Implementation Guide for Managers

HSM
Highway Safety Manual
AASHTO

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Investment in roadway safety saves lives

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16. Abstract

This guide is intended for managers of departments of transportation (DOT) charged with leading and managing agency programs impacting the project development process and safety programs. This guide is based on lessons learned from early adopters of the Highway Safety Manual (HSM), many of whom are participating in the AASHTO's Lead State Initiative. It outlines what the HSM is (and is not), how it relates to other core technical documents and policies, and the potential benefits of its use. These benefits can be broadly understood as a means to improve the safety performance of their highway system. In this context the improvement of safety is defined as a reduction in fatalities and injuries. The guide is written in three sections – Introduction to the HSM, HSM Implementation Considerations, and HSM Implementation Opportunities in Program Development and Project Delivery.

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Executive Summary

The AASHTO Highway Safety Manual (HSM), published in 2010, presents for the first time a complete collection of technical knowledge describing the quantitative safety effects – motor vehicle crashes and their outcomes – of actions involving the highway and street environment. The HSM was developed through a 10-year research effort. It was written for use by any transportation professional concerned with highway and traffic safety. The HSM is organized in four parts:

- **Part A –** Introduction, Human Factors, and Fundamentals of Safety;
- **Part B –** Roadway Safety Management Process;
- **Part C –** Predictive Methods; and
- **Part D –** Crash Modification Factors.

The HSM is a potentially transformative document for Departments of Transportation (DOT) and other agencies responsible for the planning, design, construction, and operation of their highway systems. Under current practices agency actions are based on results from proven, science-based tools to measure or estimate effects of traffic operations, of a myriad environmental factors, and of the many aspects of capital and life-cycle costs. However, no proven and accepted tools or methods for understanding explicit safety effects existed in the past in a central document. With publication of the HSM, DOTs and other agencies now for the first time have access to a proven and science-based means of characterizing the explicit safety effects (i.e., crash frequency and severity) of decisions and actions of an agency.

The mission and vision statements of most DOTs refer directly to safety as a core value. The HSM adds a new dimension to defining and understanding what the term "safety" really means. To fully understand and take advantage of the HSM, DOTs will need to conduct thorough reviews of their organization and management, data systems, program and project development policies and methods, internal training programs, and even culture. Investments in training and technology transfer, and in improved or different data and skills will be needed. An assessment of budgets may be needed.

This guide is intended for managers of DOTs charged with leading and managing agency programs impacting the project development process and safety programs. This guide is based on lessons learned from early adopters of the HSM, many of whom are participating in AASHTO's Lead State Initiative. It outlines what the HSM is (and is not), how it relates to other core technical documents and policies, and the potential benefits of its use. These benefits can be broadly understood as a means to improve the safety performance of their highway system. In this context the improvement of safety is defined as a reduction in fatalities and injuries. The guide is written in three sections – Introduction to the HSM, HSM Implementation Considerations, and HSM Implementation Opportunities in Program Development and Project Delivery.

1. Introduction to the Highway Safety Manual

The AASHTO *Highway Safety Manual* (HSM), published in 2010, represents the culmination of 10 years of research and development by an international team of safety experts, academics, and practitioners. The HSM was envisioned as a companion document to and modeled after the well-known *Highway Capacity Manual*. Under leadership from both the American Association of State Highway Officials (AASHTO) through the National Cooperative Highway Research Program (NCHRP) and the Federal Highway Administration (FHWA), and with direction from a Task Force of the Transportation Research Board (TRB), a major research program provided the technical contents of the HSM and also funded its development into a practitioner-friendly document.

The HSM represents the greatest potential for influencing the actions and outcomes of state DOTs in the past 50 years. The HSM captures the knowledge base associated with the proven relationship between crashes and their outcomes and actions or implemented decisions. The HSM is intended for use by any and all professionals charged with planning, design, construction, operations, and maintenance of a road or highway system. The HSM was developed through funding from AASHTO and the FHWA. The research basis for HSM contents has its foundation in National Academies administered peer-reviewed research. As such, users of the document can apply the values and methods with confidence, knowing they represent the best science available at the time of its publication.

Purpose of the Implementation Guide

This document is intended as a reference for managers of state DOTs and local highway agencies that are interested in or responsible for initiating the implementation of the AASHTO HSM within their organization. It provides guidance on processes, resources, approaches, and lessons learned from early adopters of the HSM.

The guide offers background on what the HSM is and what its benefits to users will be. It presents considerations to managers assigned the task of participating in or leading an HSM implementation effort. These considerations come from discussion with DOT peers who have already begun implementation and have learned valuable lessons.

Management strategies are suggested, including the need for a champion, key executive leadership support, and development of a specially tailored implementation plan, which would include training, organizational issues, revisions to agency policies and procedures, risk management, data availability, analytical tools, and information technology.

The second major section of the guide covers how the HSM, once implemented and institutionalized, can affect program and project delivery for all projects – not just those concerned with safety improvements.

For further assistance or background on the HSM, users of this Guide are encouraged to visit http://www.highwaysafetymanual.org.

Benefits of New Concepts of Safety

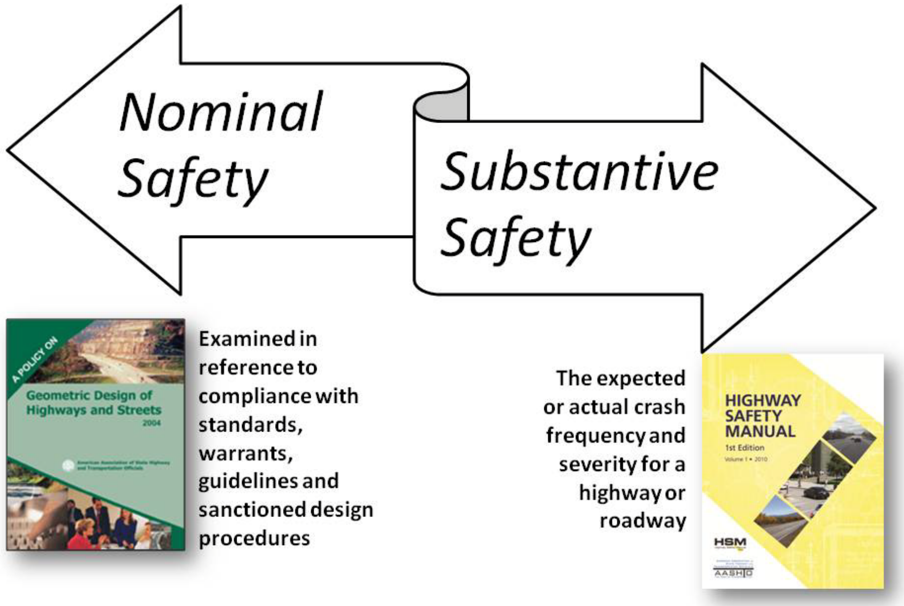
Safety is a core value of most if not all state DOTs. Safety plays a prominent role in the mission or vision statements of most. Customers, highway system users, and taxpayers have been assured and told that maintaining or improving safety is a top priority, and that much of an agency's investments are intended to produce a "safe" highway or system.

