2009 NATIONAL SAFETY PERFORMANCE FUNCTION SUMMIT

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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
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.
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.
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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.](image)

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.
Experience with SPF

- **15**: SPF is my primary responsibility within my organization
- **26**: Have prior experience
- **15**: New to the field, no prior experience
- **30**: No answer

**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.

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 3. Attendee’s future plans for SPF.**
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>
<thead>
<tr>
<th>Session</th>
<th>Presentation Title</th>
<th>Speaker / Moderator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1: Opening</td>
<td>Welcome to the SPF Summit</td>
<td>Priscilla Tobias, Illinois DOT &amp; 2009 SPF Summit Chair</td>
</tr>
<tr>
<td>Session 2: History</td>
<td>From Whence Cometh the HSM? SPF History</td>
<td>Moderator: Geni Bahar, NAVIGATS Inc.</td>
</tr>
<tr>
<td></td>
<td>AASHTO Vision for Highway Safety SPF History</td>
<td>Rick Pain, TRB, John Milton, TRB, HSM Task Force Chair</td>
</tr>
<tr>
<td></td>
<td>How Did SPF Come into Being and Why Is It Here to Stay?</td>
<td>Joel McCarroll, AASHTO, Priscilla Tobias, Vice Chair AASHTO Joint Task Force for the HSM</td>
</tr>
<tr>
<td></td>
<td>Role of SPFs in the Interactive Highway Safety Design Model (IHSDM)</td>
<td>Recorder: Kim Kolody, CH2MHill</td>
</tr>
<tr>
<td></td>
<td>SPF Development in Illinois</td>
<td>Mike Dimaiuta, FHWA</td>
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<tr>
<td></td>
<td>SPF Development and Data Needs and 10 Years of Application: A Practical Approach</td>
<td>Ray Krammes, FHWA</td>
</tr>
<tr>
<td></td>
<td>Q &amp; A</td>
<td>Doug Harwood, Midwest Research Institute</td>
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<td></td>
<td></td>
<td>Yanfeng Ouyang, University of Illinois</td>
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<td></td>
<td></td>
<td>John Milton, Washington DOT</td>
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<td></td>
<td></td>
<td>Jake Kononov, Colorado DOT</td>
</tr>
<tr>
<td>Session 4: SPF</td>
<td>Virginia’s Safety Modeling Story SPF Applications for Safety Analysis in Illinois</td>
<td>Moderator: Jim Allen, Illinois DOT</td>
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<tr>
<td></td>
<td></td>
<td>Recorder: Mario Candia, Kittleson &amp; Associates, Inc.</td>
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<tr>
<td></td>
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<td>Stephen Read, Virginia DOT</td>
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<td></td>
<td>Kim Kolody, CH2MHill for Illinois DOT</td>
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<tr>
<td>Session 5: Policy Level Issues Related to Safety in the Scheme of Planning, Design and Operations, Forecasting and Prevention</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>John Milton, Washington DOT</td>
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<table>
<thead>
<tr>
<th>Session 6: Tort Liability Issues Related to Safety in the Scheme of Planning, Design and Operations, Forecasting and Prevention</th>
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</thead>
<tbody>
<tr>
<td>John Milton, Washington DOT</td>
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</table>

<table>
<thead>
<tr>
<th>Session 7: Opening Session</th>
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<tbody>
<tr>
<td>Priscilla Tobias, Illinois DOT</td>
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<thead>
<tr>
<th>Session 8: Examples of Use of Default SPFs in HSM, Safety Analyst, and Interactive Highway Safety Design Model (IHSDM)</th>
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<tr>
<td>Mike Dimaiuta, FHWA</td>
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<table>
<thead>
<tr>
<th>Session 9: Use of the State-Developed SPFs in Their Own Tools and the National Perspective</th>
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<tr>
<td>Dave Piper, Illinois DOT</td>
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<table>
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<tr>
<th>Session 10: Training Opportunities</th>
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<tr>
<td>Karen Dixon, Oregon State University &amp; Principal Investigator for the NCHRP 17-38</td>
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<table>
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<tr>
<th>Session 11: Implementation Next</th>
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<tbody>
<tr>
<td>Priscilla Tobias, Illinois DOT</td>
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</tbody>
</table>

| Moderator: Robert Hull, Utah DOT |
| Recorder on Computer and Projector: Kim Kolody, CH2MHill |
| John Milton, Washington DOT |

| Moderator: Tim Neuman, CH2MHill |
| Recorder on Computer and Projector: Kim Kolody, CH2MHill |
| John Milton, Washington DOT |

| Moderator: Ray Krammes, FHWA |
| Recorder: Kim Kolody, CH2MHill |
| Doug Harwood, Midwest Research Institute |
| Mike Dimaiuta, FHWA |

| Moderator: Priscilla Tobias |
| Recorder: Kim Kolody, CH2MHill |
| Dave Piper, Illinois DOT |

| Moderator: Geni Bahar, NAVIGATS Inc. |
| Recorder: Geni Bahar, NAVIGATS |
| Karen Dixon, Oregon State University & Principal Investigator for the NCHRP 17-38 |
| Mike Griffith, FHWA |

| Moderator: Mike Griffith, FHWA |
| Recorder: Geni Bahar, NAVIGATS |

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**SPFs Applications by State DOTs**

**CDOT: 10 Years of SPF Applications and Experience**

Facilitated Discussions

John Milton, Washington 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.” Breland 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>
<thead>
<tr>
<th>Overall Satisfaction</th>
<th>Very Satisfied</th>
<th>Somewhat Satisfied</th>
<th>Neutral</th>
<th>Somewhat Dissatisfied</th>
<th>Very Dissatisfied</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Process</td>
<td>50</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Materials/Handouts</td>
<td>41</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Speakers/Presenters</td>
<td>43</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Venue/Facility</td>
<td>41</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td>58</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Most Important Gain</th>
<th>Number of Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction and Overview of SPF’s</td>
<td>8</td>
</tr>
<tr>
<td>SPF’s in Different States</td>
<td>29</td>
</tr>
<tr>
<td>Great Presentations</td>
<td>5</td>
</tr>
<tr>
<td>National, State, Private Sector Levels</td>
<td>2</td>
</tr>
<tr>
<td>HSM, IHDSM, Safety Analyst Information</td>
<td>5</td>
</tr>
<tr>
<td>Networking Opportunities</td>
<td>3</td>
</tr>
<tr>
<td>Policy/Tort Session</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>52</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Plan on Attending Next Year</th>
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<tbody>
<tr>
<td>Yes</td>
<td>47</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Undecided</td>
<td>4</td>
</tr>
</tbody>
</table>

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

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

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

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

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.

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

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
<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Allen</td>
<td>Illinois Department of Transportation</td>
</tr>
<tr>
<td>Mario Candia</td>
<td>Kittleson &amp; Associates, Inc.</td>
</tr>
<tr>
<td>Bryan Allery</td>
<td>Colorado Department of Transportation</td>
</tr>
<tr>
<td>James Ceragioli</td>
<td>Nevada Department of Transportation</td>
</tr>
<tr>
<td>Cemal Ayvalik</td>
<td>Cambridge Systematics</td>
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<tr>
<td>James Chapman</td>
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<tr>
<td>Dennis Bachman</td>
<td>Woodford County Highway Department</td>
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<tr>
<td>Shaila Chowdhury</td>
<td>California Department of Transportation</td>
</tr>
<tr>
<td>Geni Bahar</td>
<td>NAVIGATS Inc.</td>
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<tr>
<td>Norm Cressman</td>
<td>Georgia Department of Transportation</td>
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<td>Charity Belford</td>
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<td>Mike Curtit</td>
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<td>Darryl Belz</td>
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<tr>
<td>Michael Dimaiuta</td>
<td>LENDIS Corp.</td>
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<tr>
<td>Duane Brunell</td>
<td>Maine Department of Transportation</td>
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<tr>
<td>Karen Dixon</td>
<td>Oregon Department of Transportation</td>
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<tr>
<td>Steven Buckley</td>
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<tr>
<td>Patrick Dolan</td>
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<tr>
<td>Tom Buckley</td>
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<tr>
<td>Faria Emamian</td>
<td>Oklahoma Department of Transportation</td>
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<tr>
<td>Name</td>
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<tr>
<td>Michael Fontaine</td>
<td>Virginia Department of Transportation</td>
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<tr>
<td>Terrence H. Fountain</td>
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<tr>
<td>Albert Gan</td>
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<td>Michael Gillette</td>
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<tr>
<td>Mehrdad Givechi</td>
<td>Kansas University Transportation Center</td>
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<td>David Glabas</td>
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<tr>
<td>Brelend Gowan</td>
<td>California Department of Transportation Emeritus</td>
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<td>Michael Griffith</td>
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<tr>
<td>Kevin Haas</td>
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<td>Brett Harrelson</td>
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<td>Douglas Harwood</td>
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<td>Patrick Hasson</td>
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<tr>
<td>Alan Ho</td>
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<tr>
<td>Robert Hull</td>
<td>Utah Department of Transportation</td>
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<tr>
<td>Kurt Johnson</td>
<td>North Dakota State University</td>
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<tr>
<td>W. Scott Jones</td>
<td>Utah Department of Transportation</td>
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<tr>
<td>Dean Kanitz</td>
<td>Michigan Department of Transportation</td>
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<tr>
<td>Anthony Khawaja</td>
<td>IACE</td>
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<tr>
<td>Kimberly Kolody</td>
<td>CH2M HILL</td>
</tr>
<tr>
<td>Jake Kononov</td>
<td>Colorado Department of Transportation</td>
</tr>
</tbody>
</table>
2009 National SPF Attended List

