Science Based

- Plaintiffs experts commonly will attack what you should have done
- They will, based on opinion (anecdotal information) to indicate you failed in your duty

Anecdotal Decisions versus Science Based

Having a process & following it

Mitigates risk of occurrence

Reduces the opinion posturing of plaintiff experts

- Often the process are afforded discretionary immunity protection
- Juries are accepting

Anecdotal Decisions versus Science Based

- Challenges in highway safety
  - Data that suffers from regression to the mean
    - (i.e. fluctuates wildly in the short term)
    - This in the programming context this means that a location will be "a problem" this year and not the next.
    - However, "once a problem always a problem"

Design, Operations & Maintenance

- In some states engineering decisions are considered ministerial
- The standards, policies and procedures are often considered discretionary
  - In some states, engineering judgment can be questioned creating an issue of fact versus the discretionary process that can't be questioned.

Design, Operations & Maintenance

Consider the deviation/design exception is based on:

Scientific & Nationally Adopted SPF

20 years of engineering experience

vs

"it is my opinion that this did not need to be done."

Summary

- Lawsuits are a part of doing business
- Understanding the legal issues will help you mitigate risks
- Issues based on adopted scientific methods often stand up better than engineering opinion alone
- Training is necessary!

Session 7
Opening Session

Yesterday's Highlights

Geni Bahar, P.E.
NAVIGATS Inc.

Session 2

- A few persons can make a difference
  - Champions
- "Make safety a science" – Ezra Hauer
  - Highway Safety Manual is the 1st Science of Safety product
- AASHTO and TRB are committed
- EB Method is the appropriate analytical method
- Tutorial is available

July 29 and 30, 2009 2

Highway Safety Manual

3

Highway Safety Manual

- Result of 10 years of 1000's of voluntary work and several large research projects
- A parallel to the HCM
- Supported by two tools
  - SafetyAnalyst
  - IHSDM
- Tutorial by Dr. Hauer et al

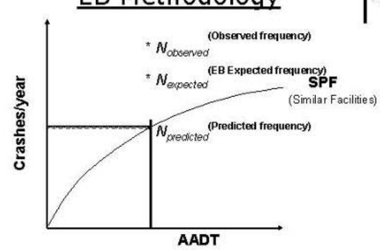
July 29 and 30, 2009 4

Methodology

- Empirical Bayes (EB) method meets these conditions
- EB in highway safety was studied in-depth for more than 30 years
- EB uses two "clues"
  - the historical crash counts of a single site
  - the average crash estimate of similar sites (same category and same traffic volume) represented by the SPF

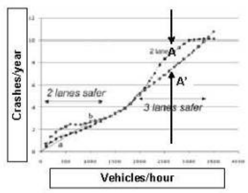
July 29 and 30, 2009 5

EB Methodology



July 29 and 30, 2009 6

Comparison between sites and highway facility types



July 29 and 30, 2009 — 7

AASHTO Safety Goal

- In May 2008, the AASHTO Board of Directors established a Towards Zero Death safety goal.
- The goal is to reduce fatalities by half in 20 years.
- The State Safety Partners (GHSA, IACP, AAMVA, and CVSA) have all adopted this goal or a similar goal.

Session 3

- Key elements for the use of a base SFP – the model, the AADT, and the length of the section
- Other elements will be added to the base model in terms of their safety effects (expressed as Accident Modification Factors – multiplicative: 0.80 = 20% decrease in number of crashes)

July 29 and 30, 2009 — 9

Session 3

- HSM, IHSDM and SafetyAnalyst ALL use EB method and are compatible with each other

$$N_{predicted} = N_{spf\ x} \times (AMF_{1x} \times AMF_{2x} \times \ldots \times AMF_{yx}) \times C_x$$

- SPFs developed for Fatal, Injury, and PDO; and for some crash types

July 29 and 30, 2009 — 10

FHWA Tools Supporting Implementation of the HSM

HSM Part	*Supporting Tool*
B: Roadway Safety Management Process	*SafetyAnalyst*
C: Predictive Methods	*IHSDM*
D: Accident Modification Factors	*CRF/AMF Clearinghouse*

July 29 and 30, 2009 — 11

Relationship among HSM, SafetyAnalyst and IHSDM

HSM	Level of Analysis	Tool
Part B – Roadway Safety Management Process	System-Wide (Network-Level)	SafetyAnalyst
Part C – Predictive Methods	Specific Roadway (Project-Level)	IHSDM

July 29 and 30, 2009 — 12

July 29 and 30, 2009
Chicago, Illinois

Roadway Segment SPFs in SafetyAnalyst

RURAL
- Two-lane
- Multilane
  - undivided
  - divided
- Freeways:
  - Within interchange area
    - 4 lanes
    - 6+ lanes
  - Between interchanges
    - 4 lanes
    - 6+ lanes

URBAN
- Arterials
  - Two-lane
  - Multilane
    - undivided
    - divided
  - One-way
- Freeways:
  - Within interchange area
    - 4 lanes
    - 6 lanes
    - 8+ lanes
  - Between interchanges
    - 4 lanes
    - 6 lanes
    - 8+ lanes

SafetyAnalyst 13

Intersection SPFs in SafetyAnalyst

RURAL
- 3-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control
- 4-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control

URBAN
- 3-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control
- 4-leg with:
  - minor-road STOP control
  - all-way STOP control
  - signal control

SafetyAnalyst 14

Ramp SPFs in SafetyAnalyst

RURAL
- Diamond
  - off-ramp
  - on-ramp
- Parclo loop
  - off-ramp
  - on-ramp
- Free-flow loop
  - off-ramp
  - on-ramp
- Free-flow outer connection
- Direct or semidirect connection

URBAN
- Diamond
  - off-ramp
  - on-ramp
- Parclo loop
  - off-ramp
  - on-ramp
- Free-flow loop
  - off-ramp
  - on-ramp
- Free-flow outer connection
- Direct or semidirect connection

SafetyAnalyst 15

Session 3

- Calibration aims to use SPFs developed for one jurisdiction to become useful/relevant to another jurisdiction
  - Climate, driver behavior, crash reporting thresholds, crash reporting system procedures
  - $N = \exp[a + b \times \ln(AADT)] \times C_f$
  - Steps listed in the HSM

July 29 and 30, 2009 16

Session 3

- SafetyAnalyst will calibrate models automatically as the data are entered into software databases
- HSM Manual calibration procedures
  - 30 to 50 sites that collectively experience at least 100 crashes/year
- IHSDM does not have calibration built-in procedures, and C factors can be entered by the user

July 29 and 30, 2009 17

Session 3

- We heard from developers of SPFs for different states; some key points:
  - Common identifiers between databases
  - Gather the road segment's details under one umbrella
  - Laws to encourage SPF development and use (WS)
  - Internal and university-based Statistical developers

July 29 and 30, 2009 18

Session 3

- Local or side roads data missing
- Roadside data collection

- Learned about relationships between levels of service and safety, and between different roads with different number of lanes

Session 4

- Applications with analysis of signalized intersections with complex models – difficult to apply
- Some key points
  - Need a good traffic counting program
  - Need regional models for acceptability of models (topography etc)

Session 4

- SPF used for network screening – using PSI values
- Need to establish a realistic number of locations for further analysis beyond screening (i.e., safety review)
- Cultural change from all to severe crashes and get the involvement of all Es

Session 4

- SPF development / application leads to a global data enhancement
- SPF is driving policy
  - Updating design guides to allow for the different approach
  - Optimized decision making
  - Provide safety information at an early stage of a potential project

Session 4

- Crash, traffic, geometric and weather are the key data elements used in WS
- SPFS can improve effectiveness of expenditures
- Provides a base line for assessment of safety of locations – e.g. LOSS
- Expand the use of SPFs with pattern recognition techniques for diagnostic

Session 5

- Quantification of safety influences agency processes
- Use of SPFs is compatible with management of risk
- Solutions must be effective and defensible; costs must be justifiable
- First step: Define the problem; is it a safety problem or not?

Session 5

- Challenges to important projects are the primary ways to stall or stop a project = e.g. when safety is not studied
- Safety is in every project at all levels and there is a need to institutionalize it

July 29 and 30, 2009 25

Session 5

- Explicit and quantitative safety is required in EAs and TIAs to bring human safety at the same level as other factors such as "endangered species"
- Needs to answer the fundamental questions – "W"s and How?

July 29 and 30, 2009 26

Session 6

- Take care of how you use the word "safety"
  - Improve safety replaced by decrease the frequency and severity of future crashes
- Document your decision
- If decision was anecdotal (versus science based), you will be found at fault

July 29 and 30, 2009 27

Session 6

- "once a problem always a problem"
  - Avoid the word – replace it with another word
- Are engineering decisions regarded as discretionary or ministerial in your State?
- "Collision analysis locations" is a good way to express it without sensitive words

July 29 and 30, 2009 28

Session 6

- It may become a failure to act reasonably if you do not use a SPF
- Statement of philosophy and LOSS together are working fine for Colorado
- HSM has a statement at the beginning: safety is not an absolute; the aim is to decrease the frequency and severity of crashes in future

July 29 and 30, 2009 29

Session 6

- Never hesitate to fix a problem and document it for future reference
- If there are SPFs – all parts of the agency need to use it –
  - There is risk of tort liability if not
  - Training is needed

July 29 and 30, 2009 30

the national SPF SUMMIT 2009

Development of State or Local Agency SPFs for Use in the HSM, IHSDM, and *SafetyAnalyst*

Doug Harwood
Midwest Research Institute

Need for State and Local Agency SPFs

- HSM Part C, IHSDM, and *SafetyAnalyst* all include SPFs that can be calibrated and used by any jurisdiction
- Jurisdiction-specific SPFs, if available, are desirable and may be used, but are not required

Development of State and Local Agency SPFs

- State and local agency SPFs must be developed properly to be valid and compatible with software tools

Available Guidance on SPF Development

- Section A.1.2 in the Appendix to HSM Part C
- SafetyAnalyst guidance document

Data Needs for SPF Development

- Site characteristics data to define facility types of interest
- Site length (for roadway segments)
- Traffic volumes (AADTs)
- Crash frequency (by severity level)
- Other potential predictor variables

SPF Development Guidelines

- Select sites that meet appropriate facility type definitions
- Assign crashes to roadway segments and intersections per HSM guidelines
- Use a valid statistical technique
- If the SPF will be used with AMFs, use sites with appropriate base conditions or convert completed SPF to appropriate base conditions

SPF Development Guidelines

- Use crash frequency, not crash rate, as the dependent variable
- Make sure that the SPF incorporates the effect of traffic volumes, which are typically nonlinear:
  - AADT for roadway segments
  - major- and minor-road AADTs for intersections

SPF Development Guidelines

- Use an appropriate functional form that is compatible with the software tool

Statistical Techniques

- Statistical techniques used for SPF development must be appropriate for the nature of crash data:
  - Ordinary least squares regression is NOT appropriate – crash data do NOT follow a normal distribution
  - Poisson regression is more appropriate, but the variance of crash data is not generally equal to the mean

Statistical Techniques

- Crash data are normally *overdispered* meaning that the variance of the data is larger than the mean:
  - **negative binomial regression** is appropraite for modeling such data
  - **negative binomial regression** provides an overdispersion parameter that is needed in software tools

SafetyAnalyst Guidelines

- An 8-page guideline for SPF development has been created for *SafetyAnalyst*
  - this guideline is also applicable to SPF development for HSM Part C and IHSDM

SafetyAnalyst Guidelines

1. What SPFs Are Needed?
2. Functional Form of SPFs
3. Data Needs for Development of SPFs
4. Statistical Assumptions and Software
5. References

Use and Modification of Default SPFs in the IHSDM

Mike Dimaiuta
LENDIS Corporation

Safe Roads for a Safer Future

Options for using SPFs in IHSDM

- Use Default SPFs "as is"
- Calibrate models, including SPFs
- Enter and use "your own" SPFs

Use Default SPFs "as is"

- Run IHSDM Crash Prediction Module (CPM) without calibrating (i.e. with calibration factors = 1.0)

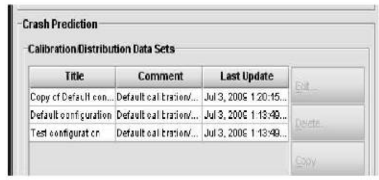
Use Default SPFs "as is"

Calibrate Models / SPFs

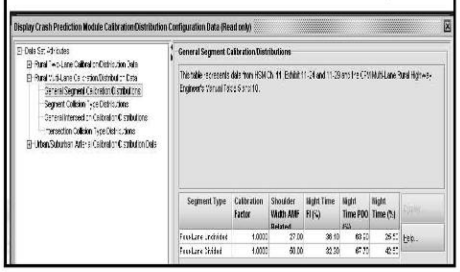
- Follow HSM Part C calibration procedure and enter factors via IHSDM Administration Tool

the national SPF SUMMIT 2009

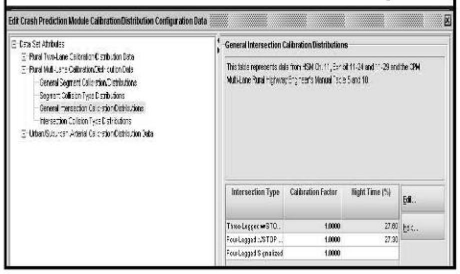
Calibrate Models / SPFs



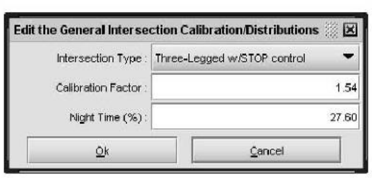
Calibrate Models / SPFs



Calibrate model / SPFs



Calibrate model / SPFs



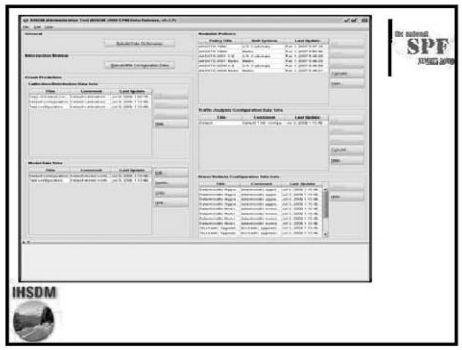
Enter and use "your own" SPFs

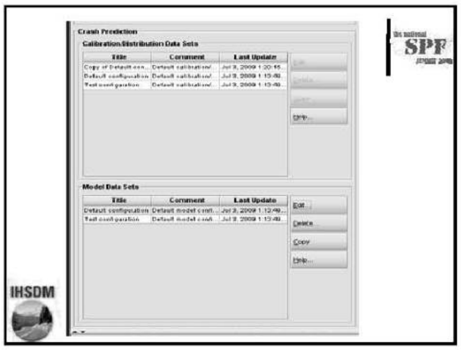
- Via the IHSDM Administration Tool:
  - "Crash Prediction" >
    - "Model Data Sets"