"Safety" has traditionally been incorporated in highway programs and projects within a "standards-based" framework. Design standards, design policies, and warrants such as the AASHTO Policy on Geometric Design, AASHTO Roadside Design Guide, and Manual on Uniform Traffic Control Devices, and individual state DOT design manuals are the core basis for decision-making and project development. Many agencies have sophisticated asset management systems that facilitate system monitoring and program development of hard assets such as bridges and pavement, but lack comparable systems for safety.

Standards, manuals, warrants, etc., serve many purposes. Among them are quality control, efficiency in design, and consistency in approach that translates to better understanding of contractors and better bids. Many design standards have some element of safety assumed or implied by their derivation of design values, but in many cases there are other considerations besides safety in how and why a design standard or design values were established. Indeed, a deep understanding of the background behind much of industry practice shows that such presumptive relationships in fact often do not exist. Ezra Hauer, a noted researcher in highway safety, referred in 1999 to the use of standards in the context of delivering safety as *nominal safety*.

What is different about the HSM, and where it offers potentially significant benefits to agencies, is in the introduction of a second dimension of safety, which Hauer described as *substantive safety.* Exhibit 1 demonstrates the difference between nominal and substantive safety. Substantive safety is quite simply the performance of a facility as measured by crashes and their outcomes, fatalities and injury. In the context of DOT programs and actions, the known substantive safety, when compared to a statistically reliable and relevant threshold, provides a basis for decision-making around project selection, scope, and basic approach. For contemplated actions or alternatives, the predicted or expected substantive safety of each alternative can be assessed and thus contribute to the selection of a preferred approach.

EXHIBIT 1
Nominal and Substantive Safety Concepts



By providing a way of estimating or understanding the substantive safety implications of design decisions or actions, DOTs can now:

- Better inform their decision-making process and thereby improve the effectiveness of countermeasures to reduce the number and/or severity of crashes;
- Improve the confidence that safety funds are being applied most effectively;
- Reduce time and improve the justification of safety improvement programs and projects;
- Provide meaningful quantitative safety measures to inform project decisions and thus improve understanding of tradeoffs involving other values such as environmental concerns, right-of-way, and stakeholder issues;
- More directly integrate safety in the overall DOT program and project development process; and
- Demonstrate and prove over time, the direct and meaningful return for investments in safety to their sponsors and stakeholders.

In effect, the full implementation and use of the HSM will help a DOT accomplish what its customers and stakeholders expect, which is providing the highest level of safety performance for the financial and other resources provided to the DOT. Managers should understand and communicate to staff that the full acceptance and implementation of the approaches, methods, and values in the HSM and companion resources offers substantial systematic benefits for enhancing safety.

2. HSM Implementation Considerations

Any new organizational initiative requires careful thought and planning. DOT managers can expect that introduction of new requirements, technical or process, will be met with some skepticism and fear. Indeed, for staff successfully doing their jobs for many years, delivering a message that they need to do something new may require extra effort and sensitivity to demonstrate the value and necessity of the new initiative.

There will be many within an agency that will understand and embrace the new approach. Such early, enthusiastic adopters should be sought and nurtured. Implementation planning for the HSM should reflect the specific attributes, culture and organizational structure, and capabilities of the organization. The culture of DOTs with respect to participation in industry research and application of new ideas and technology varies widely. Managers should understand their unique culture and plan accordingly. Managers should approach implementation with an understanding of how their agency is organized, who are the important influencers and decision-makers, who can and should be allies and supporters of the effort, and what is reasonably achievable over time given the agency's other priorities.

Implementation Guiding Principles

Lessons learned from early adopters of the HSM, including AASHTO lead states, produce the following guiding principles that managers should incorporate in their implementation efforts.

- *Employ a Consistent Technical Approach* – Predictive methods, assumptions, use of common databases, common crash modification factors, and common benefit/cost approaches are all important for both internal purposes and external credibility.
- *Encourage Gradual Changes* – Agencies will have varying levels of quality and quantity of necessary data and IT systems. Changes in policies, use of the HSM and training of staff should not "outpace" the ability or progress of the data and decision-support systems. Seek to establish and then maintain momentum in implementation.
- *Anticipate and Champion Culture Change* – Many HSM concepts are new and may run counter to staff understanding of safety. Training of staff, particularly highway designers, should carefully explain HSM concepts in their proper context stressing that the HSM does *not* replace design manuals and standards, but merely supplements them.
- *Manage Training* – Not everyone needs to be an expert in the HSM, but most will benefit from basic knowledge and all should understand the concept of substantive safety. Managers should consider how the HSM will be used, who within the organization (by position, by location) should have a deep understanding, and how their internal experts will be used. Managers should also consider how others may benefit from the knowledge base without having to undergo extensive training.

Drivers and Challenges to Successful Implementation of the HSM

Managers will find that implementing the HSM will present challenges similar to the implementation of other significant advancements or innovations in the field of transportation, such as Context Sensitive Solutions and Complete Streets initiatives. Successful implementation involves identifying and taking advantage of "drivers" and overcoming "barriers" or challenges.