Ray Krammes  
Federal Highway Administration

Brian Murphy  
North Carolina Department of Transportation

Dale Lighthizer  
Michigan Department of Transportation

Roseanne Nance  
Illinois Department of Transportation

Ron Lipps  
Maryland State Highway Administration

Timothy Neuman  
CH2M HILL

Tracy Lovell  
Kentucky Transportation Cabinet

Chimai Ngo  
Federal Highway Association

Joel McCarroll  
AASHTO

Chuck Niessner  
Transportation Research Board

Thomas McDonald  
Iowa State University

Barbara O'Rourke  
New York State Department of Transportation

John Miller  
Missouri Department of Transportation

Yanfeng Ouyang  
University of Illinois

John Milton  
Washington State Department of Transportation

Richard Pain  
Transportation Research Board

Ian Morris  
Tennessee Department of Safety

Jawad Paracha  
Maryland State Highway Administration

Murray Mullen  
California Department of Transportation

Shaun Parkman  
Kansas Department of Transportation
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
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<tbody>
<tr>
<td>Michael Pawlovich</td>
<td>Iowa Department of Transportation</td>
</tr>
<tr>
<td>Lisa Schletzbaum</td>
<td>Massachusetts Highway Department</td>
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<td>Greg Piland</td>
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<td>Hadi Shirazi</td>
<td>Louisiana Department of Transportation and Development</td>
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<td>David Piper</td>
<td>Illinois Department of Transportation</td>
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<td>David Speicher</td>
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<td>Bonnie Polin</td>
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<td>Raghavan Srinivasan</td>
<td>University of North Carolina</td>
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<td>Stephen Read</td>
<td>Virginia Department of Transportation</td>
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<td>Esther Strawder</td>
<td>Federal Highway Association</td>
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<td>Charles Reider</td>
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<td>Frank Sullivan</td>
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<td>Rebecca Szymkowskii</td>
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<td>Cathy Satterfield</td>
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<tr>
<td>Gordon Thompson</td>
<td>New Hampshire Department of Transportation</td>
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<tr>
<td>Andrew Sattinger</td>
<td>New York State Department of Transportation</td>
</tr>
<tr>
<td>Nicole Thompson</td>
<td>Champaign County Regional Planning Commission</td>
</tr>
</tbody>
</table>
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

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- 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
- 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 5th 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 SPFIs 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.

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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).
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We acknowledge and thank Dr. Hauer for allowing us to share this excellent and user-friendly tutorial with all the participants of the 2000 National SPF Summit, Chicago, Illinois.


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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,
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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 \(\sqrt{0.1/3} = \pm 0.18\). 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, one is 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 (4, 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 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 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 weighted average. That is,

\[
\text{Estimate of the Expected Accidents for an entity} = \text{Weight} \times \text{Accidents expected on similar entities} + (1-\text{Weight}) \times \text{Count of accidents on this entity}
\]

where \(\text{Weight} \neq 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 \(\mu\), 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 \(\mu = 0.0224 \times \text{ADT}^{0.564}\) 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 0.0224×4000^{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 ‘\(v\)’. For road segments, the overdispersion parameter is estimated per-unit-length. That is, the dimension of \(v\) is [1/km] or [1/mile]. The meaning of \(v\) 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 \(0[1-0/(vL)]\). The dimensions of \(v\) and \(L\) must be complementary. That is, if in the course of model calibration \(v\) is estimated per km, then \(L\) must be measured in kilometres. Note, \(v\) estimated per km = 0.622×\(v\) 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, Bonneau 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 Dzibik (11) model accidents on freeways.

In summary we defined:

- \(\mu\): 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.
- \(v\): 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:
weight = \frac{1}{1 + (\mu \times Y) / \varphi} \quad ... 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 × ADT^{0.564} accidents/(km-year), with an overdispersion parameter \( \nu = 2.05/km \). 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 × 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 \( \mu = 2.41 \) accidents/(km-year), \( Y = 1 \) and the estimate of \( \nu = 2.05/km \). Therefore: weight = \frac{1}{1 + (2.41 \times 1) / 2.05} = 0.460. Note that both \( \mu \) and \( \nu \) 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 = 6.48 accidents in one year. Note that 6.48 is not 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:

\[ \sigma(\text{estimate}) = \sqrt{(1 - \text{weight}) \times \text{estimate}} \quad ... 3 \]

Here, \( \sigma = \sqrt{0.54 \times 6.48} = 2.14 \) accidents in one year.

Numerical Example 2: Three years of accident counts.

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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 $1.8 \times 3 \times 2.41 = 13.01$ accidents.

Step 2: Weight.
The weight is $1 / [1 + (2.41 \times 3)/2.05] = 0.220$. 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 $= 0.220 \times 13.01 + 0.780 \times (12 + 7 + 8) = 23.92$ accidents in three years with $\Phi = (0.78 \times 23.92) \pm 4.32$ or $23.92/(3 \times 1.8) \pm 4.32/(3 \times 1.8) = 4.43 \pm 0.80$ 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 0.3 m 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 $1.04 \times 2.41 = 2.51$ accidents/km-year. On 1.8 km in three years we expect $1.8 \times 3 \times 2.51 = 13.55$ accidents.

**Step 2:** Weight.
The weight is $1/[1 + (2.51 \times 3)/2.05] = 0.214$.

**Step 3:** Estimate.
Expected accidents $= 0.214 \times 13.55 + 0.786 \times (12 + 7 + 8) = 24.12 \pm (0.786 \times 24.12) = 4.35$ accidents in three years or $24.12/(3 \times 1.8) = 4.47 \pm 0.81$ 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.

```
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
```

*Figure 1*

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**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>
<thead>
<tr>
<th>Subsection</th>
<th>ADT</th>
<th>Length [km]</th>
<th>AMF</th>
<th>Accidents/(km-year)</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2000</td>
<td>0.1</td>
<td>.90</td>
<td>1.466</td>
<td>0.147</td>
</tr>
<tr>
<td>2</td>
<td>2300</td>
<td>1.2</td>
<td>.95</td>
<td>1.675</td>
<td>2.010</td>
</tr>
<tr>
<td>3</td>
<td>2300</td>
<td>0.2</td>
<td>1.05</td>
<td>1.851</td>
<td>0.370</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>2.527</strong></td>
</tr>
</tbody>
</table>

Assume that, as in the earlier examples the SPF is $0.0224 \times ADT^{0.564}$ accidents/(km-year) and $v=2.05$ 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 $=0.374 \times 5.054 + 0.626 \times 11 = 8.78 \pm ((0.626 \times 8.78) / 2.34) = 2.34$ accidents or $[8.78 \times 2.34] / (1.5 \times 2) = 2.93 \pm 0.78$ 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.

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Table 2

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

Step 2: Weight.
The weight for fatal accidents is $1/(1+0.046\times3/2.05)=0.937$ as shown in column 5. The overdispersion parameter, $\nu$ 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 $=0.937\times0.247+0.063\times1=0.295\pm(0.063\times0.295)\times0.136$ 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 $\mu$ 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 $0.295\times1.118=0.347$. 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

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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 $\mu$ is estimated by $6.54 \times 10^5 \times ADT_{\text{mainline}} \times ADT_{\text{road}}$ and the estimate of $\nu$ is 1.96. Consider such an intersection with $ADT_{\text{mainline}}=4520$, $ADT_{\text{road}}=230$, the AMF to account for differences from nominal conditions is 1.27, 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 $6.54 \times 10^5 \times 4520^{.883} \times 230^{.961} = 1.041$ accidents/year. Under the real conditions of this intersection, using the AMFs, $1.27 \times 1.041 = 1.322$ accidents/year. In the three years for which accident counts are used, $3 \times 1.322 = 3.966$ accidents.