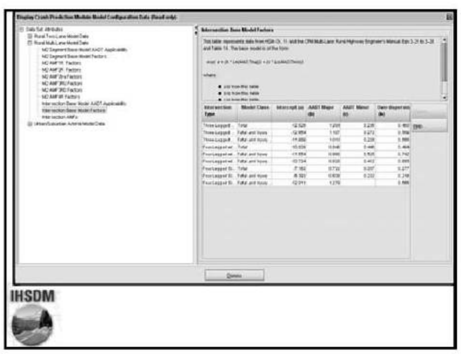
July 29 and 30, 2009
Chicago, Illinois

Enter and use "your own" SPFs

- Capabilities:
  - For all SPFs, can change:
    - Regression coefficients
    - Overdispersion parameters
- Limitation:
  - Can not change SPF functional form

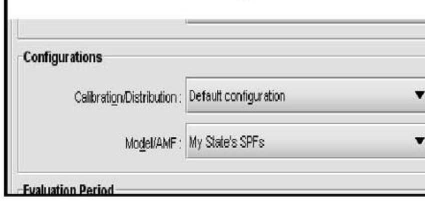






Enter and use "your own" SPFs

- After editing data, save as a new Model Data Set "configuration" and select when running CPM



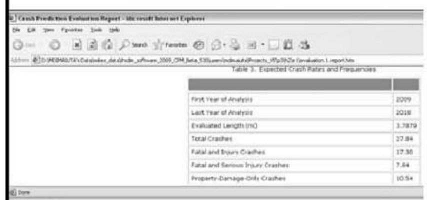
July 29 and 30, 2009
Chicago, Illinois

Enter and use "your own" SPFs

- Example: Multilane Rural H'way
  - Estimate crashes using defaults
  - Enter "My State's SPFs" into Administration Tool
  - Run CPM with modified SPFs to generate and compare results

IHSDM

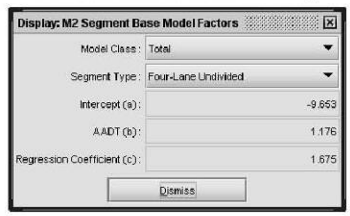
Estimate crashes using default SPFs



IHSDM

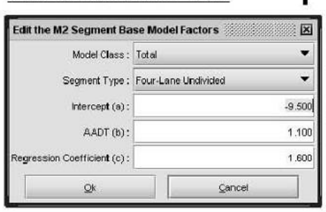
Enter "My State's" SPFs into Administration Tool

Enter "My State's" SPFs into Administration Tool



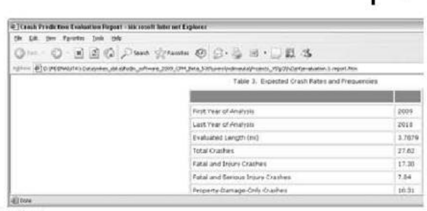
IHSDM

Enter "My State's" SPFs into Administration Tool



IHSDM

Run CPM with modified SPFs



IHSDM

July 29 and 30, 2009
Chicago, Illinois

Compare Results

- Estimated Total crashes using default SPFs: **27.84**
- Estimated Total crashes using "My State's" SPFs: **27.62**

Summary

- No requirement for agencies to develop their own SPFs for IHSDM, but...
- IHSDM provides a mechanism for agencies to edit all default SPFs (coefficients and overdispersion parameters only)
- Either way can produce good results!

Questions?

For additional information:
www.tfhrc.gov/safety/ihsdm/ihsdm.htm

IHSDM Technical Support:
IHSDM.Support@fhwa.dot.gov; (202)-493-3407

To download IHSDM software: www.ihsdm.org

Shyuan-Ren (Clayton) Chen
Clayton.Chen@fhwa.dot.gov; (202)-493-3054

the national SPF SUMMIT 2009

Uses of Safety Performance Functions and Potential for Safety Improvement Values

David L. Piper, P.E.
Illinois Department of Transportation

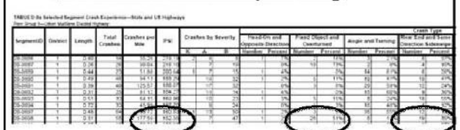
Applications of SPF and PSI

- Using the HSIP Five Percent Report
- Safety Analysis in Phase I
- Quantitative Site Analysis

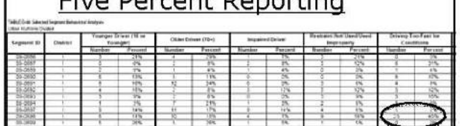
Using the HSIP Five Percent Report

- Is my location a "5%" site?
  - Map
  - Illinois Roadway Information System (IRIS) location

Five Percent Reporting



Five Percent Reporting



Listing of Crashes

Peer Group	Segment ID	District	CaseID
Urban Multilane Divided Highway	06-0698	1	03-1132731
Urban Multilane Divided Highway		1	03-1441504
Urban Multilane Divided Highway		1	03-1530306
Urban Multilane Divided Highway		1	03-1861081
Urban Multilane Divided Highway		1	03-2722779
Urban Multilane Divided Highway		1	03-3246471
Urban Multilane Divided Highway		1	03-4055707
Urban Multilane Divided Highway		1	03-4559716
Urban Multilane Divided Highway		1	03-4618983
Urban Multilane Divided Highway		1	03-4780718
Urban Multilane Divided Highway		1	03-4958181
Urban Multilane Divided Highway		1	03-5158385
Urban Multilane Divided Highway		1	03-5259712
Urban Multilane Divided Highway		1	03-5297928
Urban Multilane Divided Highway		1	03-5371848
Urban Multilane Divided Highway		1	04-0189094
Urban Multilane Divided Highway		1	04-1046301
Urban Multilane Divided Highway		1	04-1454893

July 29 and 30, 2009
Chicago, Illinois

Using SPF and PSI Information in Phase I

- Creation of the 5% Report requires a look at 100% of sites.
- Weighting of PSI supports goal to reduce K's and A's
- Substantive safety measure at project level
- Breakdown by segments and intersections within the project

7

Using SPF and PSI Information in Phase I

- Suggested triggers for Road Safety Assessment if:
  - PSI is 10 or higher
  - Segment or intersection in top 33% of its peer group
  - If segment or intersection has PSI 50% higher than adjacent similar location(s)

July 29 and 30, 2009 8

Quantitative Site Analysis

- Is this intersection performing poorly?

Thru AADT = 2575
Stop AADT = 2650
Experience = 7 crashes in 5 years. ('04 – '08)
1.4 crashes per year
1 Fatal Crash
Recent PDO crash in 12/08, and A-Injury crash in 01/09

HSM: $N_{spf4ST} = \exp[-8.56 + 0.60 \times \ln(AADT_{maj}) + 0.61 \times \ln(AADT_{min})]$
= 2.61 crashes/year (No night crashes)

IDOT SPF: N K+I = $\exp(-8.05)*((AADT_{major})$^0.674)*$((AADT_{minor})$^0.272)
= 0.55 K+I crashes per 5 years.

Quantitative Site Analysis

- Countermeasures Completed
  - Lighting
  - Improve sight distance (hedge clearing)
  - Relocated utility sign
- Countermeasures Under Consideration
  - Improved warning signs
  - Police private signs on ROW

July 29 and 30, 2009 10

Quantitative Site Analysis

- Is this intersection performing poorly?

Thru AADT = 2300
Stop AADT = 650
Experience = 10 crashes in 5 years. ('04 – '08)
2.0 crashes per year
1 Fatal Crash
3 A-Injury Crashes
2B-Injury Crashes

HSM: $N_{spf4ST} = \exp[-8.56 + 0.60 \times \ln(AADT_{maj}) + 0.61 \times \ln(AADT_{min})]$
= 1.04 crashes/year

IDOT SPF: N K+I = $\exp(-8.05)*((AADT_{major})$^0.674)*$((AADT_{minor})$^0.272)
= 0.34 K+I crashes per 5 years.

July 29 and 30, 2009 11

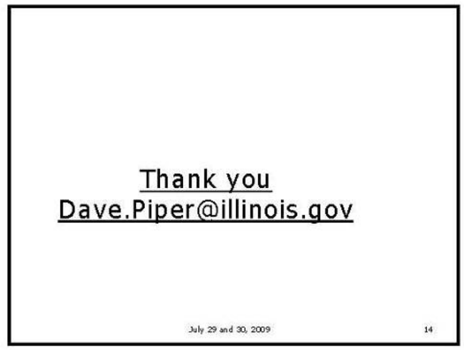
Quantitative Site Analysis

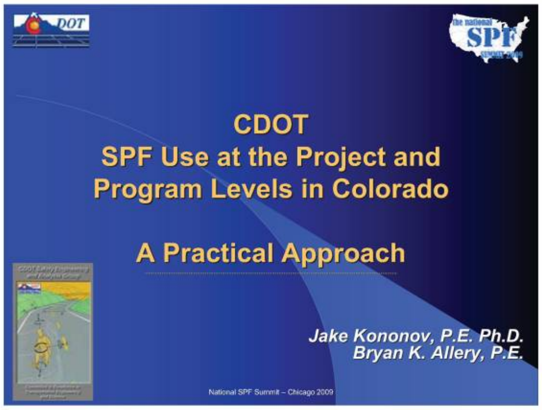
- Countermeasures Completed
  - Removed trees in sight triangle

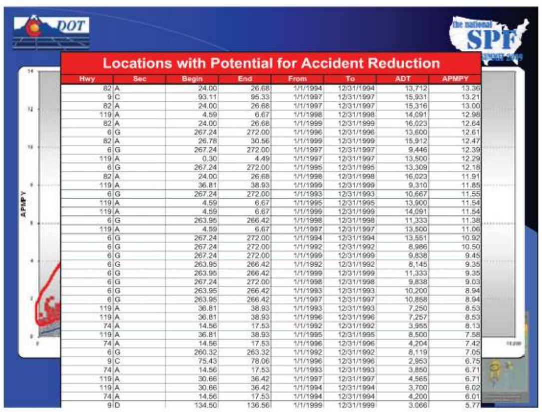
Countermeasures Under Consideration
  - Improved warning signs
  - Police private signs on ROW
  - Lighting
- Overall – Quantitative analysis supports actions taken, and informs future decisions.

July 29 and 30, 2009 12

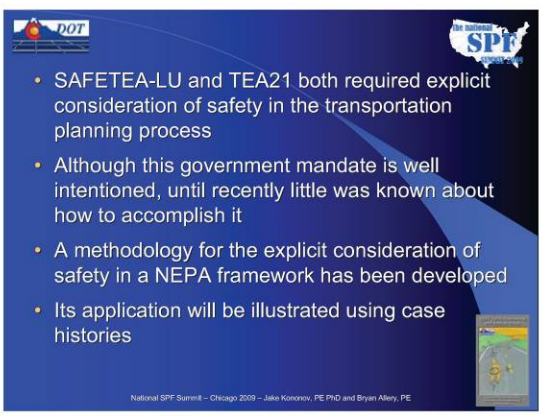

Summary
• SPF/PSI Products Support
– Identification of safety opportunities
– IDOT goal to reduce K's and A's
– Office review of 5% locations
– Focus of resources to best effect
– Credibility of analysis
• SPF/PSI Products will Support
– SafetyAnalyst
– Highway Safety Manual
July 29 and 30, 2009
13

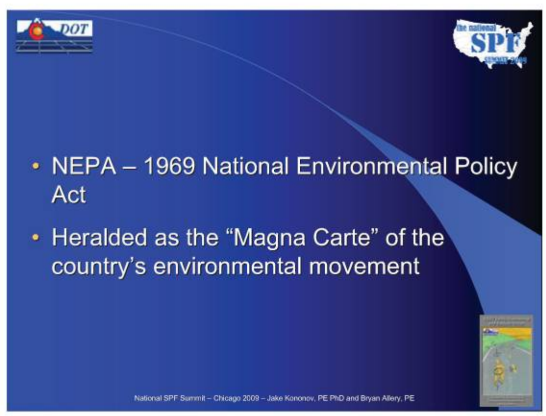

Thank you
Dave.Piper@illinois.gov
July 29 and 30, 2009
14




Locations with Potential for Accident Reduction

Hwy	Sec	Begin	End	From	To	ADT	APMPY
82	A	24.00	26.68	1/1/1994	12/31/1994	13,712	13.36
9	C	93.11	95.33	1/1/1997	12/31/1997	15,931	13.21
82	A	24.00	26.68	1/1/1997	12/31/1997	15,316	13.00
119	A	4.59	6.67	1/1/1998	12/31/1998	14,091	12.98
82	A	24.00	26.68	1/1/1999	12/31/1999	16,023	12.64
6	G	267.24	272.00	1/1/1996	12/31/1996	13,600	12.61
82	A	26.78	30.56	1/1/1999	12/31/1999	15,912	12.47
6	G	267.24	272.00	1/1/1997	12/31/1997	9,446	12.39
119	A	0.30	4.49	1/1/1997	12/31/1997	13,500	12.29
6	G	267.24	272.00	1/1/1995	12/31/1995	13,309	12.18
82	A	24.00	26.68	1/1/1998	12/31/1998	16,023	11.91
119	A	36.81	38.93	1/1/1999	12/31/1999	9,310	11.85
6	G	267.24	272.00	1/1/1993	12/31/1993	10,667	11.55
119	A	4.59	6.67	1/1/1995	12/31/1995	13,900	11.54
119	A	4.59	6.67	1/1/1999	12/31/1999	14,091	11.54
6	G	263.95	266.42	1/1/1998	12/31/1998	11,333	11.38
119	A	4.59	6.67	1/1/1997	12/31/1997	13,500	11.06
6	G	267.24	272.00	1/1/1994	12/31/1994	13,551	10.92
6	G	267.24	272.00	1/1/1992	12/31/1992	8,986	10.50
6	G	267.24	272.00	1/1/1999	12/31/1999	9,838	9.45
6	G	263.95	266.42	1/1/1992	12/31/1992	8,145	9.35
6	G	263.95	266.42	1/1/1999	12/31/1999	11,333	9.35
6	G	267.24	272.00	1/1/1998	12/31/1998	9,838	9.03
6	G	263.95	266.42	1/1/1993	12/31/1993	10,200	8.94
6	G	263.95	266.42	1/1/1997	12/31/1997	10,858	8.94
119	A	36.81	38.93	1/1/1993	12/31/1993	7,250	8.53
119	A	36.81	38.93	1/1/1996	12/31/1996	7,257	8.53
74	A	14.56	17.53	1/1/1992	12/31/1992	3,955	8.13
119	A	36.81	38.93	1/1/1995	12/31/1995	8,500	7.58
74	A	14.56	17.53	1/1/1996	12/31/1996	4,204	7.42
6	G	260.32	263.32	1/1/1992	12/31/1992	8,119	7.05
9	C	75.43	78.06	1/1/1996	12/31/1996	2,953	6.75
74	A	14.56	17.53	1/1/1993	12/31/1993	3,850	6.71
119	A	30.66	36.42	1/1/1997	12/31/1997	4,565	6.71
119	A	30.66	36.42	1/1/1994	12/31/1994	3,700	6.02
74	A	14.56	17.53	1/1/1994	12/31/1994	4,200	6.01
9	D	134.50	136.56	1/1/1999	12/31/1999	3,066	5.77