Successfully implemented innovations invariably have *drivers*, that is, forces that tend to promote the innovation. External drivers include customer expectations about the work of the agency to deliver safe roads, and the need to justify or account for value from investments in projects. For the foreseeable future, it seems clear that funding demands and competing priorities will greatly outstrip available resources. In such an environment, it may be easy to dismiss the implementation of any new initiative. In the case of the HSM, managers can turn the argument around. The DOT's customers assume that their actions and decisions are intended to produce a performance outcome. When investments are made through the application of science-based safety concepts in the HSM, agency leaders can feel confident in sharing with the public the expected reduction in fatalities and injuries that result from these investments.

Significant internal drivers include the individual professionals in the agency, their natural desire to be seen as applying the latest and best practices, and their related pride in the organization they work for and its place among its peers. Regardless of position within the agency, the vast majority of professionals want to do the best job they can and want to learn and apply the latest innovations and knowledge in their field. Managers should seek opportunities to identify and take advantage of these drivers within their organizations.

There are also typically challenges or *restraining forces* to any change, which tend to reflect the natural human tendency to resist something new. Exhibit 2 summarizes what early adopting managers have faced when attempting to introduce the HSM and concepts of quantitative safety. Note that these restraining forces tend to reflect internal factors or constraints within the agency. All such challenges can be addressed within training and during implementation.

EXHIBIT 2
Examples of Driving Forces and Restraining Forces to Apply Quantitative Safety Information to Transportation Engineering

Management Strategies

DOTs that are rapidly implementing the HSM have executed similar strategic approaches. Each of these approaches has involved:

- A well-respected leader serving as a champion;
- Development and execution of an implementation plan;
- Examination and revision or development of agency policies and resources;
- Examination of risk management and legal issues;
- Examination of data, information technology, and analytical tools;
- Assessment of budgets and phased approaches to implementation;
- Identification of technical expertise needs and sustainability of technical expertise; and
- Identification of organizational needs and issues.

All of the above are essential elements of successful HSM implementation. The amount of effort and resources to adopt each will vary from state to state. The remainder of this document will discuss each of these items in further detail.

Agency Champion(s)

There must be at least one strong, visible, and well-respected manager or executive who has a stated interest in promoting safety and who can appeal to the sense of professionalism within the staff. The finding and designation of a *champion* – someone who will accept the challenge, own the task of HSM implementation, and commit to driving it within the agency is an essential element. A champion can insure statewide, consistent, and directed effort towards the advancement of safety across various programs and processes. Lack of a champion results in no one owning the implementation task, with diversion to other priorities inevitable.

The champion should recruit other like-minded staff, if possible from different offices and with different functions or jobs. An ideal team includes someone from key headquarters functions such as the design and/or traffic engineering offices, the state safety engineer, IT experts, or owners of data systems, and mid-level project managers and department managers from field or District offices. Each individual can offer insights on the specific barriers to be overcome, technical or resource needs, potential early successes, and how to best incorporate changes in department policies or approaches.

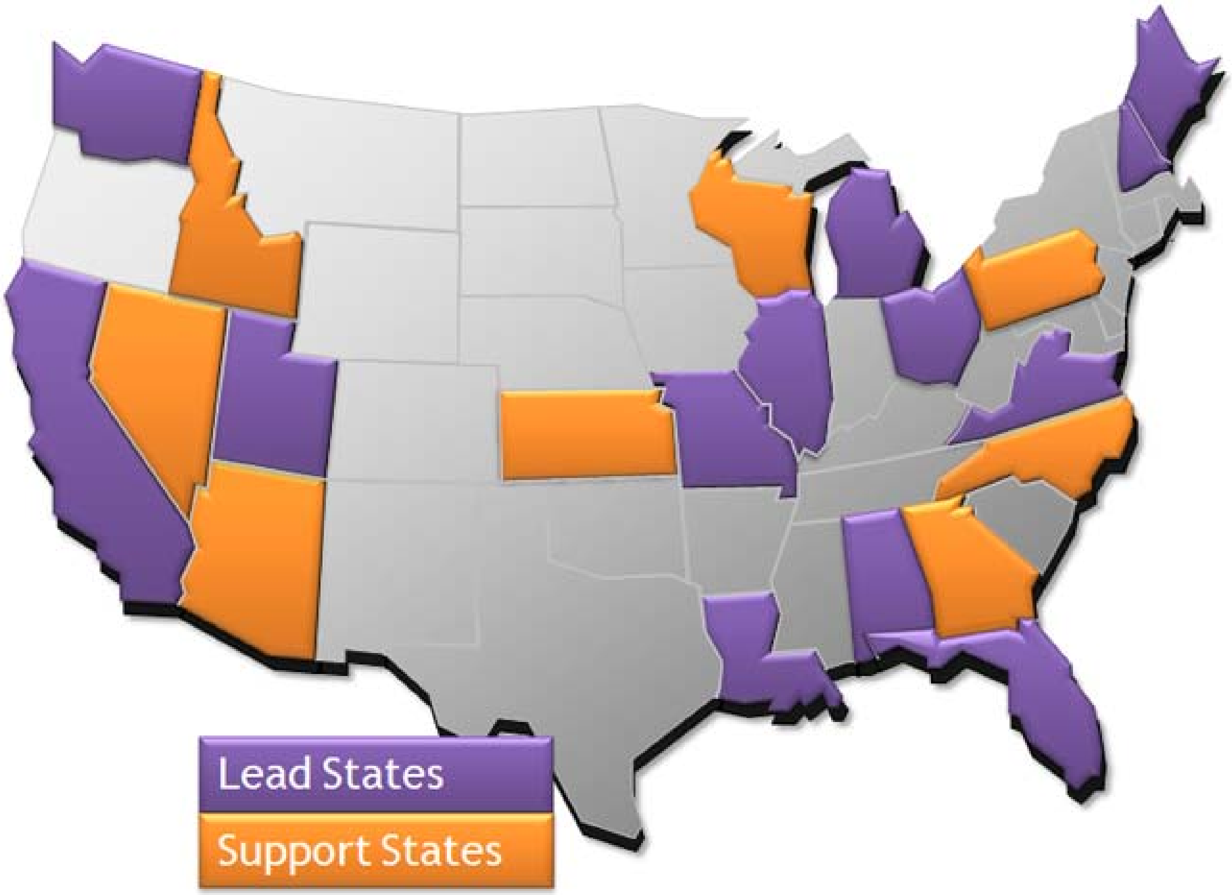
There should also be an executive sponsor who is high enough up in the organization that he or she can make clear the importance of the HSM and how safety will be dealt with going forward. The executive sponsor should act in a way that demonstrates the agency's commitment, through providing the right resources, advertising the visibility of the team and its mission, and rewarding interim milestones met and early successes.