**Step 2:** Weight.
The weight is $1/[(1+3)/1.96] = 0.331$

**Step 3:** Estimate.
Expected accidents $= 0.331 \times 3.966 + 0.669 \times 7 - 6.00 = 2.00$ accidents in three years or $[6.00-2.00]/3 = 0.67$ 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 $\mu_1$ (2.6 accidents/year), $\nu_1$ (2.2) and of $\mu_2$ (4.3 accidents/year), $\nu_2$ (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 $3 \times 2.6 + 3 \times 4.3 = 7.8 + 12.9 = 20.7$ 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 $\theta_1, \theta_2, \ldots, \theta_n$ and overdispersion parameters $\nu_1, \nu_2, \ldots, \nu_n$ and when correlation coefficient between $\theta_i$ and $\theta_j$ is $\Delta_{ij}$ then the weight should be computed by:

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weight = \frac{1}{\sum_{i=1}^{n} \eta_i^2 / \varphi_i + 2 \sum_{i=1}^{n} \sum_{j=1}^{n} \rho_{i,j} \frac{1}{\varphi_i \varphi_j} \eta_i \eta_j} \quad \ldots 4

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

When \rho_{i,j}=0, weight = \frac{1}{\sum_{i=1}^{n} \eta_i^2 / \varphi_i} \quad \ldots 5

When \rho_{i,j}=1, weight = \frac{1}{\sum_{i=1}^{n} \frac{\sqrt{\eta_i^2 / \varphi_i}}{\sum_{i=1}^{n} \eta_i}} \quad \ldots 6

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

Step 3: Estimate.
Using the simply-obtained weight of 0.088, Expected accidents=0.088×20.7+0.912×11.94×(0.912×11.94)=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.

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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 $\mu$ is estimated by $0.0224 \times ADT^{0.564}$ accidents/(km-year) and the overdispersion parameter $\nu$ 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>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>1989</th>
<th>90</th>
<th>91</th>
<th>92</th>
<th>93</th>
<th>94</th>
<th>95</th>
<th>96</th>
<th>97</th>
<th>Sums</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>ADT</td>
<td>4500</td>
<td>4700</td>
<td>5100</td>
<td>5200</td>
<td>5600</td>
<td>5400</td>
<td>5300</td>
<td>5300</td>
<td>5400</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Accidents</td>
<td>12</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>$\mu_{\text{year}}$ (accidents/(km-year))</td>
<td>2.446</td>
<td>2.506</td>
<td>2.624</td>
<td>2.653</td>
<td>2.767</td>
<td>2.710</td>
<td>2.682</td>
<td>2.682</td>
<td>2.710</td>
<td>23.781</td>
</tr>
<tr>
<td>6</td>
<td>Expected annual accident for segment</td>
<td>7.36</td>
<td>7.54</td>
<td>7.80</td>
<td>7.98</td>
<td>8.32</td>
<td>8.15</td>
<td>8.07</td>
<td>8.07</td>
<td>8.15</td>
<td>71.52</td>
</tr>
</tbody>
</table>

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:

$$\text{weight} = \frac{1}{\sum \frac{1}{\mu_{\text{year}}}} ... 7$$

August 2001
Note that equations 2 and 7 are identical when all the $\mu$s are the same. With $\nu = 2.05$ and $\Gamma \mu_{\text{year}} = 23.781$, the weight $= 1/(1+23.781/2.05) = 0.0794$.

**Step 3. Estimation.**

Now the expected number of accidents for the specific road section at hand and the period 1989-1997 is $0.0794 \times 42.846 + 0.9206 \times 74 - 71.52 = (0.9206 \times 71.52) - 8.11$. 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 $\mu_{\text{year}} / \Gamma \mu_{\text{year}}$. Thus, for 1997 the estimate is $(71.52 - 8.11) / 2170 / 23.781 = 8.15 \pm 0.92$. 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 $0.0224 \times \text{ADT}^{0.564}$ 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**

<table>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>90</th>
<th>91</th>
<th>92</th>
<th>93</th>
<th>94</th>
<th>95</th>
<th>96</th>
<th>97</th>
<th>Sums</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>Yearly Multipliers</td>
<td>1</td>
<td>0.584</td>
<td>1.053</td>
<td>1.005</td>
<td>0.996</td>
<td>0.932</td>
<td>0.931</td>
<td>0.891</td>
<td>0.927</td>
</tr>
<tr>
<td>2b</td>
<td>ADT</td>
<td>4500</td>
<td>4700</td>
<td>5100</td>
<td>5200</td>
<td>5600</td>
<td>5400</td>
<td>5360</td>
<td>5380</td>
<td>5660</td>
</tr>
<tr>
<td>3</td>
<td>Accidents</td>
<td>12</td>
<td>5</td>
<td>9</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>$\mu_{\text{year}}$</td>
<td>$\frac{\text{[accidents/\text{km-year}]}}{2.446}$</td>
<td>2.466</td>
<td>2.664</td>
<td>2.667</td>
<td>2.736</td>
<td>2.526</td>
<td>2.497</td>
<td>2.390</td>
<td>2.553</td>
</tr>
<tr>
<td>6</td>
<td>Expected annual accident for segment</td>
<td>7.58</td>
<td>7.64</td>
<td>8.56</td>
<td>8.26</td>
<td>8.54</td>
<td>7.83</td>
<td>7.74</td>
<td>7.40</td>
<td>7.79</td>
</tr>
</tbody>
</table>

**Numerical Example 10 - Projection.**

The focus so far was on estimating what the expected accident frequency was for some year

August 2001
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 \( \text{AADT}_{1997}=5400 \) 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 \((0.9 \times 6000^{0.564})/(0.927 \times 5400^{0.564})=1.030\) and for 2002 it is \((0.92 \times 6300^{0.564})/(0.927 \times 5400^{0.564})=1.083\). Therefore for 2003 we project 7.79×1.030=8.02 accidents and for 2002 we project 7.79×1.083=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 accident 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


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, AAAWA, and CVSA) have all adopted this goal of 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 SHSG
  • Research

July 29 and 30, 2009
Chicago, Illinois
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

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Jim McDonnell
jimm@aashto.org

July 29 and 30, 2009
Chicago, Illinois
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

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: 3 years of data
    - Before: 12 crashes; After: 0 crashes
    - Thus: [(12-0)/12] x 100 = 34% decrease in crashes

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?

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

25-Period Crash Counts on a Non-Treated Site

Poison-distributed counts: Average of 4.23 crashes/period
**California Rural Stop-controlled Untreated Intersections**

| Intersection with physical 
<table>
<thead>
<tr>
<th>Uncontrolled intersections</th>
<th>Crash rate Intersections</th>
<th>Crash rate Uncontrolled</th>
<th>Crash rate</th>
<th>Crash rate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>1.0</td>
<td>0.80</td>
<td>1.33</td>
</tr>
</tbody>
</table>

**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.

**Introducing Traffic Volumes**

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

**Crash Rate = Crash/exposure**

**Crash Frequency**

- Exact same data - a different graphical presentation

**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.
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

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

EB Methodology

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

Typical SPFJs

- SPFJs 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
- SPFJs are representative of the jurisdiction data used for their development

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?
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
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Safety Performance Function Development

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  - Provides equation so \( y (=\text{crash}) \) value may be predicted from \( x (=\text{AADT}) \) 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

Typical SPF

- SPF 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
- SPF are representative of the jurisdiction data used for their development

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?
Comparison between sites and highway facility types

Some References
- "Observational Before-After Studies in Road Safety" by Hauer (1997)

Where are we now?
- Preparing data
- Developing own jurisdictional SPF
- Calibrating base SPF for each jurisdiction using calibration process (HSM Part C)
- Using own applications and/or national tools such as: HSDM, Safety Analyst, and HSM
- Developing and deploying training

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

Thank you
genibahar@navigats.com

July 29 and 30, 2009
Chicago, Illinois
Rule 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

SPFs in Part C – Predictive Method

<table>
<thead>
<tr>
<th>HSM Chapter</th>
<th>Undiscounted Existing Segments</th>
<th>Undiscounted Future Segments</th>
<th>Intersections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Step Control on Place (3-legged)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-leg</td>
</tr>
<tr>
<td>19 – Rural Two-Lane Roads</td>
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<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>31 – Rural Multilane Highway</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12 – Urban and Suburban Multilane Highway</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Summary Data Needs for SPF Application

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

Application of SPFs in Part C

- 3.5-mile rural two-lane
- Tangent roadway segment
- 10,500 VPD/day
- 1% grade
- Local calibration factor = 1.10

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

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Predictive Method Sample Application