DOT
SPF
• NEPA contains the declaration of environmental policy and goals as well as "action forcing" provisions to Federal and State agencies to implement those goals
• NEPA translated into a well established methodology and institutionalized processes aimed at protecting the environment
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SPF
• Air Quality Impacts
▪ Carbon Monoxide
▪ Volatile Organic Compounds
▪ Nitrogen Oxides
▪ Particulate Matter
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SPF
• Wetlands
▪ Acres displaced carefully estimated
• Noise
▪ Expected levels predicted in decibels
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SPF
• Water Quality
▪ Total Suspended Solids (TSS Mg/L)
▪ Alkalinity – Acidity (PH)
▪ Biological Oxygen Demand (BOD Mg/L)
• Threatened and Endangered Species
▪ Habitats carefully surveyed and documented
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SPF
For Each of the Transportation Alternatives Under Consideration Environmental Impact is Described and Mitigated Explicitly
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SPF
Each Impact to the Environment is Compared with National Standards and Those Alternatives not Meeting the Standards are Rejected (or Modified)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

In Contrast to the Environmental Review Process,

The Impact Each Alternative has on Safety is Not Well Understood or Planned For

National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

No Standards Exist That Quantify The Amount of Safety Expected After Construction

It is Not Known How Much Safety to Expect!

National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

It is Collectively Hoped that Substantial Compliance with Standards will Automatically Produce an Appropriately Safe Facility

When Meeting Standards Becomes too Expensive, However, Design Variance Documentation is Prepared to Justify the Decision Not to Meet Them

National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

Is Providing an Adequate Level of Safety on the Transportation Facility *Less* Important than Protecting the Environment?

Both are Important Societal Values that Influence the Quality of Life

National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

National Statistics

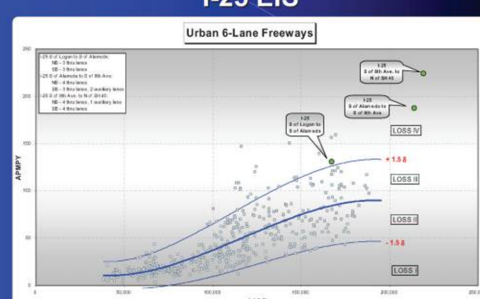
- *43,800 Fatalities (2007)*
- *2,914,000 Injuries (2003)*

Source: FARS and FHWA

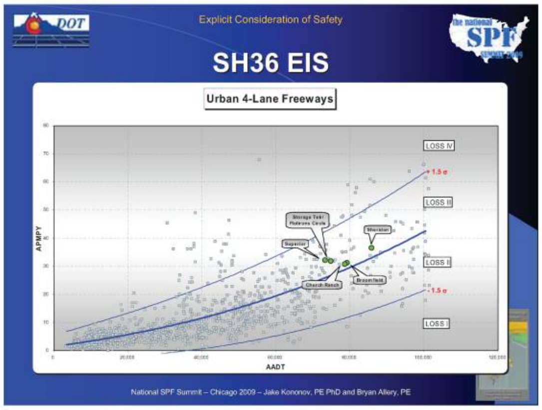
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

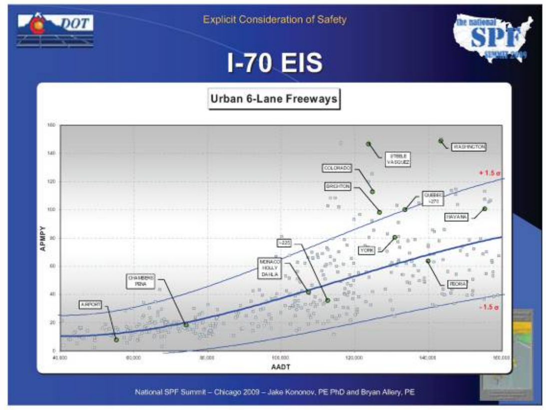
Explicit Consideration of Safety

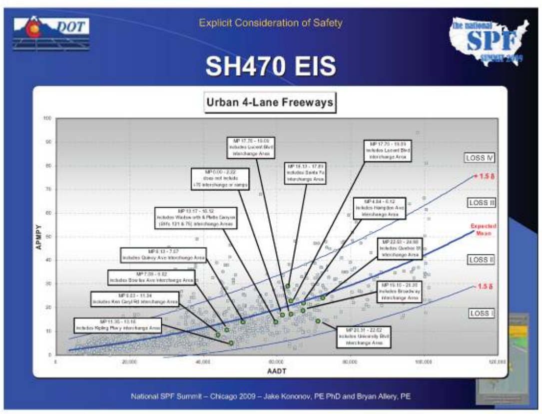
I-25 EIS

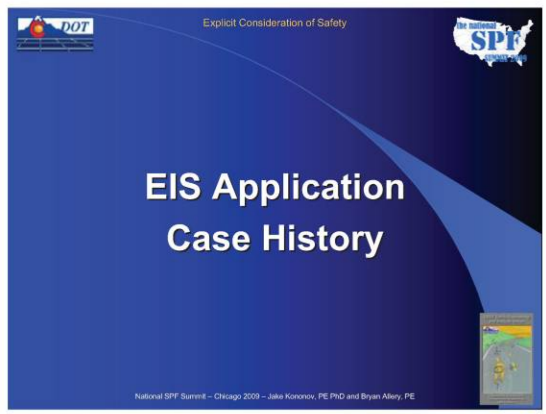


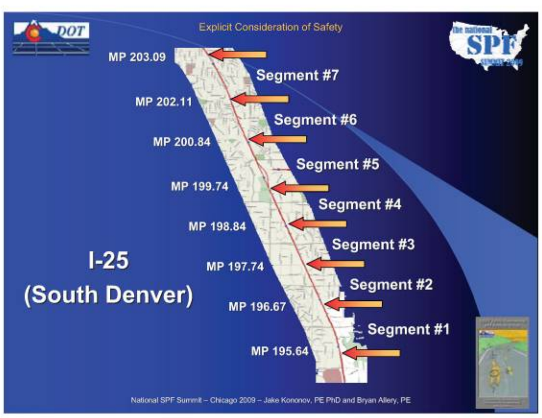
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

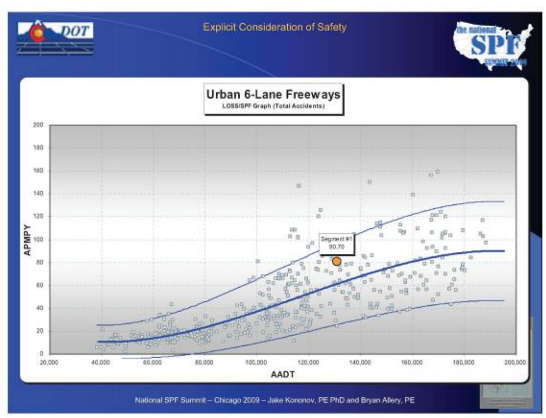

Explicit Consideration of Safety
SH36 EIS
Urban 4-Lane Freeways
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

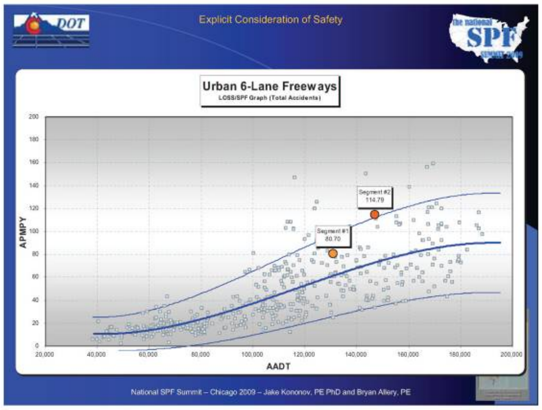

Explicit Consideration of Safety
I-70 EIS
Urban 6-Lane Freeways
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

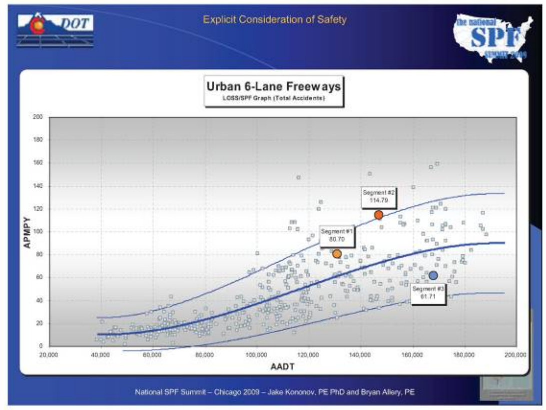

Explicit Consideration of Safety
SH470 EIS
Urban 4-Lane Freeways
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

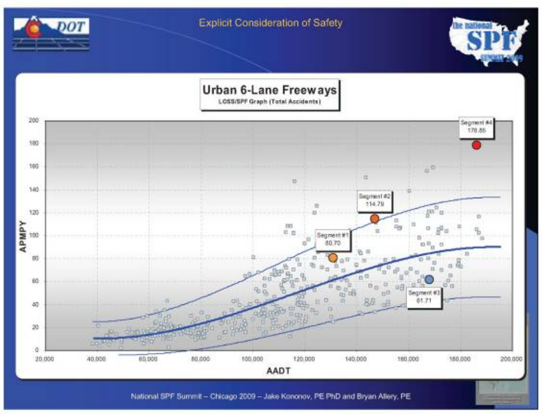

Explicit Consideration of Safety
EIS Application
Case History
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

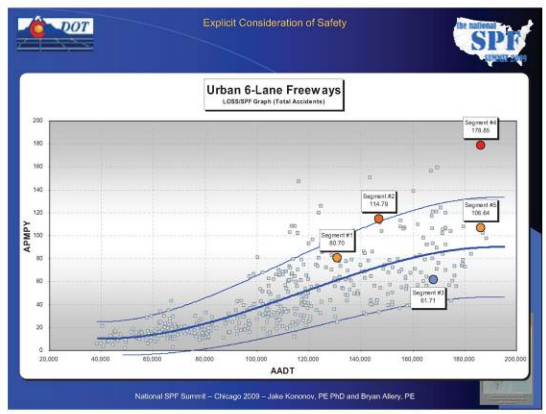

Explicit Consideration of Safety
MP 203.09
Segment #7
MP 202.11
Segment #6
MP 200.84
Segment #5
MP 199.74
Segment #4
MP 198.84
Segment #3
I-25
(South Denver)
MP 197.74
Segment #2
MP 196.67
Segment #1
MP 195.64
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

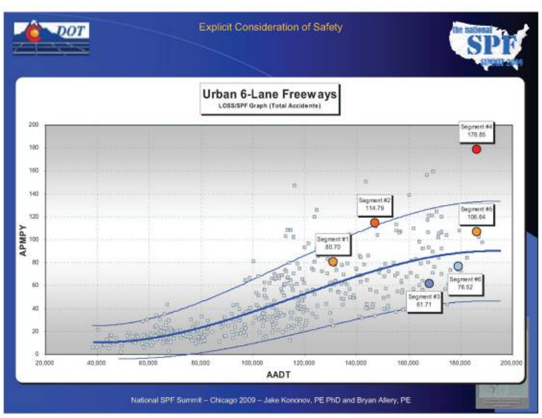

Explicit Consideration of Safety
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

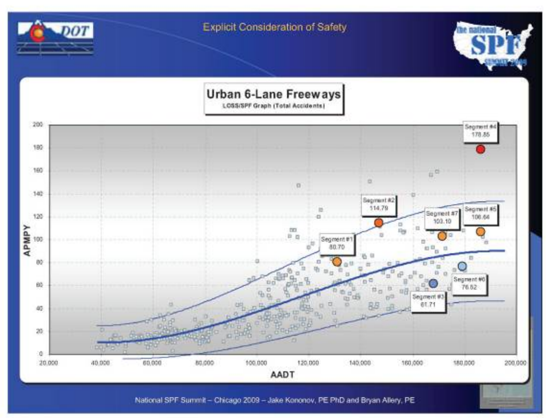

Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #2
114.79
Segment #1
80.70
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