Develop an Implementation Plan

With formation of a carefully built team of committed agency staff, the next critical strategic step is to develop a plan for HSM implementation. A good plan addresses specific actions and assigns timeframes. It need not be overly detailed, but should be sufficient to communicate what needs to be done, in what order, and what issues will need addressing in completing each task. A good plan will recognize and respect the make-up of the organization and other known priorities. It will be ambitious but not overly so. Implementation plans should contain basic tasks such as training, organizational issues, revision of agency policies, risk management and legal issues, and information technology requirements. These are discussed in detail below. For an example of an HSM implementation plan, see the Florida DOT web site: http://www.dot.state.fl.us/safety/TransSafEng/HighwaySafetyManual.htm.

NCHRP 17-50, an AASHTO-sponsored HSM Lead State Initiative, kicked off in 2011 to support and encourage the implementation of the HSM. The project allows for sharing of lessons learned and a forum for discussion among states participating in the initiative. Lead and support states were identified. Lead states provide assistance to the support states. Exhibit 3 shows the states participating in the project.

EXHIBIT 3
Lead States and Support States in the NCHRP 17-50 HSM Lead State Initiative Project



Examine and Revise Agency Policies

Implementation managers should lay out a roadmap, articulating a vision for how the HSM can over time influence how the DOT insures that safety is explicitly considered in all decisions and is incorporated into the overall project development process. The following are examples of key policies that some DOTs have begun to change based on HSM concepts or content:

- *Program Prioritization* – Use of HSM methods in agency planning and programming processes to identify "locations with promise" (i.e., black spots or high-crash locations); use of HSM values for CMFs to replace an agency's crash reduction factors, and economic value of crashes, which is used as part of benefit/cost analyses. The Illinois DOT, for example, replaced their method for identifying high-accident locations with an HSM-based method used to identify roadway segments and intersections with significant opportunity for safety improvement and to develop their five percent reports to the FHWA.
- *Asset Management* – State programs are heavily influenced by use of data and analyses from their asset management systems. These include bridge and pavement management. The

HSM offers the ability to add quantitative safety information into overall project programming, thereby redirecting or influencing the prioritization of projects based not only on asset condition and preservation but also safety performance.

- *Warrants and Guidelines* – Most state policies and manuals include warrants and guidelines for capacity and other improvements. Examples include "two-lane to four-lane" projects and grade separations to replace interchanges. The performance basis for such guidelines is typically mobility or operations-based. The HSM methods can be used to expand such guidelines to include threshold safety performance measures.
- *Project Development* – Incorporation of HSM concepts in project development decision-making process, including planning and programming, scoping, design criteria development, alternatives development, screening, and selection of preferred alternatives. This is done through revisions to DOT design manuals and reporting requirements, and is discussed in greater detail in the following section.
- *Risk Management Processes* – Design exceptions, deviations, and waivers are all fundamental design development processes. As discussed below, the HSM has direct application to how such processes are executed.

Revisions to policies or approaches will require much groundwork and coordination across offices and with the FHWA Division office. A well-thought-out roadmap will acknowledge limitations in data, and knowledge, and will produce a schedule that focuses on where early successes are most likely so that confidence is gained and benefits are immediately perceived.

Address Risk Management and Legal Issues

The team that produced the HSM over its 10-year development period included the former Chief Counsel for a state DOT, a current state DOT risk manager, and two university professors who served as risk management consultants to their state DOTs. The HSM was reviewed and vetted by the Transportation Research Board's Tort Liability Committee. Managers should be assured that, as written and properly used, the HSM would not increase risk.

Concerns over tort liability are among the early questions and barriers raised by staff when they understand what the HSM is all about. Managers should anticipate these concerns and be prepared in advance to deal with them. The following are key strategies to incorporate:

- Be familiar with the specific tort issues in your state, and how these are currently communicated to DOT staff.
- Implementation managers and trainers should meet with the agency's risk manager or chief counsel. Ideally, some risk management representation would be included in the core team. The HSM web site contains training materials that include key messages regarding tort liability, legal framework, what the HSM is (and is not), and names of DOT risk managers who worked on the HSM and can help develop deep understanding and comfort.
- Discuss the implications of the HSM on legal protections associated with USC 409 with chief counsel and data managers or IT staff. Take action to post appropriate notices, conduct

training, and implement safeguards in the access to databases, and publication or use of data to retain the legal protections.

- Review and revise or strengthen as needed guidance to staff on how to write reports dealing with crash data and HSM methods. Such guidance would include what words should be avoided (e.g., "high-accident sites," "hazardous locations," "unsafe," "unacceptable safety record," etc.); how not to characterize a decision or proposed action, how to describe analyses and properly discuss potentially controversial subjects such as safety "tradeoffs."
- Review current procedures for design exceptions reports, including the nature and type of documentation, who reviews and approves the analyses, what specific safety-based inputs are used, and how decisions are described and documented.
- Meet with FHWA Division staff to discuss design exceptions and how the process may change with application of the HSM. Make sure there is a common understanding and buy-in prior to suggesting or implementing revised design exception processes.
- Review current internal training programs on design exceptions and risk management to seek opportunities to include information on the HSM; and where no such training exists, consider developing it as part of an overall safety and project development training initiative. Note that FHWA's document "Mitigation Strategies for Design Exceptions" which was written prior to publication of the HSM actually includes technical content on safety performance from the same research sources as were cited in the HSM.