Step 1 - Base Conditions Estimate ($N_{base}$)

$$N_{base} = \frac{A \cdot D \cdot T \cdot L}{1,205 \times 365 \times 4 \times 10^3}$$

$$= \frac{10,000 \times 365 \times 10^3}{4 \times \times 1,205 \times 365 \times 4 \times 10^3}$$

$N_{base} = 4$ crashes/year

Step 2 - Estimate Predicted Average Crash Frequency

$$N_{predicted} = N_{base} \times 1.38 \times 4 \times 1,107$$

$N_{predicted} = 8$ crashes/year

Safety Performance Functions in Part B - Roadway Safety Management

SPFs and Part B - Roadway Safety Management

Chapter 4 - Network Screening

1. Drafted Plan
2. Select Target and Evaluate
3. Select Performance Measure
4. Select Screening Method
5. Screen & Evaluate Results

Chapter 4 - Network Screening

- Excess Predicted Average Crash Frequency
  Using SPFs

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Chapter 7 – Economic Appraisal

- Estimate Crash Reduction on Suburban Arterial Intersection

Estimate Crash Reduction

- Predicted Crashes - INTERSECTION
  - Predict future crash frequency with SPF
  - Data needs: SPF, 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 SPF to account for alternate conditions (Roundabout)
  - Data needs: AMFs for alternate condition

Estimate Monetary Benefit

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

<table>
<thead>
<tr>
<th>Crash Severity</th>
<th>Comprehensive Crash Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality (1)</td>
<td>$8,000,000</td>
</tr>
<tr>
<td>Severe Injury (2)</td>
<td>$150,000</td>
</tr>
<tr>
<td>Moderate Injury (3)</td>
<td>$75,000</td>
</tr>
<tr>
<td>Minor Injury (4)</td>
<td>$50,000</td>
</tr>
<tr>
<td>Property Damage (5)</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

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 E8 Method Application

SPFs in Part C – Predictive Method

SPFs, including SPF, are methods used to estimate the expected number of crashes based on traffic volume and other factors. SPF calculations help in making informed decisions about traffic safety interventions. SPF models can be used to predict the number of crashes that might occur after implementing a safety improvement project.
Predictive Method Sample Application

Step 3 – Estimate Expected Average Crash Frequency

\[ N_{\text{expected}} = w \times N_{\text{predicted}} + (1 - w) \times N_{\text{known}} \]

\[ N_{\text{expected}} = 0.507 \times 6.084 + (1 - 0.507) \times 10 \]

\[ = 8 \text{ Crashes/year} \]
Role of SPFs in the Interactive Highway Safety Design Model (IHSDM)

Mike Dimaiuta
LENDIS Corporation

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

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

Evaluation Modules (2008 Public Release)
- Policy Review
- Crash Prediction
- Design Consistency
- Intersection Review
- Traffic Analysis
- Driver/Vehicle

Crash Prediction Module Scope
- Estimates expected crash frequency based upon roadway geometry and traffic volumes

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

July 29 and 30, 2009
Chicago, Illinois
The 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

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

\[ N_{predicted} = N_{obs} \times \left( \text{AME}_1 \times \text{AME}_2 \times \ldots \times \text{AME}_n \right) \times c \]

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

CPM SPF are a function of...

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

SPFs - Highway Types

<table>
<thead>
<tr>
<th>Highway Segments</th>
<th>2L</th>
<th>MR</th>
<th>U/SA</th>
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<tbody>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2-lane divided (2D)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3-lane w/TW/LT (3T)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4-lane undivided (4U)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4-lane divided (4D)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5-lane arterial w/TW/LT (5T)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

SPFs - Collision Types

<table>
<thead>
<tr>
<th>Highway Segments</th>
<th>2L</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (all collision types)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Multi-vehicle, non-driveway</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-vehicle</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-veh., driveway-related</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle-pedestrian</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle-bicycle</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Adjustment factors only

July 29 and 30, 2009
Chicago, Illinois
### SPF - Crash Severities

<table>
<thead>
<tr>
<th>Highway Segments</th>
<th>2R</th>
<th>MR</th>
<th>U/S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fi</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fi (no &quot;C&quot;)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDO</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Multi-Vehicle (non-driven), Single Vehicle, Multi-Vehicle (driven-pedestrian-related)

### SPF - Intersection Types

<table>
<thead>
<tr>
<th>Intersections</th>
<th>2R</th>
<th>MR</th>
<th>U/S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3-lag STOP-control on minor</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3-lag Signalized</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4-lag STOP-control on minor</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4-lag Signalized</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1. No specific here conditions and no AHPs; only applicable for generalized predictions

### SPF - Collision Types

<table>
<thead>
<tr>
<th>Intersections</th>
<th>2R</th>
<th>MR</th>
<th>U/S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (all collision types)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Multi-vehicle</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-vehicle</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle-pedestrian</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle-bicycle</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. SPF for signalized intersections, adjustment factor for stop-controlled
2. Adjustment factor only

### SPF - Crash Severities

<table>
<thead>
<tr>
<th>Intersections</th>
<th>2R</th>
<th>MR</th>
<th>U/S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>X</td>
<td>X</td>
<td>X^1</td>
</tr>
<tr>
<td>Fi</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fi (no &quot;C&quot;)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDO</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Multi-Vehicle, Single Vehicle (all intersection types)

### CPM Data Needs

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

### CPM Data Needs - Segments

<table>
<thead>
<tr>
<th>ALIGNMENTS</th>
<th>2R</th>
<th>MR</th>
<th>U/S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (curves not needed)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grades (VC’s not needed)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Multi-Vehicle, Single Vehicle (all intersection types)

---

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Chicago, Illinois
### CPM Data Needs - Segments

<table>
<thead>
<tr>
<th>GENERAL</th>
<th>2R</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AADT</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Area Type</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Speed Designation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional Class</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CROSS-SECTION</th>
<th>2R</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Slope (5.5 E)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through Lane</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Lanes</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- Lane Type (2R, MR, U/SA)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- Passing/lane (2R)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulders</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overlap</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

### CPM Data Needs - Segments

<table>
<thead>
<tr>
<th>ROADSIDE</th>
<th>2R</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driveway Density</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driveway Locations/Types</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadside Hazard Rating</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side Slopes</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-Street Parking</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadside Fixed Object Density</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER</th>
<th>2R</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Speed Enforcement</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Centerline Rumble Strip</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CPM Data Needs - Intersections

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

<table>
<thead>
<tr>
<th>RTOR (approach prohibited)</th>
<th>2R</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Turn Signal Phasing</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Red Light Camera</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian Volume (all legs)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Lanes Crossed by Peds</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus Stops w/in 1000’</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School w/in 1000’</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol Sales Estab. w/in 1000’</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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CPM Data Needs - Crash History

<table>
<thead>
<tr>
<th>CRASH HISTORY DATA (Optional)</th>
<th>ZR</th>
<th>MR</th>
<th>U/SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment-related Crashes</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Intersection-related Crashes</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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

Future Plans

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

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

July 29 and 30, 2009
Chicago, Illinois
Role of SPF in SafetyAnalyst

Ray Krammes
Federal Highway Administration

FHWA Tools Supporting Implementation of the HSM

<table>
<thead>
<tr>
<th>HSM Part</th>
<th>Supporting Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>B: Roadway Safety Management Process</td>
<td>SafetyAnalyst</td>
</tr>
<tr>
<td>C: Predictive Methods</td>
<td>IHSDM</td>
</tr>
<tr>
<td>D: Accident Modification Factors</td>
<td>CRF/AMF Cleaninghouse</td>
</tr>
</tbody>
</table>

Relationship among HSM, SafetyAnalyst and IHSDM

<table>
<thead>
<tr>
<th>HSM</th>
<th>Level of Analysis</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part C – Predictive Methods</td>
<td>Specific Roadway (Project-Level)</td>
<td>IHSDM</td>
</tr>
</tbody>
</table>

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

Relationship between the HSM and SafetyAnalyst

<table>
<thead>
<tr>
<th>HSM Chapter</th>
<th>SafetyAnalyst Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project</td>
<td>1. Project Screening</td>
</tr>
<tr>
<td>2. Design</td>
<td>2. Design Screening</td>
</tr>
<tr>
<td>5. Predictive Analyses</td>
<td>5. Predictive Analyses</td>
</tr>
</tbody>
</table>

Use of SPF 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 SPF

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**SPFs in Safety Analyst**

- 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 TxDOT and P&I accident data
  - Calibration procedures available to account for local conditions
  - User-defined SPFs may be input