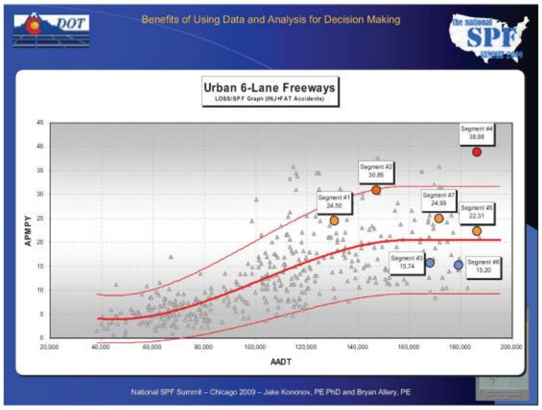

Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #2
114.79
Segment #1
80.70
Segment #3
61.71
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

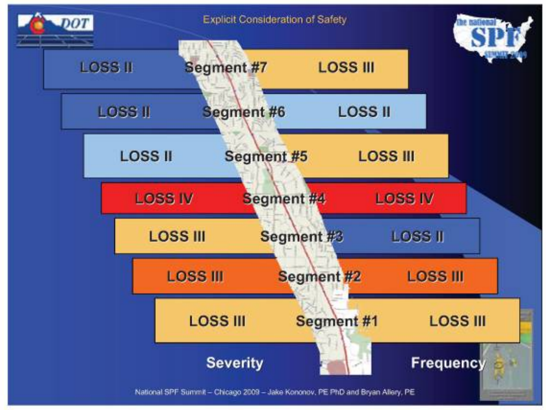

Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #4
178.85
Segment #2
114.79
Segment #1
80.70
Segment #3
61.71
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

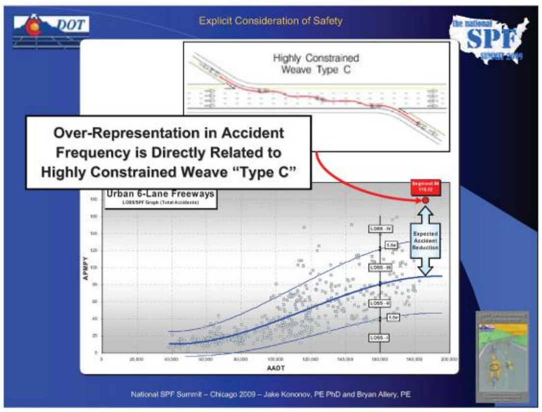

Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #4
178.85
Segment #2
114.79
Segment #5
106.64
Segment #1
80.70
Segment #3
61.71
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

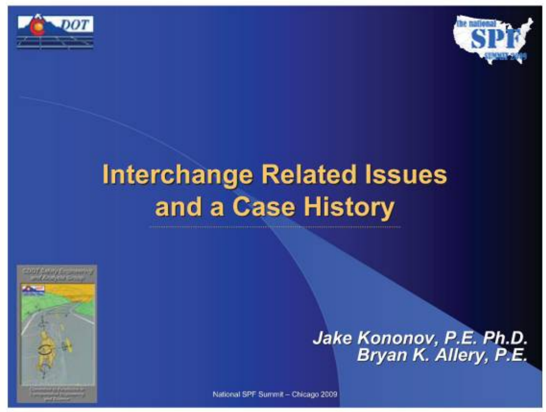

Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #4
178.85
Segment #2
114.79
Segment #5
106.64
Segment #1
80.70
Segment #6
76.62
Segment #3
61.71
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Explicit Consideration of Safety
DOT
the national SPF SUMMIT 2009
Urban 6-Lane Freeways
LOSS/SPF Graph (Total Accidents)
Segment #4
178.85
Segment #2
114.79
Segment #7
103.10
Segment #5
106.64
Segment #1
80.70
Segment #6
76.62
Segment #3
61.71
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

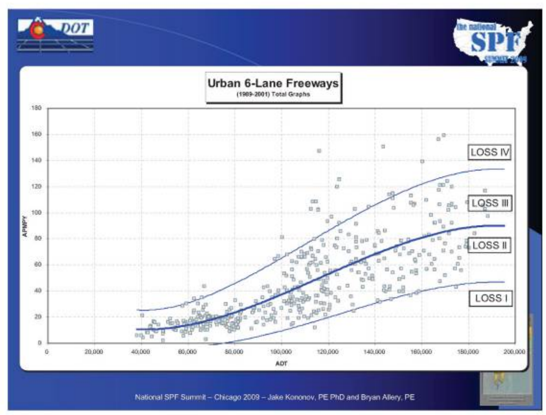

Benefits of Using Data and Analysis for Decision Making
Urban 6-Lane Freeways
Segment #4
38.88
Segment #2
30.86
Segment #1
24.50
Segment #7
24.99
Segment #5
22.31
Segment #3
15.74
Segment #6
15.20
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

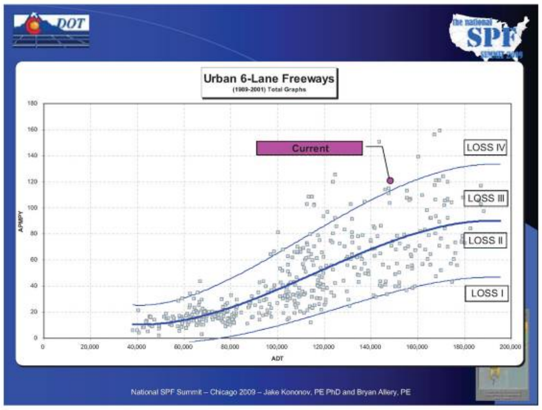

Explicit Consideration of Safety
LOSS II
Segment #7
LOSS III
LOSS II
Segment #6
LOSS II
LOSS II
Segment #5
LOSS III
LOSS IV
Segment #4
LOSS IV
LOSS III
Segment #3
LOSS II
LOSS III
Segment #2
LOSS III
LOSS III
Segment #1
LOSS III
Severity
Frequency
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

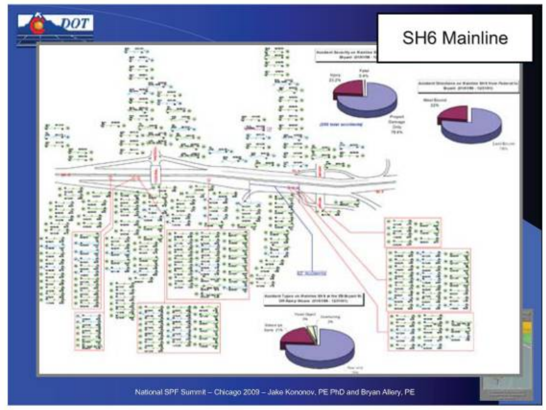

Explicit Consideration of Safety
Highly Constrained Weave Type C
Over-Representation in Accident Frequency is Directly Related to Highly Constrained Weave "Type C"
Urban 6-Lane Freeways
Expected Accident Reduction
APMPY
AADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

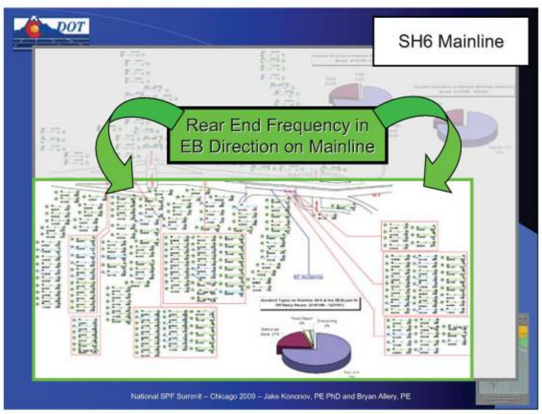

Interchange Related Issues and a Case History
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
National SPF Summit – Chicago 2009

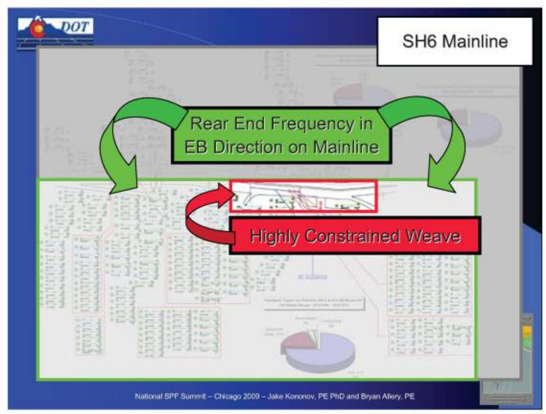

Project Limits
Project Limits
I-25 and US 6 in Central Denver
Project Limits
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

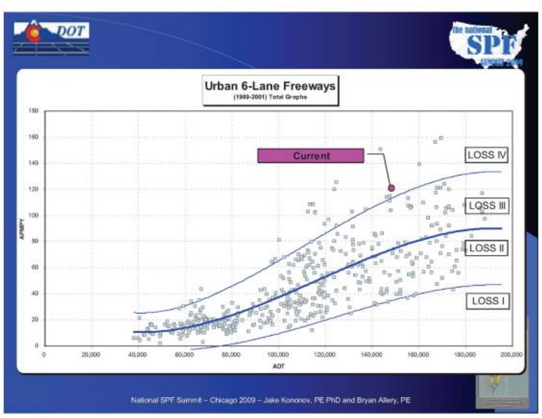

Urban 6-Lane Freeways
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

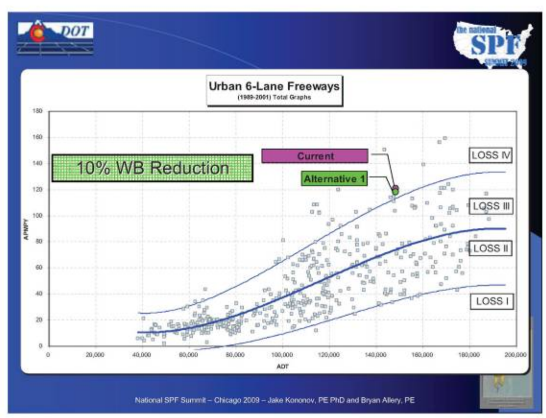

DOT
Urban 6-Lane Freeways
(1989-2001) Total Graphs
Current
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

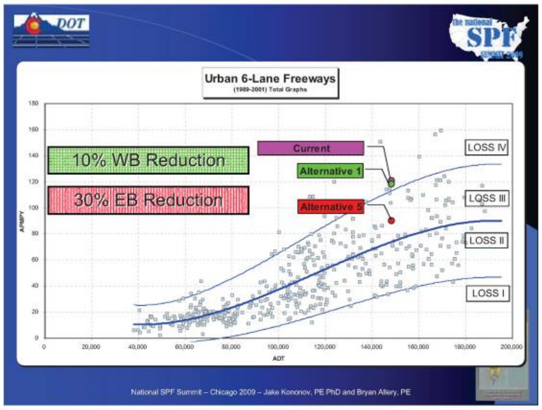

DOT
SH6 Mainline
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

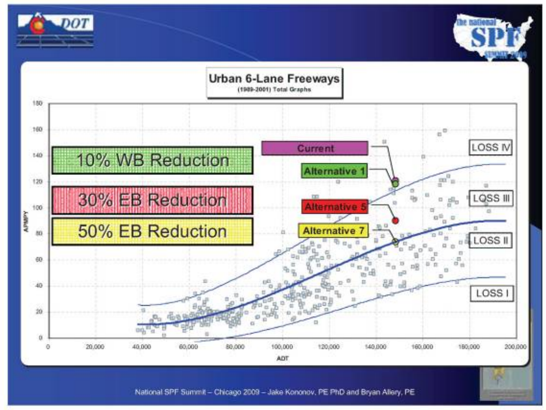

DOT
SH6 Mainline
Rear End Frequency in EB Direction on Mainline
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

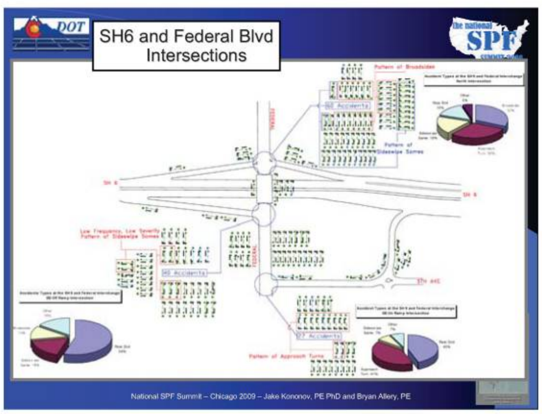

DOT
SH6 Mainline
Rear End Frequency in EB Direction on Mainline
Highly Constrained Weave
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

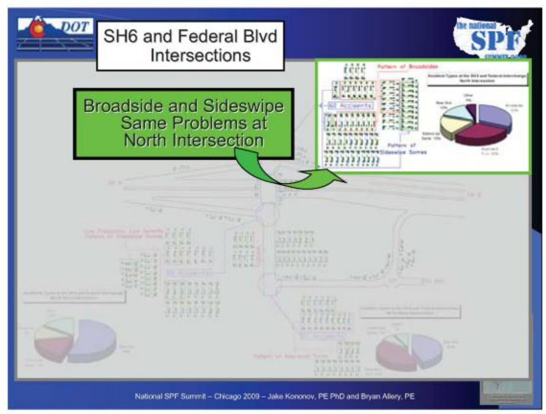

DOT
Urban 6-Lane Freeways
(1989-2001) Total Graphs
Current
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

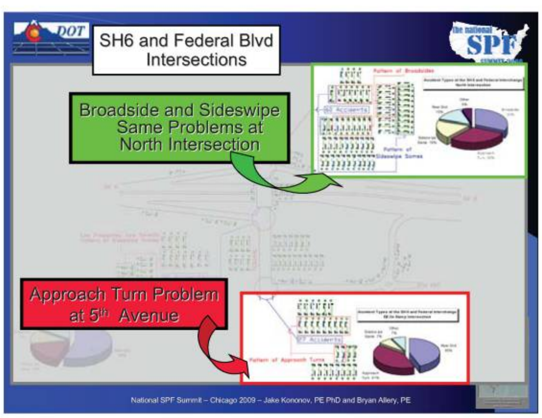

DOT
Urban 6-Lane Freeways
(1989-2001) Total Graphs
10% WB Reduction
Current
Alternative 1
LOSS IV
LOSS III
LOSS II
LOSS I
APMPY
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