Data and Data Systems

Data to support implementation include crash records, traffic volume data, roadway inventory and traffic control data such as locations of signalized and stop-controlled intersections. As noted above, such data are typically maintained by different offices and different data management systems. For traffic volume and roadway inventory data the quality of the data may reflect other needs such as asset management systems. Data managers will need to understand the level of data quality needed to support HSM analyses. Investments in increased coverage or updating of data will need to be considered. For example, the agency may wish to consider expansion of intersection traffic volume counting programs. The extent of such investments should reflect and influence decisions about how the agency will adopt the HSM Part C predictive methods for their system (discussed below). The NCHRP Research Results Digest (2008) offers a reference to the data requirements to support the HSM.

Many questions need answering, such as: *Who owns the data needed for implementation?* (crashes, driver licensing, roadway geometry, design information, traffic data); *Are the crashes geo-referenced*? *How complete are the different data sources? Are data available for all roads in the state or just state-maintained roads? How often are databases updated? How can the agency integrate data sources geographically? Is the data infrastructure compatible across data sources? What are the resources – funding and staffing – needed to implement improved data and data systems?*

Virtually all state HSM Implementation plans will include acquisition of data not already gathered. These may include additional traffic volume information, alignment data, and roadside condition data. In working with IT staff, the full vision of eventual data needs to be understood and accommodated. This may not occur for five years or more, but the technology requirements to be able to collect, maintain, and use all potential data need to be understood.

Information Technology

Most agencies do not currently maintain data systems robust enough to support full HSM analyses. Implementation of the HSM will require establishing close relationships with IT staff to outline what needs to be done to facilitate implementation. Many questions need answering, such as: *How often are databases updated? Who has access to databases for analyses? What types of security are necessary to safeguard sensitive information? If consultants outside the agency are used routinely how will access to these data sources by their staff be managed? Are policies and procedures in place to accommodate for any liability and risk concerns that may exist? Is legal or risk management part of considerations related to implementation? Are there any existing tools in place at the agency? Are any other tools anticipated to support HSM implementation? How can the database infrastructure support seamless integration of these tools – is a phased approach necessary?*

Development of Tools for HSM Implementation

The HSM contains presentation and documentation of models, and worksheets and methodology descriptions. Two types of tools will be needed for efficient application of the HSM – *network screening tools* and *project-level design tools*.

Many states are implementing SafetyAnalyst to serve as the basis for Part B HSM methods. SafetyAnalyst is a software tool which supports safety management decision-making by state and local highway agencies using state-of-the-art analytical methods. SafetyAnalyst was developed through an FHWA-pooled funds study and is now offered as AASHTO-Ware. Many states are implementing SafetyAnalyst to serve as the basis for Part B HSM methods. For example, Ohio is currently using SafetyAnalyst to develop a new roadway safety management process. Working together with their IT department was critical in implementing the software. Assistance for states encountering technical difficulties in getting SafetyAnalyst to work is available through the service units for those licensing SafetyAnalyst or through FHWA for states considering licensing SafetyAnalyst. For project-level design analysis, FHWA's Interactive Highway Safety Design Model (IHSDM) contains all Part C predictive models. IHSDM is a suite of software tools that support **project-level** geometric design decisions by providing **quantitative** information on the expected safety and operational performance. FHWA will continue the use of IHSDM as the support platform for Part C predictive models in future editions of the HSM. The IHSDM software is available for free download at http://www.ihsdm.org. The National Highway Institute (NHI) offers training in the IHSDM.

For many applications such as small project or site specific analyses, simple spreadsheet tools will suffice. Some states are developing their own tools. NCHRP Project 17-38 produced a spreadsheet designed as a training tool; this has been adopted and refined by some states for their use. These spreadsheets can be downloaded from the AASHTO HSM web site: http://www.highwaysafetymanual.org.

Budgets for Implementation

Implementation efforts will require both staff time and other budgets. These will generally come from reallocation and deferral of other agency priorities. External assistance in many areas is available and thus should be considered. In addition to the Federal funding programs that would generally support research and implementation, State Planning and Research (SPR) funds, state training set-asides, and STP funding, other sources at the Division Office, such as technology transfer funding may be available to support implementation of the HSM.

Some states have undertaken their own research or development efforts for their own HSM-type tools. University partners can assist states here using funds to perform implementation tasks such as development of safety performance functions, benefit/cost tools, or conduct special studies of CMFs of interest to the state.

While the law (23 U.S.C. 148) and regulation (23 CFR 924) governing the HSIP lists transportation safety planning and improvement in the collection and analysis of safety data as eligible highway safety improvement projects, these activities must directly support HSIP implementation efforts. Activities supported with HSIP funds should address SHSP priorities, be supported by a data-driven process, and be used where they are likely to achieve significant reductions in fatalities and serious injuries.

States may leverage other federal-aid funds to support HSM implementation efforts. For example, state planning and research funds can be used to support data collection efforts. In addition, training is an eligible expense under core federal-aid programs. Improvements to the collection and analysis of safety data can also be funded by NHTSA Section 402 and 408 State Highway Safety Grant Programs.

Initiate HSM Training

Training of staff will undoubtedly be a part of any agency's plan. Indeed, it tends to be among the first things discussed and conducted. Before signing up for training, review the agency's plan for overall implementation. Focus on training materials that will address early action items. Lessons learned from states who were early recipients of training include the following insights:

- Resist the urge to train everyone initially or at once. Think strategically about which staff within the agency needs to learn the HSM first. This may be a select group of mid-level or senior managers or PMs; technical experts, and others who can be trusted to transfer the knowledge to others.
- Recruit and encourage senior leadership participation in at least part of the training to "set the stage" and send a clear message that implementing the HSM is a top priority of the agency, and that it will be beneficial to them and their customers.