---

**Intersection SPFs in Safety Analyst**

**RURAL**

- 3-lag with:
  - minor-road STOP
  - all-way STOP
  - signal control

- 4-lag with:
  - minor-road STOP
  - all-way STOP
  - signal control

**URBAN**

- 3-lag with:
  - minor-road STOP
  - all-way STOP
  - signal control

- 4-lag with:
  - minor-road STOP
  - all-way STOP
  - signal control

---

**Safety Analyst Data Requirements**

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

---

**Roadway Segment SPFs in Safety Analyst**

**RURAL**

- Two-lane
- Multi-lane
- Undivided
- Divided
- Freeway
- Within interchange area
  - 4 lanes
  - 6 lanes
  - 8 lanes

**URBAN**

- Two-lane
- Multi-lane
- Undivided
- Divided
- Freeway
- Within interchange area
  - 4 lanes
  - 6 lanes
  - 8 lanes
  - 10 lanes

---

**Ramp SPFs in Safety Analyst**

**RURAL**

- Diamond
- Offset ramp
- On-ramp
- Off-ramp
- Free-Flow Loop
- Direct or semidirect connection

**URBAN**

- Diamond
- Offset ramp
- On-ramp
- Off-ramp
- Free-Flow Loop
- Direct or semidirect connection

---

**Roadway Segment Inventory Data**

- Segment number
- Segment location (linkable to accident data)
- Segment length (mi)
- Area type (rural/urban)
- Number of through 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/interstate)
- ADT (veh/day)
- Within interchange area (freeways only)

---

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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)

**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)

**Accident 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)

**For More Information about Safety Analyst**
- 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

**Safety Analyst Modules**
- Module 1 - Network Screening
- Module 2 - Diagnosis and Countermeasure Selection
- Module 3 - Economic Appraisal and Priority Ranking
- Module 4 - Countermeasure Evaluation

**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

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Chicago, Illinois
Module 1 - Network Screening

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)

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

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

Module 3 - Economic 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 F1 accidents reduced
- Number of F5 accidents reduced

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

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

---

July 29 and 30, 2009
Chicago, Illinois
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:
\[ N = \exp(a + b \times \ln(\text{AADT})) \times C \]

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?
\[ C = \text{Sum of observed crashes} / \text{Sum of predicted crashes} \]
Calibration in **Safety Analyst**

- 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?

**Safety Analyst SPF** with calibration factor:

\[ N = \exp(a + b \times \ln(\text{AADT})) C \]

---

Data Needs for Calibration of **Safety Analyst**

- Site characteristics
- Crash frequencies
- All needed data are mandatory variables in the Safety Analyst data set.

Calibration in HSM Part C

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

\[ N_{\text{predicted}} = N_{\text{ref}} \times (AMF_1 \times AMF_2 \times \ldots \times AMF_n) \times C \]

---

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 sample 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

---

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Chicago, Illinois
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
SPF Development in Illinois

Yauking C. Onwug
Department of Civil & Environmental Engineering
University of Illinois at Urbana-Champaign

Outline
- Background
  - Methodology review
  - SPF Development in Illinois
  - Data preparation
  - SPF's development
- SPF Applications
  - Kim Kelley, Session 6
- Use of SPF and PSI Values
  - (David Pimp, Session 7)

Background
- Safety performance functions (SPF)
  - Descriptive statistical relationship between crash count and contributing factor (e.g., traffic volume)

Model Specifications
- Lognormal Regression Models
  - Lognormal distribution
  - Ordinary least squares estimation

- Logit Regression Models
  - Logistic models
  - Discrete, binary outcomes
  - Logistic distribution (variance = 1/mu)
  - Negative binomial models
  - Overdispersed distribution
  - Overdispersion parameter, k
  - Maximum likelihood estimation

Explanatory Variables
- Quantitative
  - Values that represent a condition, characteristic, or quantity
  - Can be directly entered into SPF
  - E.g., AADT, lane width, # lanes, etc.

SPF Types
- Level I SPF
  - Determine crash count based only on traffic volumes (AADT)
  - From past studies, AADT has the largest impacts on crashes
  - \( E(\lambda) = \beta_0 AADT^\beta_1 \)
  - \( E(\lambda) = \beta_0 (AADT_{avg})^\beta_1 \) (AADT_{avg})

- Level II SPF
  - Multivariate analysis that explicitly includes other variables
  - Can be used for education and enforcement purposes
  - \( E(\lambda) = \beta_0 \log(\text{AADT}) + \beta_1 \log(AADT_{avg}) + \beta_2 \log(AADT_{avg})^2 + \cdots + \beta_k \log(AADT_{avg})^k \)
Data Preparation
- Required fields in the Input Data:
  - Survey Number, Engineering Design, Building Design, AADT, AADT Year, Road Name, Segment Length, Road Functional Class, County Name, Township/Countyship Name, Duo Group, Matched Control (C, A, B, and B)

SPF Development Example
- Segments:
  - Functional form: \( R \) is (Seg Length), \( \alpha \), \( \beta \), \( \gamma \)
  - Maximum Likelihood Estimation (MLE) in SAS
  - Estimation for 12 seg groups and four severity types (A, B, C, and D + C + D)

PSI Calculation
- Weighted PSI (Potential for Safety Improvements):
  - PSI = how much the safety performance will change the expectation
  - Required Regression (RR) Method: Find a weighted average of the predicted and observed numbers of crashes
  - Default values of weights: Field P, (2), Injury-A (1), and Injury-B (5)

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

Process Automation

Other Related Work
- Multivariate SPF development
- Implementation of SPF in local safety tools
- Utilization and applications of SPF:
  - (E. Kolb, Session 6)
  - (D. Piper, Session 7)
SPF Development and Data Needs

Washington State Department of Transportation

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

Overview

- Why SPFfs?
- Model Development (Frequency vs. Severity)
- Data Collection
- Model Specification Issues
  - Homoskedasticity
  - Regression to the Mean
  - Omitted Variable Bias
- Transferability
  - Cost/Lowest Unit Cost

Why SPFfs?

- 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

Staff

| University of Washington |

Data

| Most data readily available |
| Potential additional sources |
| - Traffic 1 |
| - Streets 1 |
| Ongoing statewide roadside data collection |
| Data needs: primarily intersection ADT for minor roads (will require use of non-violent funds) |

Data in Washington

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

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Chicago, Illinois
Development of SPFs in WA State

- Homogeneous 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 Homogeneous 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
      - Same 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 ITM!
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.
CDOT SPF Development and 10 Years of Application

A Practical Approach

Jake Kononov, P.E. Ph.D.
Bryan K. Allen, P.E.

In Order to Manage Safety Effectively,
We Need to be Able to Measure it

How To Measure Safety?

Accident Rate is Still the Most Common Measure of Safety

Rate = \#Acc \times \frac{1,000,000}{AADT \times 365 \times Length}

Let’s Examine Its Application...

Before Gambling
Average Rate = 2.28

Highway Alignment and Typical Cross-Section have not Changed

After Gambling
Average Rate = 1.24
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.

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%

Between 1990 and 2004
AADT increased from 36,011 to 77,680
Total accident rate increased by 146%
Injury and fatal rate increased by 50%

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.
This Relationship is Reflected by Safety Performance Function (SPF)

Calibration of Safety Performance Functions in Rural and Urban Environments

Rural Mountainous 2-Lane Highway LOSS/SPF Graph

Rural 2-Lane Highway
The following assumptions typical of the urban freeway environment were used to estimate LQI boundaries:

- DHV (Design Hourly Volume) = 16% of AADT for AADT < 130,000
- DHV (Design Hourly Volume) = 8% of AADT for AADT > 130,000
- PHF (Peak Hour Factor) = 0.8
- %Truck during peak period = 2%
- Terrain – Level
- Lane Width = 12 ft
- Shoulder Width ≥ 6 ft
- Interchange spacing = 1 Interchange/Mile
Sigmoid Or Dose-Response Curve

Relationship Between the Number of Lanes and Safety
Number of Lanes and Conflict Points

- 4-Lane Freeway
  - (2 Potential Conflicts)

- 6-Lane Freeway
  - (7 Potential Conflicts)

- 8-Lane Freeway
  - (16 Potential Conflicts)

\[ C_p = f(n) = n(n-1) \]
\[ C_s = f(n) = n(n-1) + \frac{n!}{2(n-3)!}(n-3-1) \]

As the Number of Lanes Increases, the Degree of Freedom for Things to go Wrong also Increases.
9 is Less Than 30

Safety Performance of Signalized Intersections

Jake Kononov, P.E., Ph.D.
Bryan K. Allensy, P.E.

26 Year Old Male
164 Lbs
Blood Pressure
Diasatic
Systolic

Does he have Hypertension?

43 Year Old Male
254 Lbs
Blood Pressure
Diasatic
Systolic

Does he have Hypertension?

Does anyone here have Training in Internal Medicine or Cardiology?