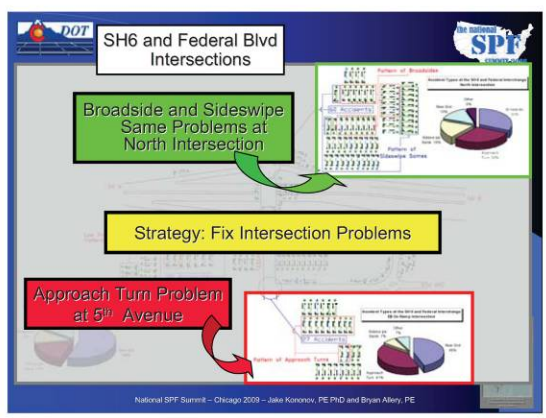

Urban 6-Lane Freeways
10% WB Reduction
30% EB Reduction
Current
Alternative 1
Alternative 5
LOSS IV
LOSS III
LOSS II
LOSS I
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


Urban 6-Lane Freeways
10% WB Reduction
30% EB Reduction
50% EB Reduction
Current
Alternative 1
Alternative 5
Alternative 7
LOSS IV
LOSS III
LOSS II
LOSS I
ADT
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

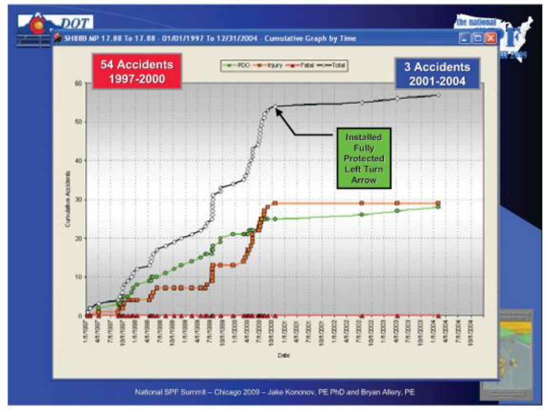

SH6 and Federal Blvd Intersections
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

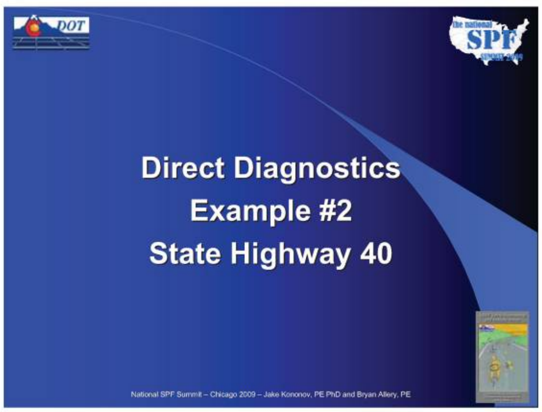

SH6 and Federal Blvd Intersections
Broadside and Sideswipe Same Problems at North Intersection
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

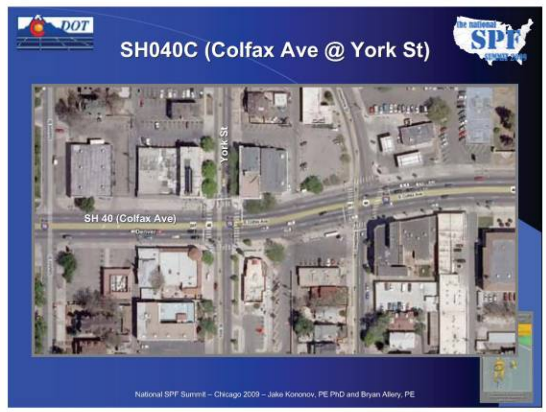

SH6 and Federal Blvd Intersections
Broadside and Sideswipe Same Problems at North Intersection
Approach Turn Problem at 5th Avenue
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

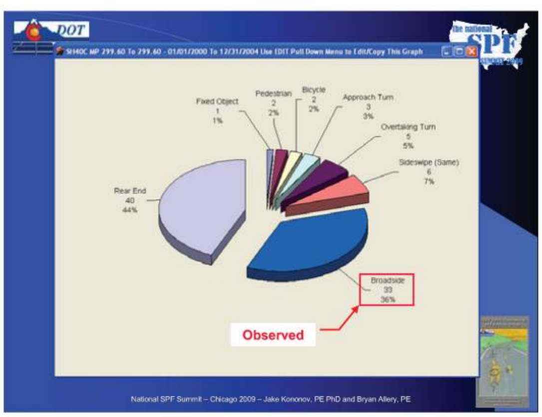

SH6 and Federal Blvd Intersections
Broadside and Sideswipe Same Problems at North Intersection
Strategy: Fix Intersection Problems
Approach Turn Problem at 5th Avenue
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
Diagnostic Normative Percentages (Urban 6-Lane Signalized)
70.50% PDO
29.32% INJ
0.17% FAT
14,926 Persons Injured
61 Persons Killed
5.16% Single Vehicle Accidents
80.32% Two Vehicle Accidents
14.29% Three or more Vehicle Accident
0.23% Unknown Number of Vehicles
96.33% On Road
1.46% Off Road Left
1.98% Off Road Right
0.04% Off Road at Tee
0.01% Off Road in Median
0.18% Unknown Road Location
0.35% Overturning
0.29% Other Non Collision
0.11% School Age Pedestrians
1.36% All Other Pedestrians
12.61% Broadside
0.44% Head On
48.86% Rear End
9.20% Sideswipe (Same Direction)
0.36% Sideswipe (Opposite Direction)
1.31% Overtaking Turn
0.40% Parked Motor Vehicle
0.02% Railway Vehicle
0.86% Bicycle
0.01% Motorized Bicycle
0.03% Domestic Animal
0.06% Wild Animal
0.46% Light or Utility Pole
0.35% Traffic Signal Pole
0.39% Sign
0.00% Bridge Rail
0.06% Guard Rail
0.14% Median Barrier
0.01% Bridge Abutment
0.01% Column or Pier
0.04% Delineator Post
0.05% Fence
0.09% Tree
0.00% Large Boulder
0.00% Rocks in Roadway
0.02% Barricade
0.05% Wall or Building
0.01% Crash Cushion
0.01% Mailbox
0.15% Other Fixed Object
0.16% Involving Other Object
0.02% Road Maintenance Equipment
0.20% Unknown Accident Type
3.26% Total Fixed Objects
0.18% Total Other Objects
73.23% Daylight
2.97% Dawn or Dusk
21.64% Dark -Lighted
0.92% Dark -Unlighted
1.25% Unknown Lighting
89.96% No Adverse Weather
4.49% Rain
3.83% Snow or Sleet or Hail
0.09% Fog
0.00% Dust
8.21% Wet Road
0.09% Muddy Road
1.28% Snowy Road
1.63% Icy Road
0.35% Slushy Road
0.14% Foreign Material Road
0.19% With Road Treatment
0.15% Dry with Icy Road Treatment
0.07% Wet with Icy Road Treatment
0.03% Snowy with Icy Road Treatment
0.06% Icy with Icy Road Treatment
0.01% Slushy with Icy Road Treatment
1.67% Unknown Road Condition
20.10% Approach Turn Expected
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

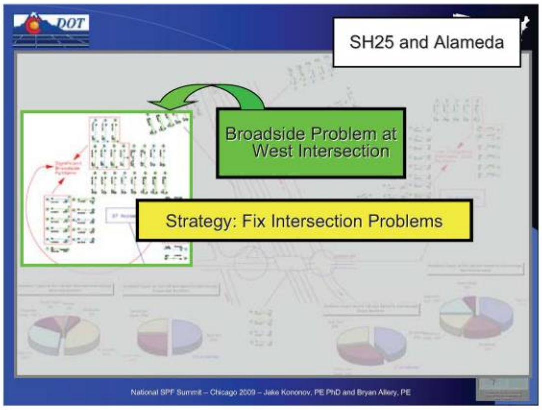

DOT
54 Accidents 1997-2000
3 Accidents 2001-2004
PDO
Injury
Fatal
Total
Installed Fully Protected Left Turn Arrow
Cumulative Accidents
Date
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

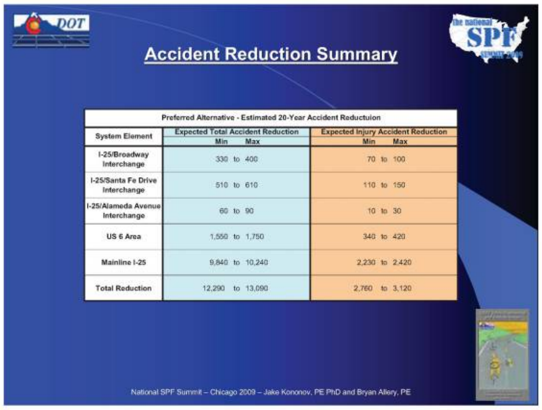

DOT
Direct Diagnostics
Example #2
State Highway 40
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
SH040C (Colfax Ave @ York St)
York St
SH 40 (Colfax Ave)
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE


DOT
Fixed Object 1 1%
Pedestrian 2 2%
Bicycle 2 2%
Approach Turn 3 3%
Overtaking Turn 5 5%
Sideswipe (Same) 6 7%
Rear End 40 44%
Broadside 33 36%
Observed
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE

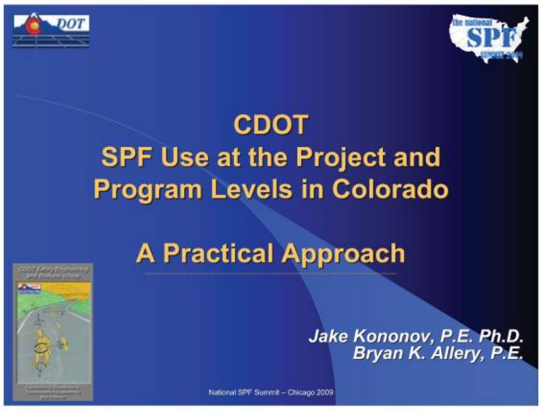

DOT
Diagnostic Normative Percentages (Urban 6-Lane Signalized)
70.50% PDO
29.32% INJ
0.17% FAT
14,926 Persons Injured
61 Persons Killed
5.16% Single Vehicle Accidents
80.32% Two Vehicle Accidents
14.29% Three or more Vehicle Accident
0.23% Unknown Number of Vehicles
96.33% On Road
1.46% Off Road Left
1.98% Off Road Right
0.04% Off Road at Tee
0.01% Off Road in Median
0.18% Unknown Road Location
0.35% Overturning
0.29% Other Non Collision
0.11% School Age Pedestrians
1.36% All Other Pedestrians
0.44% Head On
48.86% Rear End
9.20% Sideswipe (Same Direction)
0.36% Sideswipe (Opposite Direction)
20.10% Approach Turn
1.31% Overtaking Turn
0.40% Parked Motor Vehicle
0.02% Railway Vehicle
0.86% Bicycle
0.01% Motorized Bicycle
0.03% Domestic Animal
0.06% Wild Animal
0.46% Light or Utility Pole
0.35% Traffic Signal Pole
0.39% Sign
0.00% Bridge Rail
0.06% Guard Rail
0.14% Median Barrier
0.01% Bridge Abutment
0.01% Column or Pier
0.04% Delineator Post
0.05% Fence
0.09% Tree
0.00% Large Boulder
0.00% Rocks in Roadway
0.02% Barricade
0.05% Wall or Building
0.01% Crash Cushion
0.01% Mailbox
0.15% Other Fixed Object
0.16% Involving Other Object
0.02% Road Maintenance Equipment
0.20% Unknown Accident Type
3.26% Total Fixed Objects
0.18% Total Other Objects
73.23% Daylight
2.97% Dawn or Dusk
21.64% Dark -Lighted
0.92% Dark -Unlighted
1.25% Unknown Lighting
89.96% No Adverse Weather
4.49% Rain
3.83% Snow or Sleet or Hail
0.09% Fog
0.00% Dust
8.21% Wet Road
0.09% Muddy Road
1.28% Snowy Road
1.63% Icy Road
0.35% Slushy Road
0.14% Foreign Material Road
0.19% With Road Treatment
0.15% Dry with Icy Road Treatment
0.07% Wet with Icy Road Treatment
0.03% Snowy with Icy Road Treatment
0.06% Icy with Icy Road Treatment
0.01% Slushy with Icy Road Treatment
1.67% Unknown Road Condition
12.61% Broadsides Expected
National SPF Summit – Chicago 2009 – Jake Kononov, PE PhD and Bryan Allery, PE





Preferred Alternative - Estimated 20-Year Accident Reductuion

System Element	Expected Total Accident Reduction (Min to Max)	Expected Injury Accident Reduction (Min to Max)
I-25/Broadway Interchange	330 to 400	70 to 100
I-25/Santa Fe Drive Interchange	510 to 610	110 to 150
I-25/Alameda Avenue Interchange	60 to 90	10 to 30
US 6 Area	1,550 to 1,750	340 to 420
Mainline I-25	9,840 to 10,240	2,230 to 2,420
Total Reduction	12,290 to 13,090	2,760 to 3,120



Use of State Developed SPFs in Their Own tools & the National Perspective

the national SPF SUMMIT 2009

Washington State Department of Transportation

John Milton Ph.D., P.E.,
Washington State Department of Transportation

July 29th, 2009
Chicago, Illinois

National Safety Performance Function Summit

Overview

- Use on Rural Two Lane Highway
  - Programming and Design
- Use at Signal Priority Array
  - Programming
- Use for Determination of Safety Projects on Interstate Highways
- Rural Multilane

Rural Two Lane Highway SPFs

- Formed a major component of the Prevention Program within Washington State
- Developed by University of Washington/WSDOT
  - Not Empirical Bayes
  - Difficult for some to accept the fact that at some locations expected collision were higher than or lower than actual
  - Regions were allowed flexibility in use

Signal & Channelization Priority Array

- Formed major component of prevention program
- Used to programmatic rank signal and channelization priority array locations.
- Developed by University of Washington/WSDOT in two separate projects.
- Accepted by public
- Still used

Interstate Highways

- Will constitute Interstate Safety Program
- Negotiated to not do blind standards applications because of paving.
- Focus on identification of locations with potential for serious and fatal crashes.
- Used Hierarchical Bayes
- Negotiated as part of Stewardship Agreements

Rural Multilane

- Next Step of Development
- Will use Hierarchical Bayes or Neural Network Analysis
- Penn State University

Two-Lane Highway Development

- Reviewed surrogate measures with SPF development
- Arizona State University/Oregon State University

Summary

- SPFs are in use in WA primarily at the programming level.
- Use by design and traffic increasing
- Training is necessary, to gain clarity on usage!