- Seek trainers who are capable of tailoring the training to the agency's needs, systems, and terminology. DOTs that have invested a little money in tailoring the standard, available materials from NCHRP or FHWA have found staff understand better and are more receptive when they recognize references to their processes, data systems, manuals, etc.
- Consider commissioning different training for different staff within the agency. Most available core training materials address all four parts of the HSM. Training for planning and program staff, may best focus on the Part B materials and on the applications and use of SafetyAnalyst. Training of traffic engineering and design staff may best focus on Parts C (predictive methods) and D (CMFs).
- Include FHWA Division staff in training sessions, regardless of who the trainers are and whether Division staff has undergone their own training. Everyone will be working together and using the new materials. Having open discussions of how things will work, what assumptions will be needed, what approaches seem best will foster a cooperative learning environment and minimize conflicts in actual project settings.
- Incorporate into the training a module where the vision for implementation and the agency's implementation plan are laid out and discussed. This can include the ongoing activities within the agency, timeframes, and individuals and offices included. This module can serve to solicit volunteers to be included in the roll-out of the new material.

A final important point regarding training involves the skills and capabilities and credibility of the trainers themselves. The HSM presents new safety concepts. HSM trainers must have sufficient fundamental knowledge of the new concepts, and be able to effectively communicate them. Among the more important concepts are why the use of crash rate is not the optimal approach, how to compute *predicted* crash frequencies using the Part C predictive methods, and how to incorporate both actual crash history and predicted crashes to compute *expected* crashes using the Empirical Bayes' techniques. They also should be able to explain the relationship between Part D contents and FHWA's CMF Clearinghouse.

FHWA has also recently released the Highway Safety Manual Training Guide as a resource document for state DOTs that are developing HSM training plans. It focuses on identifying HSM training currently available to state and local agencies who are considering implementation of the HSM, as well as identifying additional courses under development. Several training opportunities exist for highway safety and safety analysis, but the guide focuses only on courses directly applicable to content in the HSM and only those provided by NHI, FHWA, and ITE. The HSM training guide is available at http://safety.fhwa.dot.gov/hsm/training/hsmguide.pdf.

Develop Sustainable Technical Expertise

Agencies should have one or more staff at mid- to senior-level management with a deep understanding of what the HSM is and represents. Many states participated in research and development efforts for the HSM and FHWA companion projects such as SafetyAnalyst and the IHSDM. Such internal knowledge is helpful to explain benefits and value to the organization.

Most states will find it necessary to acquire additional expertise. Sources may include:

- Technical training of staff with their assignment as internal experts/resources;
- Retaining of on-call consultants with HSM expertise or background (this strategy can be stand-alone, or used as part of on-call contracting for traffic engineering or related services);
- FHWA Resource Center, Headquarters, and Division Office staff (for conducting of training and consultation on initial project applications); and
- Contracting with University resources who have demonstrated expertise in the HSM contents and concepts.

Such expertise can be used to help the DOT with certain aspects of implementation, or merely with review and analysis of projects as well as revision of policies. The AASHTO HSM User Discussion Forum, accessible through http://www.highwaysafetymanual.org, provides technical assistance to users. A number of support products, such as the HSM User Guide and the HSM Training Guide are currently under development. Once finalized and published, these documents will also be posted on the AASHTO HSM web site or a link to the particular document will be provided on the AASHTO HSM web site.

Technology Transfer to External Partners

Each agency's plan should envision significant outreach to their partners within the state. County engineers, cities, and MPOs will all eventually need to implement the HSM on their system as well. Clearly, a state needs first to deal with its own data, staff, and systems. Given that in most states at least half the fatalities occur on the local system, outreach and cooperation will need to take place.

A well-thought-out plan envisions eventual institutionalization of the HSM, but recognizes the practical time and resource limitations. A common challenge is the limited technical expertise and resources of county public works agencies. In many instances the county engineer may lack an engineering degree. Strategies to develop and nurture this outreach include:

- Inviting local agencies to attend HSM training, either as a separate group or with the DOT. (The Alabama DOT included a number of County engineers in their initial training in 2010. As part of this effort the county engineers were given copies of the HSM paid for by the state. This was a significant action, as the county engineers noted that they lacked budgets to purchase expensive manuals like the HSM.)
- Enlist the LTAP centers to develop and deliver training on proven, low-cost treatments as for country roads as documented in the HSM.
- Offer technical assistance either using DOT staff or consultants to work with and for the local agencies to apply the HSM methods on their programs, offer additional investments in data acquisition and management to local agencies so that their system can be evaluated in a manner consistent with that of the state system.

Organizational Needs and Issues

The implementation team will need to make decisions regarding what fundamental approaches will be followed in actual implementation of the HSM. These decisions should reflect full understanding of not just initial work, but continuing upkeep and maintenance of the system; the organizational structure of the agency; and business processes.

Implementation actions, timing and needs will vary depending on the organization's size, structure, and operations. State DOTs can be broadly characterized as either centrally focused or decentralized. In the former, programs are built and projects managed at the Central Office. Geographic responsibilities may be limited to maintenance and operating regimes. In the latter instance, District or Regional staff may be located throughout the state, with professionals building their own programs (following Central Office-driven policies and procedures) and managing their own projects.

Clearly, in the case of decentralized operations the time to successfully implement a new technology or procedure will be greater. This is not just a function of resources but also of reaching professional staff, conducting training and outreach, and in many cases "persuading" them to adopt the new methods. Lessons learned from one lead state, the Illinois DOT, suggest that early positive engagement with regional staff is important, as is patience in rolling out the new approaches. Also, offering "hands-on" assistance to staff through development of tools, making technical resources (DOT staff, on-call consultants) available, or other measures also is important. Finally, seeking out and working directly with District "champions" can help sell the new approaches. This mirrors the "Lead State" approach FHWA and AASHTO promote.

3. HSM Implementation Opportunities in Program Development and Project Delivery

The core mission of state DOTs and other similar agencies is to develop and manage a transportation system. Managers explaining and promoting the HSM will find that explaining its potential use in the context of the project development process in their state will resonate with staff. The emphasis here should be on all projects and all activities, not just those that refer to “safety.” Most projects that comprise a state’s program are not “safety projects” but rather are prioritized for other reasons. Regardless of the project’s purpose and need, the HSM offers benefits and can be used in the delivery of the overall program and each project.

FHWA also maintains a Crash Modification Clearinghouse. HSM content on crash modification factors (CMF) is in Part D. As research continues and the knowledge base grows, agencies will want to take advantage of HSM-quality CMF research. The FHWA Clearinghouse (http://safety.fhwa.dot.gov/tools/crf/resources/) is a core tool that most states are using.