Urban
4 Leg
6-Lane
Signalized
Fully Actuated
Mast Arm Signal Layout
Lighted
Virginia’s Safety Modeling Story

Outline
1. Past Initiatives
   - SHSP given causal studies & regional issues
2. Present Initiatives
   - HSM and Safety Analyst preparation
3. Future Efforts
   - SPF modeling refinements and comparisons

SHSP and Action Planning

Deaths and Injury Crashes by Synchro or Line/Phase

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
- Choice & key intersections
- Collected data in 43 intersections from four sources:
  - Signal files (traffic volume by vehicle movement and left turn signal phase)
  - MDOT files (signal phase changing plan and times of day)
  - Crash DB (crash and vehicle data)
- 43 sites – approaches were 14% split, 21% perp, 3% combinations, 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)
- Created 9 subgroups based on crash patterns & TOD

Intersection SPF Development

The end result was a model for SPF in Virginia:

\[ \hat{A} = \hat{E}(e^\hat{a}) \]

\[ \hat{a} = -3.8355 + 0.7796 \log(PF_{\text{perp}}) - 0.9886 \log(PF_{\text{split}}) \]

\[ \hat{a} = -3.4156 + 0.9258 \log(PF_{\text{perp}}) - 0.7068 \log(PF_{\text{split}}) \]

\[ \hat{a} = -3.2155 + 0.8783 \log(PF_{\text{perp}}) - 0.7289 \log(PF_{\text{split}}) \]
Virginia’s Safety Modeling Story

Outline
1. Past Initiatives
   - SHSP given causal studies & regional issues
2. Present Initiatives
   - HSM & Safety Analyst preparation
3. Future Efforts
   - SPF modeling refinements and comparisons

Previous SPF Development:
Regional Issues & SHSP
Safety Evaluation Procedure for
Signalized Intersections in NOVA District

Objective
- Traffic control – phasing of protected vs. permitted
- Choice & leg intersections
- Collected data at 43 intersections from three sources:
  - Signal logs (traffic volume by vehicle movement and left turn signal phasing)
  - SCDOT (signal phase changing plan and time cycles)
  - Crash DB (crash and vehicle data)
- 43 split – approaches were 14% prd, 21% prm, 5.5% 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)
- Inverted
- Created 9 subgroups based on 3 crash patterns & TOD

Intersection SPF Development

\[
A = e^{(a + b \cdot \log(\text{Flow} \cdot \text{Prm}) - c \cdot \text{Flow} \cdot \text{Prm})}
\]
The Safety Performance Function of an Intersection can be viewed mathematically as a 3-Dimensional Response Surface, where:

\[
\text{# Crashes/Year} = f(\text{ADT}_{\text{Mainline}} \text{ADT}_{\text{Side Road}})
\]
Virginia's Safety Modeling Story

Outline
1. Past Initiatives
   - SHSP given causal studies & regional issues
2. Present Initiatives
   - HSM and Safety Analyst preparation
3. Future Efforts
   - SPF modeling refinements and comparisons

SHSP and Action Planning

Deaths and Injury Crashes by Synchro Score Lane/Mileage

Previous SPF Development:
Regional Issues & SHSP
Safety Evaluation Procedure for
Signalized Intersections in NAVA District

Purpose and Data
- Traffic Control - phasing of protected vs. permitted
- Double & leg intersections
- Collected data in 43 intersections from three sources:
  - Synchro (traffic volume, vehicle movement and left-turn signal phase)
  - METRAX (signal phase changing plan and time study)
  - Crash DB (crash and vehicle data)
- 43 sites - approaches were 16% yield, 21% perp, 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 (PAM peak, PM peak, mid-day & evening (PAM))
- Created 9 subtypes based on 3 crash patterns & TDD

Intersection SPF Development

The Fitted Poisson regression model (vs. TDD) is specified as:

\[ A = \beta_0 e^{-0.275 TDD} \]

\[ A = \beta_0 e^{-0.275 TDD} - \beta_1 TDD e^{-0.275 TDD} \]
**Intersection Analysis**
- Deliberative
  - Etiology
  - Usurpable
- Issues
  - Matching directions between crash files and Synchro files
  - Small sample sizes
  - Manual matching into the spreadsheet
- Potential: When signal database containing Synchro files is correlated with crash database, all of the above issues would be resolved.

**SHSP Driven Safety Action Plans**
**Crash Causal Factors for High Risk Two-lane Highways**
- Predominant factors on high crash segments
  - From 230 (8 to 10 mi) sites choose 144 to collect detailed crash, traffic and geometric data
  - Evaluated 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 OGM – 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
  - Total Crashes: $0.058 \times \text{AADT} + 0.764 \times \text{Length} = 2.245 \times \text{Passing Allowed} - 0.966 (\text{p-value})$
- Urban Primary
  - Total Crashes: $0.058 \times \text{AADT} + 0.764 \times \text{Length} = 2.245 \times \text{Passing Allowed} - 0.966 (\text{p-value})$
- Urban Secondary
  - Total Crashes: $0.044 + 0.049 \times \text{Op Speed} - 0.0051 \times \text{AADT}$
  - $0.044 + 0.049 \times \text{Op Speed} - 0.0051 \times \text{AADT}$

**SHSP Driven Safety Action Plans**
**Crash Causal Factors for High Risk Multi-lane Primary Highways**
- Predominant factors on high crash segments
  - From 306 (1 to 2 mi) sites choose detailed crash, traffic and geometric data
  - Evaluated signalized intersection crashes (using 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 OGM – 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

http://www.transportation.virginia.gov/
http://www.highway.tamn.texas.gov/shsp/SPF/1-1.pdf
Two-Lane Highway Data

<table>
<thead>
<tr>
<th>AREA</th>
<th># DT LOC/MNT</th>
<th>LENGTH (km)</th>
<th>REGION</th>
<th># DT LOC/MNT</th>
<th>LENGTH (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>176.2</td>
<td>504.6</td>
<td>Northern</td>
<td>174.5</td>
<td>495.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Central &amp; Southern</td>
<td>117.7</td>
<td>303.0</td>
</tr>
<tr>
<td>Rural</td>
<td>153.5</td>
<td>483.7</td>
<td>Northern</td>
<td>167.8</td>
<td>476.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Central &amp; Southern</td>
<td>116.4</td>
<td>301.5</td>
</tr>
</tbody>
</table>

Two-Lane Highway SPF Models

\[ \text{crashes} = e^a \cdot \text{AADT}^b \cdot \text{segment length} \]

<table>
<thead>
<tr>
<th>AREA</th>
<th>(a)</th>
<th>(b)</th>
<th>(k)</th>
<th>(R^2)</th>
<th>(R^2 (adj))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>6.158</td>
<td>0.811</td>
<td>1.148</td>
<td>35.6%</td>
<td>32.5%</td>
</tr>
<tr>
<td>Rural</td>
<td>5.721</td>
<td>0.740</td>
<td>0.957</td>
<td>34.6%</td>
<td>31.0%</td>
</tr>
<tr>
<td>Urban</td>
<td>6.191</td>
<td>0.814</td>
<td>1.128</td>
<td>35.5%</td>
<td>32.2%</td>
</tr>
<tr>
<td>Rural</td>
<td>5.684</td>
<td>0.812</td>
<td>0.981</td>
<td>34.0%</td>
<td>9.3%</td>
</tr>
</tbody>
</table>

Two-Lane Highway SPF Models

- Developed OLM – NB models based on four years average AADT for
  - Total Crashes
  - F
- Issues
  - Defining Traffic Volumes
  - Secondarys counted every 5 years
  - Understanding of roadway inventory for systematic definition of intersections, cross-section, and traffic volume by LRI6 segments
  - Attempting regional level models (results TBD)

Planning Level SPF

- 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 SPF to 2-3 mile sections of road

Planning Level SPF

- Project Goals
  - Develop SPF to identify 2-3 mile long sections of road for more detailed analysis
  - Help to identify longer sections where a safety assessment (real or co-funded set of improvements may be beneficial
- Summary of Approach
  - SPF to aggregate intersections and segments together (e.g. separate intersections and segment SPF)
  - Using data from 2003 to 2007 on Virginia's primary system to develop SPF as a test case
  - 739 miles of road and almost 100,000 total crashes
  - Different models for distinct regions of the state: greater DC suburbs, western mountains, and central-eastern urbanized area
Planning Level SPFs

Crashes = \( e^{a \cdot (ADT)^b \cdot (Length)} \)

- SPF breakdown:
  - Use same model form as SafetyAnalyst
  - SPFs for all crashes and fatality
  - SPFs for rural/urban

- Geometric categories:
  - 2 lanes
  - Multi-lane crossroad
  - Multi-lane divided – not access controlled
  - Multi-lane divided – access controlled