THE END

Session 9: Local SPF Use- Iowa

Michael Pawlovich, Ph.D., P.E.
Iowa Dept. of Trans.,
Traffic and Safety

Iowa Department of Transportation

Iowa "SPF" Development

- Don't really use "SPF"s, per se, currently – do use CRFs/AMFs
- Have developed models, mostly for evaluation of past countermeasures
- Don't use EB...
  - went from classical → FB
  - essentially same difference but Iowa resources allowed
  - development continues

Iowa Department of Transportation July 29 and 30, 2009 2

Iowa "SPF" Examples

- Examples of Iowa FB use:
  - Bayesian Intersection Ranking (past)
    - limited # of sites
    - demonstration case
  - 4 → 3-lane Before/After Evaluation Study (past and published)
    - could use as an SPF but haven't had need
  - 2 → 3-lane Before/After Evaluation Study (ongoing)

Iowa Department of Transportation July 29 and 30, 2009 3

Iowa "SPF" Examples

- More examples of Iowa FB use:
  - Impacts of Bypasses Before/After Evaluation Study (ongoing)
  - Bayesian SICL (network screening) – intersection and segment (1st ongoing, 2nd future)
  - Comparables/Expected Values (future)
  - Alternate considerations for location – not site-based but crash-based (future)

Iowa Department of Transportation July 29 and 30, 2009 4

Iowa SPF Thoughts

- Methodologically, we can develop prediction models or SPFs
  - begin from engr. problem and site data
  - develop stat. models faithful to engr. concepts and include parameters interpretable in the engineering context
  - Model parameters estimated using fully Bayesian (hierarchical) methods

Iowa Department of Transportation July 29 and 30, 2009 5

Iowa SPF Thoughts

- We are trying to develop models/SPFs useable over a reasonably wide range of site types
  - base estimates on datasets with a diversity of site attributes
  - model over these diverse attributes

Iowa Department of Transportation July 29 and 30, 2009 6

Iowa SPF Thoughts

- For example, if we wish to investigate one type of site vs. another we can use the same SPF as long as the data and model properly contain the means
- Limitation not software or stat. tools but rather that needed data not available to permit estimating *canonical* SPFs – working towards

Iowa Department of Transportation July 29 and 30, 2009 7

Conclusion

- Data improvement crucial
  - *canonical* SPFs
  - specific SPFs
  - analyses in general
- Learning and improving as we go
  - "If we knew what it was we were doing, it would not be called research, would it?" - Albert Einstein

Iowa Department of Transportation July 29 and 30, 2009 8

Thank you

michael.pawlovich@dot.iowa.gov

Iowa Department of Transportation July 29 and 30, 2009 9

HSM Use and Training

HSM

Karen K. Dixon, Ph.D., P.E.
Oregon State University

Presentation Summary

1. What is the HSM?
2. Why is the HSM needed?
3. How can the HSM be used?
4. When will the 1st Edition be available?
5. Where can one find more information about the HSM?

Overview of the new HSM

I. WHAT IS THE HSM?

What is the HSM?

Provide **Information** / **Tools**

To facilitate explicit safety considerations for:

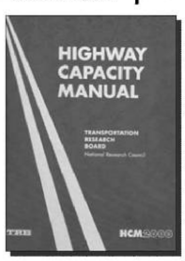
- *Planning*
- *Design*
- *Operations*
- *Maintenance*

through

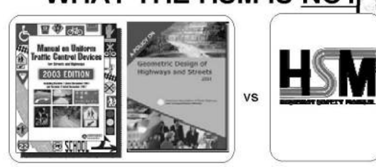
- Synthesis of validated highway research
- Adapted & integrated to practice
- Analytical tools for predicting impact on road safety

The Vision of the HSM - A Document Akin To the HCM

1. Definitive; represents quantitative 'state-of-the-art' information
2. Widely accepted within professional practice of transportation engineering
3. Science-based; updated regularly to reflect research

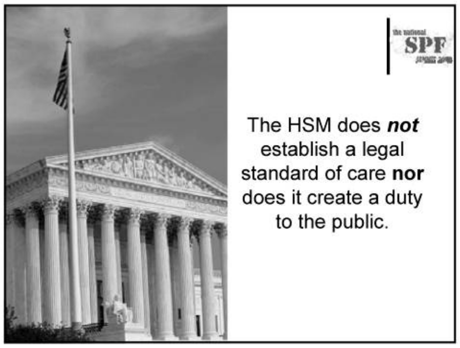


WHAT THE HSM IS NOT

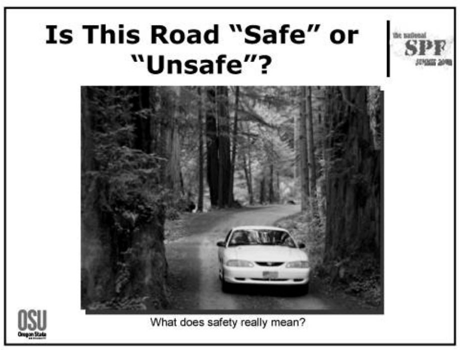


- The HSM does ***not*** set requirements or mandates
- The HSM is ***not*** a best practice document for design or operations.
- The HSM contains **no** warrants or standards and does **not** supersede other publications that do.

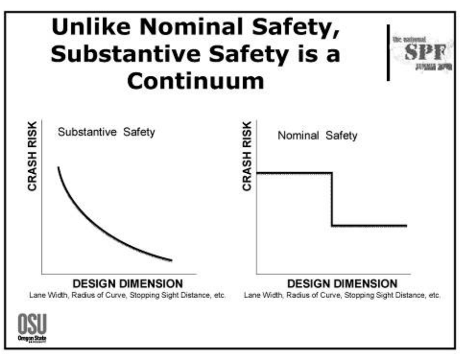
July 29 and 30, 2009
Chicago, Illinois

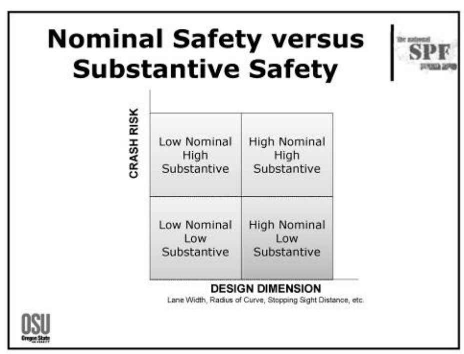

The HSM does *not* establish a legal standard of care **nor** does it create a duty to the public.

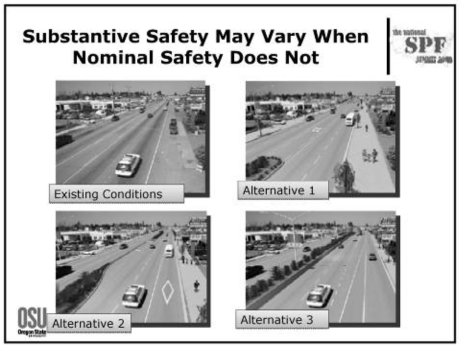

Overview of the new HSM
II. WHY DO WE NEED THE HSM?
OSU

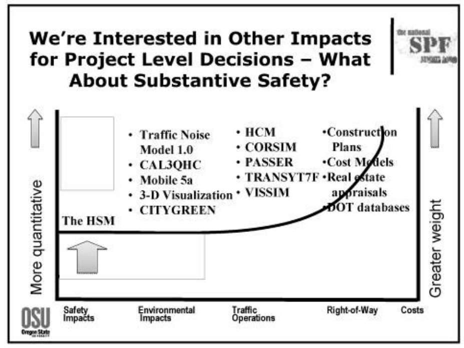

Is This Road "Safe" or "Unsafe"?
What does safety really mean?
OSU

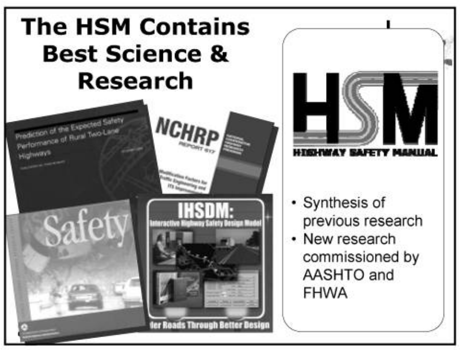

Highway Safety Has Two Dimensions
Nominal Safety
Substantive Safety
Examined in reference to compliance with standards, warrants, guidelines and sanctioned design procedures
The expected or actual crash frequency and severity for a highway or roadway
OSU

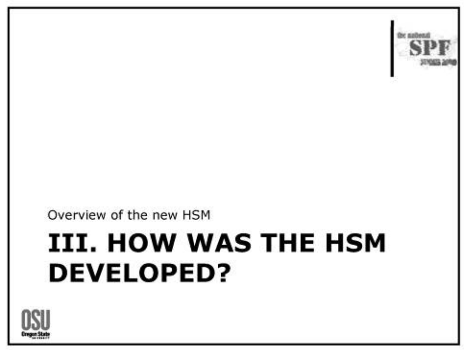

Unlike Nominal Safety, Substantive Safety is a Continuum
CRASH RISK
Substantive Safety
DESIGN DIMENSION
Lane Width, Radius of Curve, Stopping Sight Distance, etc.
CRASH RISK
Nominal Safety
DESIGN DIMENSION
Lane Width, Radius of Curve, Stopping Sight Distance, etc.
OSU

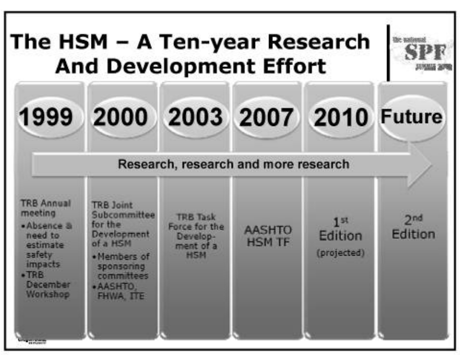

Nominal Safety versus Substantive Safety
CRASH RISK
Low Nominal High Substantive
High Nominal High Substantive
Low Nominal Low Substantive
High Nominal Low Substantive
DESIGN DIMENSION
Lane Width, Radius of Curve, Stopping Sight Distance, etc.
OSU


Substantive Safety May Vary When Nominal Safety Does Not
Existing Conditions
Alternative 1
Alternative 2
Alternative 3


We're Interested in Other Impacts for Project Level Decisions – What About Substantive Safety?
• Traffic Noise Model 1.0
• CAL3QHC
• Mobile 5a
• 3-D Visualization
• CITYGREEN
• HCM
• CORSIM
• PASSER
• TRANSYT7F
• VISSIM
•Construction Plans
•Cost Models
•Real estate appraisals
•DOT databases
The HSM
More quantitative
Greater weight
Safety Impacts
Environmental Impacts
Traffic Operations
Right-of-Way
Costs


The HSM Contains Best Science & Research
HSM
HIGHWAY SAFETY MANUAL
• Synthesis of previous research
• New research commissioned by AASHTO and FHWA
NCHRP
Safety
IHSDM:
Interactive Highway Safety Design Model


Overview of the new HSM
III. HOW WAS THE HSM DEVELOPED?


The HSM – A Ten-year Research And Development Effort
1999
2000
2003
2007
2010
Future
Research, research and more research
TRB Annual meeting
•Absence & need to estimate safety impacts
•TRB December Workshop
TRB Joint Subcommittee for the Development of a HSM
•Members of sponsoring committees
•AASHTO, FHWA, ITE
TRB Task Force for the Development of a HSM
AASHTO HSM TF
1st Edition (projected)
2nd Edition


Significant Effort & Professional Support Produced the HSM
• Joint Subcommittee sponsored by 7 TRB committees
• Thousands of hours of volunteer effort
• Research program funded by NCHRP, AASHTO & FHWA

Research Path to the HSM v.1

Project	Description
NCHRP Project 17-18(04)	Development of a HSM - Draft Table of Contents for the HSM.
NCHRP Project 17-25	Crash Reduction Factors for Traffic Engineering and ITS Improvements
NCHRP Project 17-26	Development of Models for Prediction of Expected Safety Performance for Urban and Suburban Arterials
NCHRP Project 17-27	Prepare Parts I and II of the HSM
NCHRP Project 17-29	Safety Prediction Models for Rural Multilane Highways for Use in the HSM
NCHRP Project 17-34	Prepare Parts IV and V of the HSM
NCHRP Project 17-36	Production of the First Edition of the HSM
NCHRP Project 17-37	Pedestrian Predictive Crash Methodology for Urban and Suburban Arterials
NCHRP Project 17-38	HSM Implementation and Training Materials

Overview of the new HSM

IV. WHAT IS COVERED BY THE HSM?

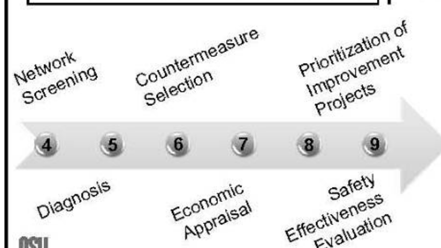
Outline of the HSM

HSM PART	SUPPORTING TOOL
PART B: Roadway Safety Management Process	SafetyAnalyst http://www.safetyanalyst.org/
PART C: Predictive Methods	IHSDM http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm
PART D: Accident Modification Factors	FHWA CRF/AMF Clearinghouse

PART A
INTRODUCTION, HUMAN FACTORS, & FUNDAMENTALS

- Chapter 1 — Introduction and Overview
- Chapter 2 — Human Factors
- Chapter 3 — Fundamentals

Part B
Roadway Safety Management Process



Part C
Predictive Method

Two-Lane Rural Roads
Urban/ Suburban Arterial Highways
Rural Multilane Highways

- Methodology
- Applications
- Safety issues not explicitly addressed by the methodology
- Example problems
- References

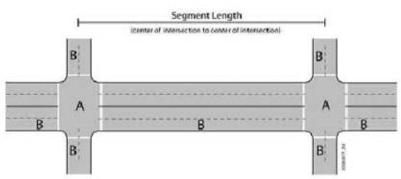
Special Part C Common Procedures

- Calibration
- Combining predicted with observed crashes

Definition of HSM Terms

- **Safety Performance Function** (SPF) – a regression equation used for estimating the predicted crash frequency at a site for a given "base condition"
- **Accident Modification Factor** (AMF) – used to adjust the "base condition" in the SPF to specific site characteristics
- **Calibration Factor** (C) – adjusts average crash frequencies calculated from the SPF to local site conditions

Predicting Crashes – Defining Roadway Segments and Intersections



A All crashes that occur within this region are classified as intersection crashes.
B Crashes in this region may be segment or intersection related, depending on on the characteristics of the crash.