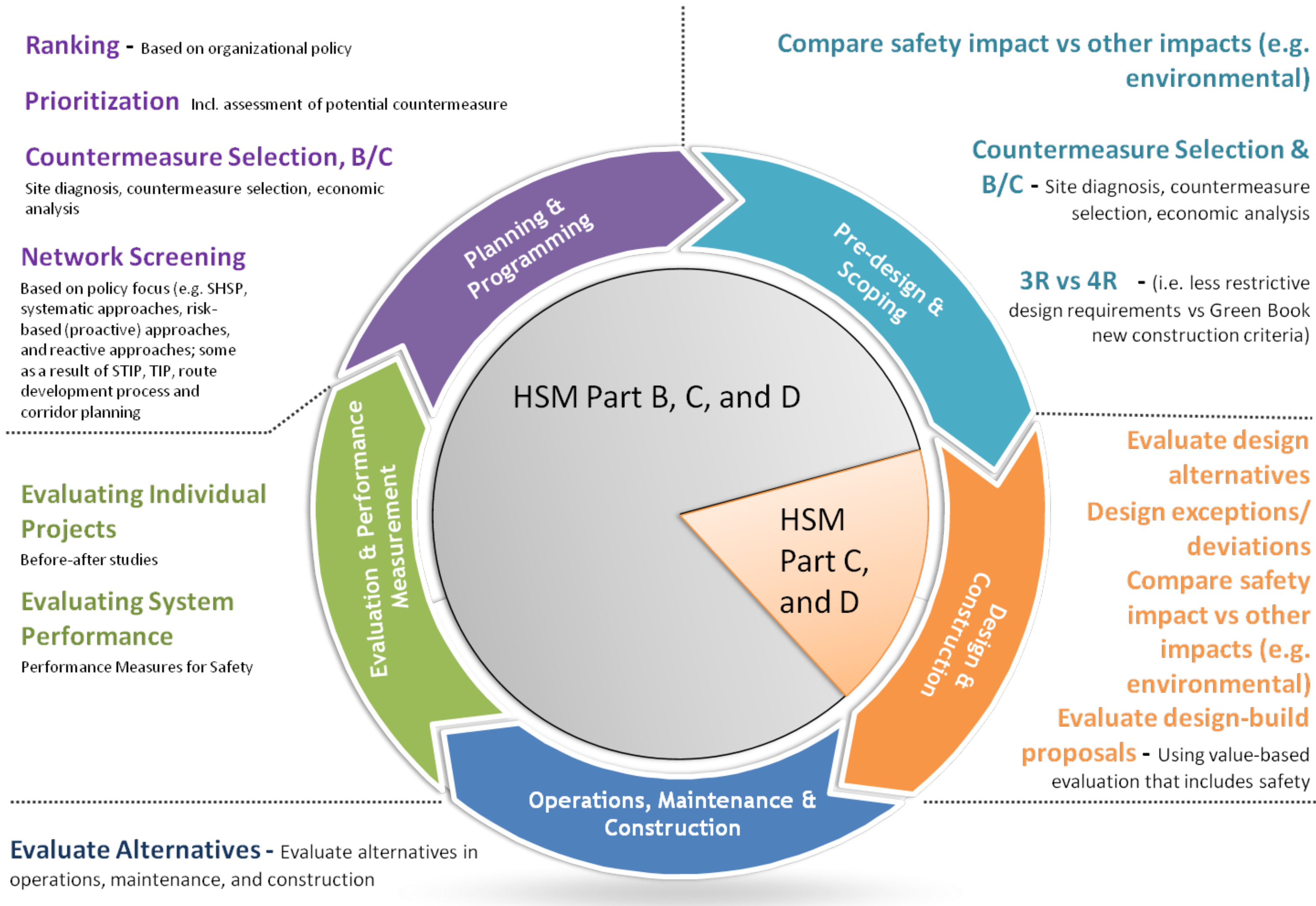
Exhibit 4 shows a typical project development process and opportunities to implement the HSM. The following is an overview of how implementing the HSM can influence program and project delivery. As training progresses and policies are changed, eventually actual project applications will gradually become the norm for the agency’s delivery process. Strategies and insights for successful project delivery implementation are included in each section.

Program Development

The Federal Aid Highway Program includes a portion of every state’s allocation specifically set aside for safety improvements. Within each state program, these funds are subject to a formal prioritization process that takes into account crash history and exposure. The HSM can enhance the effectiveness of that prioritization process, as well as providing data to support the allocation of additional state and Federal funding to address safety needs.

The HSM offers improvements over many agencies’ historic approaches to the Highway Safety Improvement Program (HSIP). For example, HSM methods and concepts from Part B were incorporated within the Illinois DOT’s process for developing their “Five Percent Report” to the FHWA. Over time, the HSM-based methods were refined and found so valuable that the report replaced Illinois DOT’s old methodology for identifying safety projects. Illinois DOT District staff was at first encouraged to use the data and methods in Parts B and D, and eventually required to use them to have their HSIP projects funded. IDOT developed a benefit/cost tool with CMFs to staff. The tool, using HSM values for CMFs, supports consistency in approach and a high degree of confidence.

EXHIBIT 4
The Project Development Process and Opportunities to Implement the HSM



A lesson learned from this exercise involves the use of consistent approaches to CMF applications at the state program level. The published HSM is dated to 2007. FHWA's CMF Clearinghouse is kept current with published CMF research. The Clearinghouse may contain multiple CMF studies with differing values for the same treatment or countermeasure. State managers need to recognize and address the issue of who decides which CMF is appropriate, what constitutes a minimum level of technical acceptability to the agency and how to keep the agency's list of approved CMFs current as more are added to the Clearinghouse.

Another decision and action to take includes how crashes and their outcomes will be valued. The HSM offers the "willingness to pay" approach to valuing crashes and severity, but there are other methods used (including a different valuation used in AASHTO's RSAP program for roadside design). Again, a common and consistent approach should be determined and then communicated as part of program development guidance and documentation.