Overview of Data for Planning SPFs

<table>
<thead>
<tr>
<th>SPF Category</th>
<th>Centerline Miles</th>
<th>Links</th>
<th>Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Two-Lane</td>
<td>4529.3</td>
<td>11591</td>
<td>36,930</td>
</tr>
<tr>
<td>Rural Multilane Divided</td>
<td>1327.57</td>
<td>4110</td>
<td>28,250</td>
</tr>
<tr>
<td>Rural Multilane Undivided</td>
<td>255.91</td>
<td>1039</td>
<td>4176</td>
</tr>
<tr>
<td>Rural Limited Access</td>
<td>192.23</td>
<td>312</td>
<td>1065</td>
</tr>
<tr>
<td>Urban Two-Lane</td>
<td>261.68</td>
<td>172</td>
<td>8095</td>
</tr>
<tr>
<td>Urban Multilane Divided</td>
<td>447.94</td>
<td>3543</td>
<td>69,868</td>
</tr>
<tr>
<td>Urban Multilane Undivided</td>
<td>105.51</td>
<td>881</td>
<td>12,005</td>
</tr>
<tr>
<td>Urban Limited Access</td>
<td>179.21</td>
<td>593</td>
<td>7361</td>
</tr>
<tr>
<td>Totals</td>
<td>7,338.23</td>
<td>23,370</td>
<td>169,464</td>
</tr>
</tbody>
</table>

Future Initiatives: SPF Refinements

- In Virginia, we can identify some segments on intersections every year.
  - Thus, the more complex models need to be evaluated and implemented.
  - We can connect panel data to a seemingly single-year data (cross-sectional)
  - Category of existing data over years.

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 was found.
  - In dispersion parameter, cross-sectional models for some subtypes significantly underestimated dispersions.

Sub-category SPF Model Differences

- Urban & Routed Two-Way Step Intersections:
  - Panel Model: \( I^2 \cdot (I - v) \cdot Crash \)
  - Cross-Sectional Model: \( I^2 \cdot (I - v) \cdot Crash \)

  - Where \( v = 1 / (1 + 4 \cdot I \cdot Crash) \)
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.
SPF Applications for Safety Analysis in Illinois

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

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)

Timeline to SPFs

2005 2006 2007 2008 2009

Year for First Percent Report

SPF and Weighted PSI

To determine high priorities

Weighted crashes/mi and weighted crash/MEV by peer group

To determine high priorities and all state route locations

Implementing SPFs

- Evolving to the latest procedure
  - 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

State System Performance

- Intersections - 8 peer groups
  - Over 47,000 intersections analyzed
- Segments - 12 peer groups
  - Over 69,000 analysis segments total (16,077 miles)
  - More complicated process

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

July 29 and 30, 2009
Chicago, Illinois
Unique PSI Values: Segments

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

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).

100 Percent List

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

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 149(c)(4)(D)]."

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

FIVE PERCENT Segments

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

July 29 and 30, 2009
Chicago, Illinois
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

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.

---

The national SPF SUMMIT 2009

July 29 and 30, 2009
Chicago, Illinois
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

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

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

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
SPF Applications for Safety Analysis in Illinois

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

SPF Applications for Safety Analysis in Illinois

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

Thank you

Kim.Kolody@ch2m.com
773-693-3800x245
SPFs Applications by State DOTs

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
<table>
<thead>
<tr>
<th>Development of SPFs in WA State</th>
<th>Development of SPFs in WA State</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Over time WSDOT moved from a focus on all severity collision to fatal and serious</td>
<td>• Rural two lane highways early development in 1994</td>
</tr>
<tr>
<td>• With interstate development use Data Envelopment Analysis to allow for modifications of policies within program needs</td>
<td>• Previously used critical rate solely</td>
</tr>
<tr>
<td></td>
<td>• Used negative binomial estimation</td>
</tr>
<tr>
<td></td>
<td>• Homogeneous sections</td>
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<tr>
<td></td>
<td>• Entire rural highway systems for collectors, minor arterials and principle arterials with East/West split.</td>
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<table>
<thead>
<tr>
<th>Development of SPFs in WA State</th>
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<tbody>
<tr>
<td>• Rural two lane highways</td>
<td>• Interstate highways</td>
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<td></td>
<td>• Large Data Set</td>
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<td></td>
<td>• Geometric</td>
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<td>• Traffic</td>
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<td>• Crash</td>
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<td></td>
<td>• Weather</td>
</tr>
<tr>
<td></td>
<td>• Hierarchical Bayes</td>
</tr>
<tr>
<td></td>
<td>• Used to analyze entire network</td>
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<td></td>
<td>• Data Envelopment Analysis to allow for flexibility in policy</td>
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<table>
<thead>
<tr>
<th>Development of SPFs in WA State</th>
<th>Development of Severity SPFs in WA State</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rural Multilane</td>
<td>• Multilane divided highways</td>
</tr>
<tr>
<td>• Refinement of two-lane models</td>
<td>• Using multinomial, nested and mixed logit estimation</td>
</tr>
<tr>
<td></td>
<td>• Mixed Logit offered flexibility</td>
</tr>
<tr>
<td></td>
<td>• Allows for estimation of coefficients and variance</td>
</tr>
<tr>
<td></td>
<td>• Developed utility functions (SPFs) for PDO, Minor and Major Injury</td>
</tr>
<tr>
<td></td>
<td>• Future to incorporate full roadside database</td>
</tr>
</tbody>
</table>
Future Relationships to HSM, Safety Analyst and IHSDM

- WSDOT intends to adopt the tools consistent with current WSDOT Policy that prefers SFPs
- 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 SFPs as an important element
- Severity Models using Roadside Features will occur

Lessons from Past Experience

- SFPs can improve efficiency of expenditures
- SFPs are currently available with HSM, Safety Analyst, and IHSDM and scalable
- SFPs can be developed relatively easily if data is available
- SFPs have multiple uses in the project development context
- 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.
Quantitative Safety Information and Project Development
Session 0
Policy Level Issues Related to Safety
Timothy Freuman, PE
Chief Highway Engineer
CFHM 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?

Transportation Agency Responsibilities
- Programming and Prioritization
- Project Development
- Operations and Maintenance

Project Development Process

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)

Safety Information and Project Development

If the problem is truly a safety one, then what solutions make sense? If it is a conflict of other priorities, what does the solution look like?
- How important is safety relative to other factors in our decision making?
- Are design solutions acceptable or not? If so, what type? When? Under what circumstances?

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Chicago, Illinois
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 xiii

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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

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

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.

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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 roadway)
  - 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

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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 measureable 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

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Determining the Scope of Use

- SPF's have uses throughout the Project and Program Development Stages
  - Each step in the process will require a review of policies
    - For instance, SPF's 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

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

- 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.
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>• Washington experience indicates:</td>
<td>• Use of SPF is far-ranging within the organization</td>
</tr>
<tr>
<td>– You’ll need to answer these fundamental questions as part of the policy development</td>
<td>– Policy should address &amp; indicate organizational use and need</td>
</tr>
<tr>
<td>– These questions will come from the executive and elected officials</td>
<td>• As the use of SPF varies, so will the need for review of current policy documents</td>
</tr>
<tr>
<td>– Lack of clarity will result in outcomes will vary across regional boundaries</td>
<td>– Assessment of gaps and opportunities is critical</td>
</tr>
<tr>
<td></td>
<td>– Think outside the box</td>
</tr>
<tr>
<td></td>
<td>• Answer the fundamental questions of Who, What, Where, Why, When and How?</td>
</tr>
<tr>
<td></td>
<td>• Training is necessary!</td>
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</tbody>
</table>

THE END
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 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

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

- 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

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

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
  - Safety Analyst
  - IHSIM
- Tutorial by Dr. Hauer et al

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

EB Methodology

\[ N_{\text{expected}} = \frac{N_{\text{observed}}}{N_{\text{predicted}}} \]

Crashes/Year

AADT

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Comparison between sites and highway facility types

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)

FHWA Tools Supporting Implementation of the HSM

<table>
<thead>
<tr>
<th>HSM Part</th>
<th>Supporting Tool</th>
</tr>
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<tbody>
<tr>
<td>B: Roadway Safety Management Process</td>
<td>Safety Analyst</td>
</tr>
<tr>
<td>C: Predictive Methods</td>
<td>IHSDM</td>
</tr>
<tr>
<td>D: Accident Modification Factors</td>
<td>CRP/AMF, Clearinghouse</td>
</tr>
</tbody>
</table>

Relationship among HSM, Safety Analyst, and IHSDM

<table>
<thead>
<tr>
<th>HSM Level of Analysis</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part C - Predictive Methods</td>
<td>Specific Roadway (Project-Level) IHSDM</td>
</tr>
</tbody>
</table>
**Roadway Segment SPF in Safety Analyst**