HSM Regional SPF Calibration

Step 1 – Identify facility types of interest

Step 2 – Select sites for calibration of each facility type

Step 3 – Obtain data for each facility type applicable to the calibration period

Step 4 – Apply the appropriate Part C predictive model to estimate expected crash frequency for each site during the calibration period

Step 5 – Compute calibration factors for use in Part C predictive model

Part D
Accident Modification Factors

- CHAPTER 13 Roadway Segments
- CHAPTER 14 Intersections
- CHAPTER 15 Interchanges
- CHAPTER 16 Special Facilities and Geometric Situations
- CHAPTER 17 Road Networks

Overview of the new HSM

V. WHO SHOULD USE THE HSM?

Who Should Use the HSM?

System Planning → Project Planning → Preliminary Design, Final Design, & Construction → Operations & Maintenance

---

System Planning → Project Planning → Preliminary Design, Final Design, and Construction → Operations and Maintenance

- Assess the system needs & identify projects/studies
- Program projects
- Evaluate system-wide safety effects of programs

System Planning → **Project Planning** → Preliminary Design, Final Design, and Construction → Operations and Maintenance

- Define problem(s) and assist in scoping
- Identify potential solutions
- Assess or evaluate multiple alternatives and expected quantitative safety effects
- Aid in identification of a preferred alternative

System Planning → Project Planning → **Preliminary Design, Final Design, and Construction** → Operations and Maintenance

- Evaluate safety of alternative design approaches
- Assist in review & documentation of design exceptions, variances and waivers
- Inform decisions on construction staging, work approaches, etc.

System Planning → Project Planning → Preliminary Design, Final Design, and Construction → **Operations & Maintenance**

- Monitor operations to maintain balance among safety, mobility and access.
- Evaluate the effectiveness of implemented improvements

Overview of the new HSM

VI. WHEN WILL THE HSM BE AVAILABLE?

Implementation Schedule

- Now through July 31, 2009: *Review & balloting by AASHTO 's Subcommittee of Traffic Engineering, Standing Committee on Highway Traffic Safety, and Subcommittee on Design*
- Sept 1st to 30th, 2009 – *Ballot by AASHTO's Standing Committee on Highways & Standing Committee on Highway Traffic Safety*
- Expected Release Date: *Early 2010*

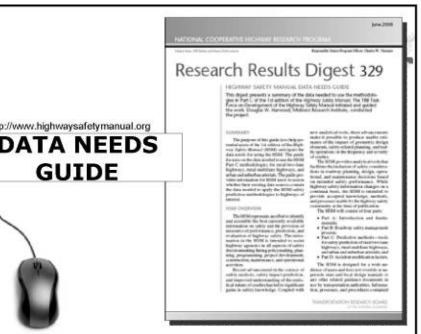
Training & Outreach Activities

- Sept 2009 – Jan 2010
  - Conduct two or three multi-state pilot courses
- August 2009
  - TRB Task Force Meeting
- TRB 2010 Annual Meeting
  - One-day workshop
- Training materials, including "Train-the-trainer" available upon HSM release

Overview of the new HSM

VII. WHERE CAN ONE FIND MORE INFORMATION ABOUT THE HSM?

http://www.highwaysafetymanual.org



http://www.highwaysafetymanual.org

DATA NEEDS GUIDE

Key Contacts

- **AASHTO**
  - Ken Kobetsky: kenk@aashto.org, (202) 624-5254
  - Jim McDonnell: jimm@aashto.org, (202) 624-5448
  - Joel McCarroll: jmccarroll@aashto.org, (202) 624-3632
- **AASHTO JOINT TASK COMMITTEE FOR THE HSM**
  - Don Vaughn, ALDOT, vaughnd@dot.state.al.us, (334) 242-6319

Key Contacts

- **TRB/ NCHRP**
  - Rick Pain: rpain@nas.edu, (202)334-2964
  - Chuck Niessner: cniessne@nas.edu, (202) 334-1431
- **TRB HSM TF: Development of a Highway Safety Manual**
  - John Milton, miltonj@wsdot.wa.gov, (360)704-6363
- **TRB HSM TF: User Liaison**
  - Geni Bahar (User Liaison Subcommittee of the TRB HSM Task Force): genibahar@rogers.com, (416) 932-9272
- **TRAINING**
  - Karen Dixon (PI of NCHRP Project 17-38): karen.dixon@oregonstate.edu, (541) 737-6337

The End

Questions?

Session 10
Training Opportunities

Brief Overview of Related Courses in USA / Canada

Geni Bahar, P.E.
NAVIGATS Inc.

Introduction

- Training
  - Content and duration
  - Statistical modeling
  - SPF applications
- Customized or generic

July 29 and 30, 2009 2

Generic Courses
(with Some Customization)

July 29 and 30, 2009 3

National Highway Institute
New Approaches to Safety Analysis (No.380075)

DAY 1
- Overview of the Highway Safety Improvement Program (HSIP)
- Approaches to Measuring Safety
- Safety Performance Functions
- Principles of Network Screening

Thomas.Elliott@dot.gov

July 29 and 30, 2009 4

National Highway Institute
New Approaches to Safety Analysis (No.380075)

DAY 2
- Safety & Standards
- Human Factors Issues
- Diagnosis of Safety Problems and Selection of Countermeasures
- Analysis of Roadway Departure Crashes

DAY 3
- Analysis of Intersection Crashes
- Analysis of Pedestrian Crashes

July 29 and 30, 2009 5

Road Safety 101 Syllabus

- Flexible delivery
  - Blended learning
  - All classroom (3-4 days)
  - Online
- Five Units and 25 modules

cniessner@nas.edu

July 29 and 30, 2009 6

Road Safety 101 Syllabus

1. The Nature of Road Safety
2. History and Institutional Settings of Road Safety Management
3. Origins, Characteristics, and Uses of Crash Data

July 29 and 30, 2009 7

Road Safety 101 Syllabus

4. Contributing Crash Factors, Countermeasure Selection, and Evaluation
5. Road Safety Program Management

July 29 and 30, 2009 8

University Courses
Graduate Studies in Civil Eng.

July 29 and 30, 2009 9

University of Colorado

- ***Explicit Consideration of Safety in Geometric Design of Highways***
  - Philosophy of Explicit Consideration of Safety in Highway Design
  - Review of Critical Design Standards from the Safety Perspective
  - Accident Report Form and Structure of Relational Database
  - Problems with Using Accident Rates
  - Introduction to Safety Performance Functions
  - Elements of Statistics and Review of Relevant Distributions

July 29 and 30, 2009 10

University of Colorado

- ***Explicit Consideration of Safety in Geometric Design of Highways (cont'd)***
  - Regression Analysis and Philosophy and Methodology of Model Fitting
  - Level of Service of Safety, Relationship between Number of lanes and safety
  - Direct Diagnostics Analysis of Intersections and Roadway Segments
  - Development of Diagnostic Menus
  - Principles of Mathematical Pattern Recognition
  - Benefit/Cost Sensitivity Analysis, Observational Before and After Studies

Jake.Kononov@dot.state.co.us

July 29 and 30, 2009 11

Ryerson University – TO Canada

- Road Safety
  - probability models of crash occurrence
  - estimation of safety in developing and evaluating countermeasure
  - methods for identifying hazardous elements
  - safety of road facilities: intersections, roadways, roadsides, and traffic control elements

July 29 and 30, 2009 12

Ryerson University – TO Canada

- Road Safety
  - driver, pedestrian and bicycle safety
  - applications of human factors principles
  - safety audits

bpersaud@ryerson.ca

July 29 and 30, 2009 13

DOT Courses

July 29 and 30, 2009 14

Texas DOT

Texas Transportation Institute

- Safety training 1-day workshops
  - Application of safety information in the highway geometric design process
    - Rural two-lane roads
    - Urban Streets / Suburban Arterials
    - Freeways and Multi-lane Highways
- More information at:

http://tcd.tamu.edu/documents/rsd.htm

July 29 and 30, 2009 15

Texas DOT

Texas Transportation Institute – Freeway and Rural Multi-lane Highways

- Session 1: *Review of highway safety issues*
- Session 2: *Overview of safety evaluation*
- Session 3: *Procedure for multilane highway segments*

July 29 and 30, 2009 16

Texas DOT

Texas Transportation Institute – Freeway and Rural Multi-lane Highways

- Session 4: *Procedure for freeway segments*
- Session 5: *Procedure for interchange ramps*
- Session 6: *Section evaluation*
- Session 7: *Alternatives analysis*

J-Bonneson@tamu.edu

July 29 and 30, 2009 17

Dr. Ezra Hauer

- Close to 40 years of leadership and on-going innovation in the advancement of road safety
- Author of 1997 "Observational Before-After Studies in Road Safety"
- Customized workshops
  - 2 to 5 days (with tutorials)
  - Case studies with local data

July 29 and 30, 2009 18

Iowa DOT
Dr. Ezra Hauer

- Session1: Safety Performance Functions, Crash Causation, Countermeasures, and Crash Modification Functions.
- Session 2: An Overview of Safety Evaluation
- Session 3: Can Multivariate Regression Modeling Lead to Cause-Effect Inferences?

July 29 and 30, 2009 19

Iowa DOT
Dr. Ezra Hauer

- Session 4: A Review of Speed and Safety
- Session 5: Evidence-based safety: The other side of the coin
- Session 6: The Road Ahead

ezra.hauer@utoronto.ca

July 29 and 30, 2009 20

Web-seminars

July 29 and 30, 2009 21

ITE Webinars

- Introduction to Highway Safety
  - 8 modules
- The Fundamentals of Highway Safety
  - 9 modules

ntavares@ite.org

July 29 and 30, 2009 22

Introduction to Highway Safety (ITE)

1. History, Perspectives and Institutionalization of Traffic Safety in the United States
2. The Es of Safety
3. Introduction to Traffic Safety Data
4. Introduction to Transportation Safety Planning
5. Introduction to Human Factors

July 29 and 30, 2009 23

Introduction to Highway Safety (ITE)

6. Introduction to The Road Environment
7. Introduction to Crash Analysis
8. Introduction to Safety Evaluation: Part I
9. Introduction to Safety Evaluation: Part II

July 29 and 30, 2009 24

The Fundamentals of Highway Safety (ITE)

1. An Introduction to Statistics in Road Safety
2. Evaluation and Application of Statistical Analysis Techniques
3. Economic Evaluations of Highway Safety Projects
4. Defining & Assessing Intersection and Roadway Segment Attributes for Safety

July 29 and 30, 2009 25

The Fundamentals of Highway Safety (ITE)

6. Selecting A Safer Intersection Type Based on Crash Histories
7. Modern Roundabouts and Intersection Safety
8. Technology-Oriented Safety Solutions: Red-Light Camera Deployment Issues
9. Roadway Departure Crashes
10. Measures to Reduce Roadway Departure Crashes

July 29 and 30, 2009 26

Thank you

genibahar@navigats.com

July 29 and 30, 2009 27

APPENDIX E: RECORDS OF DISCUSSIONS, QUESTIONS & ANSWERS

Session 2:

Question: Will the tutorial documents and other handouts be available electronically?
Answer: Yes, Tutorial page will be available on the website maintained by the U of I. We will send the website link to all attendees after the Summit.

Question: The presentation mentioned about Expected Number from similar sites, so is there any restriction to the site or choice of sites from jurisdictions?
Answer: There will be a discussion on this topic in the next session.

Question: Where will the crash rates and SPF usefulness go in the future?
Answer: First, allow SPF to compare similar sites (equal attributes, e.g. ADT) which crash rates cannot do; second, SPF will be useful for analysis of safety while crash rates can be only used for risk assessment.

Question: What is the difference between a 2-lane road and multi-lane road? How to get the capacity – ADT seems high
Answer: The speaker can send an article with a complete study.

Session 3:

Question: Crashes are usually not occurring during congestions, so how does crash relate to congestion?
Answer: To estimate the peak hour LOS, the crashes used in the SPF occurred during 24 hour period and we have a representation of congestion during the peak period. Then superpose the LOS during peak period onto the SPF to get an idea of the degree of congestion. This relationship is typical in urban environment.

Particularly in transaction periods, it is more of a speed differential issue than just congestion-related factor or an ETT-related issue. Higher degree of congestion has higher speed differential and thus results in higher accident frequency and even severity.

We are going to try to look at hourly data and hourly volume and the crashes by hourly days. So maybe next year during the meeting, I may have an answer to this question.

Question: About the values occurring in the world, how does a state agency establish a roadside hazard rating?
Answer: In the Highway Safety Manual, there are descriptors of roadside crashes, where to make breaks between levels is not a simple process. There is a general guideline partially quantitative.

Question: What are the outreach efforts for training and understanding calibration factors?
Answer: Certainly there is a training effort underway right now. Calibration is certainly an issue and there is information in the manual itself about the calibration process. It has been thought of, but if we are really going to institutionalize the Highway Safety Manual, it now is just a start of what are going to be needed.