**RURAL**
- Two-lane
- Multiline
- Undivided
- Divided
- Freeways:
  - Within interchange area
  - Interchange
  - between interchanges
  - Unconnected
  - 2 lanes

**URBAN**
- Arterials
- Two-lane
- Multiline
- Undivided
- Divided
- Freeways:
  - Within interchange area
  - Interchange
  - between interchanges
  - Unconnected
  - 2 lanes

**Intersection SPF in Safety Analyst**

**RURAL**
- 3-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

**Session 3**

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

**Ramp SPF in Safety Analyst**

**RURAL**
- Diamond
- Offset ramp
- on-ramp
- Off-ramp
- Free-flow
- Free-flow outer connection
- Direct or semidirect connection

**URBAN**
- Diamond
- Offset ramp
- on-ramp
- Off-ramp
- Free-flow
- Free-flow outer connection
- Direct or semidirect connection

**Session 3**

- Safety Analyst 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
- IHSMD does not have calibration built-in procedures, and C factors can be entered by the user

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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
- SPF can improve effectiveness of expenditures
- Provides a base line for assessment of safety of locations – e.g. LOSS
- Expand the use of SPF's with pattern recognition techniques for diagnostic

Session 5
- Quantification of safety influences agency processes
- Use of SPF's 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

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?

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

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

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

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

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

Doug Harwood
Midwest Research Institute

Need for State and Local Agency SPF

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

Development of State and Local Agency SPF

• State and local agency SPF 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

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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 overdispersed meaning that the variance of the data is larger than the mean:
  - Negative binomial regression is appropriate for modeling such data
  - Negative binomial regression provides an overdispersion parameter that is needed in software tools

Safety Analyst Guidelines
- An 8-page guideline for SPF development has been created for Safety Analyst
  - This guideline is also applicable to SPF development for HSM Part C and IHSDM

Safety Analyst 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

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

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Calibrate Models / SPF

Calibrate Model / SPF

Calibrate Model / SPF

Enter and use "your own" SPF

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

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Enter and use "your own" SPF

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

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

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Enter and use "your own" SPFs

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

Estimate crashes using default SPFs

Enter "My State's" SPFs into Administration Tool

Enter "My State's" SPFs into Administration Tool

Run CPM with modified SPFs

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Compare Results

- Estimated Total crashes using default SPF: 27.84
- Estimated Total crashes using "My State’s" SPF: 27.62

Summary

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

Questions?

For additional information:
www.fhwa.dot.gov/ihsdm/ihsdm.htm

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

To download IHSDM software: www.ihsdm.org

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

July 29 and 30, 2009
Chicago, Illinois
**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**
- PSI = 150
- Fixed Object Overturns = 3.5%
- Rear End and Same Direction Side Impact = 1.5%

**Listing of Crashes**

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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

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)

Quantitative Site Analysis

- Is this intersection performing poorly?

This AADT = 3050
Step AADT = 5000
Experience = 20 crashes
T 3 years (94 – 98)
3 crashes per year
1 Fatal Crash

Quantitative Site Analysis

- Is this intersection performing poorly?

This AADT = 2000
Step AADT = 5000
Experience = 10 crashes
T 3 years (94 – 98)
3 crashes per year
1 Fatal Crash

Quantitative Site Analysis

- Countermeasures Completed
  - Lighting
  - Improved sight distance (hedge clearing)
  - Relocated utility sign

Quantitative Site Analysis

- Countermeasures Under Consideration
  - Improved warning signs
  - Police private signs on ROW

Countermeasures Under Consideration

- Improved warning signs
- Police private signs on ROW
- Lighting

Overall – Quantitative analysis supports actions taken, and informs future decisions.
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
  - Safety Analyst
  - Highway Safety Manual

Thank you
Dave.Piper@illinois.gov
CDOT SPF Use at the Project and Program Levels in Colorado
A Practical Approach

Jake Kononov, P.E. Ph.D.
Bryan K. Aliery, P.E.

System Level Planning and Program Development

Corridor Level Planning (EA / EIS)

- SAFETEA-LU and TEA21 both required explicit consideration of safety in the transportation planning process
- Although this government mandate is well intentioned, until recently little was known about how to accomplish it
- A methodology for the explicit consideration of safety in a NEPA framework has been developed
- Its application will be illustrated using case histories

- NEPA – 1969 National Environmental Policy Act
- Heralded as the “Magna Carta” of the country’s environmental movement
- 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.

- Air Quality Impacts
  - Carbon Monoxide
  - Volatile Organic Compounds
  - Nitrogen Oxides
  - Particulate Matter

- Wetlands
  - Acres displaced carefully estimated
  - Noise
  - Expected levels predicted in decibels

- 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

For Each of the Transportation Alternatives Under Consideration Environmental Impact is Described and Mitigated Explicitly

Each Impact to the Environment is Compared with National Standards and Those Alternatives not Meeting the Standards are Rejected (or Modified)
In Contrast to the Environmental Review Process, The Impact Each Alternative has on Safety is Not Well Understood or Planned For

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

It is Not Known How Much Safety to Expect!

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

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 Statistics**

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

Source: NHTSA and FHWA
EIS Application
Case History

I-25
(South Denver)
CDOT
SPF Use at the Project and Program Levels in Colorado
A Practical Approach

Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.
Use of State Developed SPFs in Their Own tools & the National Perspective

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!
Session 9: Local SPF Use - Iowa

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

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 "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 tried need
  - 2 → 3-lane Before/After Evaluation Study (ongoing)

Iowa "SPF" Examples

- More examples of Iowa FB use:
  - Impacts of Bypasses Before/After Evaluation Study (ongoing)
  - Bayesian SIGL (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 SPF Thoughts

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

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

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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

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

Thank you
michael.pawlovich@dot.iowa.gov

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I. WHAT IS THE HSM?

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

1. Definition: represents consensus within professional practice of transportation engineering.
2. Widely accepted within professional practice of transportation engineering.

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.
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?

Is This Road “Safe” or “Unsafe”?

What does safety really mean?

Highway Safety Has Two Dimensions

Nominal Safety

Substantive Safety

The expected or actual crash frequency and severity for a highway or roadway

Unlike Nominal Safety, Substantive Safety is a Continuum

Nominal Safety versus Substantive Safety

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Substantive Safety May Vary When Nominal Safety Does Not

The HSM Contains Best Science & Research

The HSM – A Ten-year Research And Development Effort

We’re Interested in Other Impacts for Project Level Decisions – What About Substantive Safety?

Overview of the new HSM

III. HOW WAS THE HSM DEVELOPED?

Significant Effort & Professional Support Produced the HSM

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Part C
Predictive Method

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

Special Part C
Common Procedures
- Methodology
- Applications
- Safety issues not explicitly addressed
- Example problems
- References
- 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

Segment Length

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 12: Roadway Segments
- CHAPTER 13: Intersections
- CHAPTER 14: Interchanges
- CHAPTER 15: Special Facilities and Geometric Situations
- CHAPTER 16: 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, and Construction
- Operations & Maintenance

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

- 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

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

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

VI. WHEN WILL THE HSM BE AVAILABLE?
Implementation Schedule

- Sept 1st to 30th, 2009
  - 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

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

http://www.highwaysafetymenual.org

Key Contacts

- AASHTO
  - Ken Kobetsky: kenk@aashto.org, (202) 624-5254
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- AASHTO JOINT TASK COMMITTEE FOR THE HSM
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- TRAINING
  - Karen Dixon (PI of NCHRP Project 17-36): karendixon@oregonstate.edu, (541) 737-0337

The End
Questions?

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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

Generic Courses
(with Some Customization)

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

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

Road Safety 101 Syllabus
- Flexible delivery
  - Blended learning
  - All classroom (3-4 days)
  - Online
- Five Units and 25 modules

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

University of Colorado

- Explicit Consideration of Safety in Geometric Design of Highways (cont’d)
  - Regression Analysis and Philosophy of 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 Analyses, Observational Before and After Studies

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

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**Ryerson University – TO Canada**

- Road Safety
  - Driver, pedestrian and bicycle safety
  - Applications of human factors principles
  - Safety audits

**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

**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

**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

**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

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Iowa DOT
Dr. Ezra Hauer

- Session 1: 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?

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

Web-seminars

ITE Webinars

- Introduction to Highway Safety - 8 modules
- The Fundamentals of Highway Safety - 9 modules

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

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

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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

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

Thank you
genibahar@navigats.com
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 SPF, 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.

Session 8:

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.

Session 9:

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 through 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.

**Session 11: (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 Safety Analyst, 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

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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?
3. Do you plan to attend the Summit again in the near future (e.g., next year)?

☐ Yes ☐ No

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