Question: Since we are lacking intersection data, what's the impact if the intersection crashes are not removed from the segment analysis?

Answer: In Colorado, we pretty much use the area right around the intersection and filter out some crash types for intersections that may not be intersection related. Even if you do not have any data on the side road traffic, just remove those that are intersection or intersection related when analyzing segments.

You have to have a way to rational, dependable choice. Caution should be added to take 250ft buffer alone and to assume all crashes are attributed to the intersection (i.e. animal, driveway crashes).

Session 4:

Question: How many states are using SPFs?
Answer: Among the 89 attendees, 26 states have prior experience and 15 states have extensive uses of SPFs. Colorado has used it for 10 years. Colorado and Washington have used it most extensively.

Question: How are you using crash rates and SPFs?
Answer: In Washington State, crash rates are no longer being used and Colorado is similar. Crash rates are being used for informative reasons. In all other areas the state has moved away from crash rates.

Question: How do you develop SPFs for low volume, low crash local roads?
Answer: SPFs developed for other roadways have been applied to local roads.
Colorado and Washington have observed leveling off in the SPF curves.

Question: What do you do when highways begin to look like freeways but are not built in interstate standards? What SPFs would you use?
Answer: In Colorado, these facilities are still analyzed with highway SPFs. An important part of this analysis is the base conditions of the SPFs.

Presence of the at-grade intersections introduces non continuous flow performances characteristics and high speed arterial multilane safety performance function is used. The HSM has a rural multi-lane procedure, and there is also a similar freeway procedure that will become part of the manual soon. There is software completed for conducting this type of analysis.

Question: Is calibration required for SPFs developed with local data?
Answer: Calibration is conducted from year to year because the data changes year by year, therefore it will be required. Additionally Safety Analyst calibrates even SPFs developed with local data.

Question: About the Colorado model, are those percentages averages or averages plus standard deviation?
Answer: They are not averages but means of the assumed binomial distribution.

Question: Where is analysis conducted in Colorado?
Answer: In Colorado, analysis is conducted at the central office. Training is provided in Colorado DOT for other offices for all engineers.

Question: How can this methodology be pushed down to the local level, particularly to facilities that are not under state jurisdiction?
Answer: In Colorado, there is a variety of counties and cities analysis that we have done and they are trying to use that approach. In Illinois SPFs have not yet been directly applied to local

routes and there is projects developing tools. For Washington, the application of Safety Analyst worked well for local jurisdictions.

Session 5:

Question: Condition rating of pavement may drive a project, but safety performance may not be adequate--- how is this being addressed in other states? How easy is the implement of the related approach?
Answer: In Washington, we don't do safety and preservation project together. We generally do separately because the great benefit for legislatures to see.

Colorado has different approach. We have safety program $30M /year and our resurfacing program used to be $150 M, and we have a big gap. We also have some money attached to resurfacing program to deal with safety. Additionally, we have a policy directive to address safety and resurfacing issues. We do everything extensively not limited to resurfacing.

Session 6:

Question: Colorado uses LOS for safety, Illinois talking about using this or not. What is the advice in using this term?
Answer: Colorado uses “soft” language (e.g. better or less than expected safety performance) to define LOS for safety I – IV rather than use the word “hazard” or “danger” to begin with. Most safety assessment report begins with a statement of philosophy with the idea that limited funds have to be optimized.

However, some of the concepts and terms were in draft of HSM but were taken out. We found more neutral descriptors in order to keep that piece out of the manual. There is no absolute safety in HSM. We are really looking at reducing frequency and severity of crashes

In Washington, we cannot bring in cost of project (use of seat belt, maintenance) for the reason that we are not doing something. So we need to think about state specifics.

LOS for safety seemed too similar to LOS (capacity) and too coincidental, so we did not want to involve reliability issue by guarantee or promise that cannot be accomplished.

Question: Would “409” protect the agency if the crash data is publicly available?
Answer: It depends on state law. It has to be turned over unless the state law says something about it. However even though another side has it, they will not be introduced as evidence, and plan will have to get data from other sources. When turning over public records, a watermark (e.g. Washington) or stamp documents to alert user that it is protected information. We also send out protective order to protect from use in court.

States prepare safety assessment reports and it is the duty of the department to address safety within available budget (make the most with what you have). This is stated in policies and the intent is to make the most of what we have. We need to draw and line between ethical discharges of professional duty in concert with response and find appropriate balance. Totally shy away with things like potential crash reduction or maximize the crash reduction within budget available. Therefore, it is suggested each state conduct a risk assessment based on specific state terms.

There may be a problem when make decisions if there is no documentation about why the decisions are made. Good documentation should be made when you are fixing a problem in a location. Inform decisions using SPF or other statistical methods to explain decision making.

Question: If an agency adopts SPFs, is there a risk if it is not used consistently?

Answer: That's part of what we are trying to get policy and training out to make sure there is consistency. The reason we document is that decisions are questioned years after the decision is made and it is the only way to defend when assumptions have to be made and. Project file better tell the whole story.

Question: If you have a list of locations that are all under the use of terminology like "most potential safety improvement", do you set some variability or do you need a policy about how much percent to look at of the list?
Answer: It is actually advantageous that you are working on the list of locations. In some cases it does open up the agency for potential issues.

<u>Session 8:</u>

Question: Why was SA supported by AASHTOware and IHDSM by FHWA? States may have a hard time spending 45,000 per year to use SafetyAnalyst.
Answer: AASHTO is interested in SafetyAnalyst because they support HSM. SafetyAnalyst will be used by state DOTs and AASHTOware was a good mechanism for availability of the software and facilitating the long term support. You can use the highway safety improvement program to pay for the license which is an eligible expense for HSIP money.

Question: How is severity distribution determined in SafetyAnalyst?
Answer: Severity distributions are determined as part of the calibration process from state actual data. The tool accesses all crashes to get distributions for those including collision type and severity. There are separate SPFs for total crashes and fatal crashes and they are broken down further with those distributions. It is applied to the route by functional classification and area type.

<u>Session 9:</u>

Question: Do SPFs help you to make informed decisions in the program?
Answer: In Colorado when we started 10 years ago, introduction of SPFs help communicate effectively and built consensus. We felt that every level of our program makes constructive discussion and decision making. And people buy into it quickly.

In Washington, programmatic level gain consistency which has been helpful to control the roadway. The other issue we see is that the methodology has scientific components to make the public and the elective feel better about the orders of the maintenance.

Question: Decisions and evaluations like prediction of crash reduction are made, but there is trade-offs between safety and capacity. How is this addressed?
Answer: During peak periods, we don't buy the whole lot of accidents because of the high frequency. We sometimes run SynChro traffic and re-examine the storage availability. Most of time, we move toward time of day protection at intersections when changing phasing to reduce the potential reduction of capacity. We would examine these factors and make a balanced decision. If it is an existing intersection and there is a strong pattern, we got to protect.

Question: About the detailed safety analysis, is it done centrally? Do you train consultants and staff?
Answer: In Colorado, we initially and largely do it centrally but are moving away from that model. For the last year and half, we are conducting classes at DOT on the explicit

consideration of safety and highway traffic engineering in the project environment to teach people how to interpret report and how to use them. Additionally, for the last eight years, we provide a graduate course in the University of Colorado which creates consultants that understand the approaches. We also provide cross-training to staff in regions to work though the safety assessment process and they can understand the methodology well when they go back.

Question: In Colorado, you are using the same SPFs for all freeway segments, but there is a lot of variability in the segments i.e. interchanges, weaving. How are these issues dealt with? Also in IL, SPFs are based on state routes and sometimes applied to 2-lane rural roadways. If the SPF is based on higher ADT can it be directly applied in this manner as it may underestimate the number of crashes expected?
Answer: In the real world, we are dealing with a variety of situations – interchange spacing may be different, weaving sections longer/shorter more traffic, etc. It is not practical to collect all of this data and to create more specific SPFs (plus there may not be a large enough sample size for comparison). We isolate homogeneous freeway segments by removing crashes associated with interchanges and weaving sections to compare the mainline itself. We simplify the issue in such a way that we can solve the problem and make approximation of reality because we are in business of reducing crashes rather than precisely estimating crashes.

<u>Session 11:</u> (Panel Discussion)

Next steps:

- We need to do training for IDOT staff and consultants because there are agencies dependent on consultants to do a lot of work. Local agency training is needed as well.
- Local roadway data need to be enhanced
- Getting SA and incorporating HSM and all those safety tools into our safety program. Integrate the program into the entire decision making, policies, planning and design process.
- More experts and supports will be needed to within the agency in the districts
- We are trying to developing SPFs for the local system

- Virginia started looking at detailed models and have stepped back to look at ADT models.
- Virginia needs based budgeting with asset management and is trying to use estimation tools to develop more information.
- Looking at highway engineering and asset management and hopefully expand in future. First, collect all the roadway linear assets and geometry and collect from data management system to get more roadway data. Collect signing and pavement marking data, signal inventory data. Developing a state wide database is in the process now and geocoding is along the way.

- See how SPFs perform once calibrated.
- Make safety decisions on 95% of pie (Resurfacing, reconstruction, preservation, maintenance). Most benefits are from expanding the work in safety to the other portions of the department.
- Use SPF as diagnostic tools to put together Safety Assessment reports
    - Cover page
    - Legal statement about admissibility
    - Statement of philosophy Discussion of SPF calibration and LOSS
    - Provide the function for freq and severity

- Identify various attributes of crash occurrence and geometric improvements
- Suggest intersection improvements
- Conclusions: recommendation, benefit-cost ratio
- Appendix: supporting steps, analyses, collision diagrams, etc

- Keep consistency with improvements and intent

Question: What recommendations for next steps for other states?
Answer: First, Highway Safety Manual is not a perfect document and need to adapt state now. Second, start working with residency to build credibility within the department. Use in simple to understand terms to related to resident engineers to deliver your ideas. Proliferate methodology throughout the department.

Question: We have used traditional methods in the past and have used new methods now. What is the evaluation process you are using to ensure you are making the proper decisions with the methodology? What are the keys using the advanced methods versus using the traditional methods?
Answer: Evaluation process is not as rigorous as the analysis. We see substantial improvements when applying improvements based on pattern recognition. State-wide evaluation is difficult due to lots of factors. We only do evaluation at project level and committed to looking at site specific evaluations with an eye on the overall. It would be good to have more resources to conduct more Before-and-After analyses.

There has been research that shows that using these advanced methods versus using the classical methods, we do get more precise estimates.

States find it is a good amount of work to get into SafetyAnalyst, but they easily quickly be evaluated when SA has been set-up. Washington looks at after analysis with every HSIP program. As we move forward using tools that explicitly affect safety, we limit our scope to safety problems. I like the way that Colorado is doing, but I suggest thinking about broad terms like safety not safety problem as we go forward.

Question: For those states that have not developed SPFs yet, are you going to calibrate existing SPFs or develop your own SPFs?
Answer: The result is 50/50.

Question: For those states that will develop their own SPFs, what support is needed?
Answer: Probably the primary support would be funding, but technical support will be needed as well.

Question: Do you think your state will use HSIP (Colorado) to calibrate?
Answer: Yes. In Illinois, there is an option for using SPR money.

Comment: In our state, we have evaluation tool that we have used for 20-30 years, but we do not have the same analysis and we would be interested in getting data on the local system. Our major problem is that we are decentralized (11 different kingdoms within New York State and New York City). We are looking for central office to develop the tools, but we need to change the paradigm of how the tools are used.

- Some of the training courses will be very useful FHWA will look for opportunities to assist.
- In Oregon, decentralization is a huge issue. Districts control HSIP funds and there is no headquarter staff.
- Washington also have decentralized set-up.

- Colorado was on the same boat – headquarter staff was marginalized. We just started working in the safety area and began offering a service to market the ideas.
  - Colorado developed a logo to give identity and kept on expanding to provide more information in the report
  - We kept promoting the service since the gap is huge and need to be filled. We started to expand the complexity and then the number and overtime it became the expectancy of the resident engineer who makes most decision of the project. Eventually nothing is completely until the safety assessment report is completed.
  - We help the locals to system application, the methodology, etc.

Question: Is there possible resources available to seek money to get states started? Is it an option for a pooled fund to use the university experience to help states develop SPFs to address the decentralization?
Answer: FHWA will investigate these options.

Question: Is it possible to have a SPFs manual that gives details about the function in terms of data and methodology?
Answer:
- MRI has been working on these and may post on the website as they are not right now
- FHWA will take the suggestion in to consideration and make SPFs more transparent.
- Clearinghouse may be expanded for SPFs

Notes:
- Email Priscilla if you need additional information after the summit.
- Website posting - Acronym list
  - All presentations from this SPF Summit
  - Summary of discussions
  - Illinois' SPF development report (upon IDOT approval)

APPENDIX F: POST-CONFERENCE SURVEY

Attached is a copy of the post-conference survey distributed after the conference.

National 2009 Safety Performance Function Summit

Thank you for participating in the inaugural National SPF Summit. We would appreciate your opinions on the following items. Your comments will enable us to better plan and execute future SPF Summits to meet your needs.

Name (Optional):________________________________

1. Please indicate your overall satisfaction with this Summit

	Very Satisfied	Somewhat Satisfied	Neutral	Somewhat Dissatisfied	Very Dissatisfied
Registration Process	☐	☐	☐	☐	☐
Materials/Handouts	☐	☐	☐	☐	☐
Speakers/Presenters	☐	☐	☐	☐	☐
Venue/Facility	☐	☐	☐	☐	☐

If you are not satisfied with any of the above, please let us know in what ways the Summit could be improved:

2. What did you like most about the Summit and what is your most important gain from this Summit?

1/2

3. Do you plan to attend the Summit again in the near future (e.g., next year)?

☐ Yes ☐ Not

4. What kinds of sessions would you like to see included at the next Summit?

5. While developing and implementing the SPF tools in your organization, what kinds of resources and support would you like to have between now and future Summits (e.g., training, conference calls, tutorial and meetings) within your state, regionally, and nationally?

Thank you!

National SPF Summit 09 Committee