Project Development

The HSM also offers opportunities to influence how agencies develop individual projects. Early in project development, key decisions are made that influence how the project will be completed. These include defining project scoping, project purpose and need, project objectives, and from all of these, which "track" the project will follow. In later stages, as the project takes shape, detailed studies establish the basic footprint and attributes of the project.

Actual implementation of the HSM within projects should be planned in cooperation with Districts and project managers. As an example, Florida DOT instituted a pilot program with its Districts, in which specific projects typical of the District's work were identified and HSM methods tested. District involvement in the identification of projects and assistance of the HSM team in data gathering, coding, and interpretation of the results produced understanding and buy-in to the process and tools. Implementing agencies may consider working with one or two Districts with strong champions and interest, establish the process, and then extend it to other Districts.

Project Scoping and Design Criteria

At project initiation, agencies conduct a project scoping exercise. This includes all offices concerned with any aspect of the project, as well as external partners such as the FHWA. Project objectives, project limits, and coordination activities are discussed and established.

Project scoping decisions and establishment of design criteria can have a significant influence on the cost, physical feasibility, and ultimate value of a project. Direct incorporation of HSM-based analyses as part of agency scoping offers significant cost-saving potential without degrading overall safety performance.

Many projects involve an existing facility. For such projects that are not envisioned to include major lane or capacity additions, the safety performance of the existing facility can play an important role in defining the scope of the project.

Scoping Using the Two Dimensions of Safety

Existing highways, intersections, and streets will have crash records, traffic volume data and known geometric features. Agencies that have implemented the HSM will have predictive methods that can provide insights on how the existing safety performance (substantive safety) is relative to a threshold representative of other sites with similar characteristics. The threshold, established by the agency with reference to the HSM methods, quantifies the anticipated average performance of a typical site to identify potential for improvement. The comparison answers a basic question – *Is this site/project performing as or better than expected in terms of the number and severity of crashes (Yes or No)?*

The second dimension of safety, its *nominal safety*, is straightforward to understand. Given the design characteristics of the facility, does it meet current design criteria and standards of the agency or not? (Or perhaps more precisely, *to what extent and for what geometric features is the location either "nominally acceptable" or not?)*. Armed with these simple answers an agency could as a matter of project development policy implement a performance-based design decision approach across the two dimensions of safety.

There are many reconstruction projects in which one or more geometric features do not meet current criteria and standards. This case is very typical of roads designed and constructed more than 30 years ago when design standards were much different. If the existing safety performance record meets or exceeds (is better than) the agency's threshold of acceptability, the agency may reasonably and confidently scope the project as a 3R project, retaining the basic geometry and thus avoiding incurring of potentially substantial construction costs as well as avoiding or mitigating environmental conflicts and additional right-of-way acquisition. The key insight is that applying HSM knowledge can prevent costly investments made in the name of safety when no actual benefit or return from such investments should be expected.

Purpose and Need

The identification of the fundamental reason for the project – its "purpose and need" is among the most important project drivers. This should be a performance-based determination, whether the problem is pavement or bridge condition, delay, travel time or level of service, or safety. Clearly, the HSM offers the best means of establishing a science-based and hence defensible approach to defining whether the performance of the facility merits "safety" being mentioned as part of its purpose and need.

Project Planning, Alignment, and Alternative Studies

HSM methods and concepts have clear application to development of project alternatives. Indeed, the forerunner of the HSM, FHWA's Interactive Highway Safety Design Model, which executes through software the predictive methods in Part C of the HSM, is an interactive tool to be used during the design process to iterate and understand implications of design decisions in the same way that cost analysis and estimation tools are used to understand differences in quantities and construction costs. Applications apply not only to projects involving the same highway type, but also studies in which a different type is envisioned. The best example of these is conversion of an existing two-lane highway to a multilane facility. Such projects often involve multiple alignments and can include different cross sections.

One insight gained through training sessions of state DOT staff is that the manner in which Part C can be used may vary. In fact, many designers may never actually use the HSM to calculate the anticipated long-term safety performance of a site such as the one being designed (predicted average crash frequency) or the long-term performance of an existing site (expected average crash frequency). But merely using the HSM Part C as a reference, designers can easily gain insights on the relative safety performance of design alternatives they typically consider, and adjust their thinking about how to make good design decisions.

The training of designers has focused, for the most part, on the importance of nominal safety. Many designers have been taught that adherence to nominal safety directly translates into substantive safety performance. The following list presents general understanding by designers unfamiliar with the highway substantive safety knowledge base in the HSM:

- Many designers overestimate the relative importance of 0.5-foot or 1-foot differences in lane width to substantive safety on two-lane rural highways;
- Many designers overestimate the effect of relatively minor changes in alignment on crash frequency;
- Many designers lack the ability to assess the order of magnitude of expected crash frequency (the long-term anticipated average project safety performance) as a function of traffic volume; and
- Many designers assume that the design criteria in the AASHTO Policy on Geometric Design are based on safety performance, and that even modest changes in design dimensions carry significant safety risk.

Managers can encourage designers to learn and apply the HSM knowledge base even if they will not actually apply the predictive methods. In doing so, the quality of their work will be greatly enhanced. The ability of a designer to consider substantive safety is strongly dependent on a sound understanding of HSM concepts and the science of safety captured in Part C of the HSM (predictive method) and positive guidance principles described in Chapter 2 of the HSM. The National Highway Institute has a number of courses that has more of a road design focus:

- HSM Applications to Two-Lane Rural Roads (FHWA Resource Center Webinar);
- HSM Applications to Urban/Suburban Intersections (FHWA Resource Center Webinar);
- HSM Applications to Rural Intersections (FHWA Resource Center Webinar);
- HSM Applications to Multilane Highways (FHWA Resource Center Webinar);
- HSM Application to Urban/Suburban Roads (FHWA Resource Center Webinar);
- HSM Applications to Rural Multilane Intersections (FHWA Resource Center Webinar);
- HSM Applications to Horizontal Curves (FHWA Resource Center Webinar); and
- HSM Relationship to Roadway Departure Crashes (FHWA Resource Center Webinar).

Also, AASHTO produced a three-hour webinar on Flexibility in Design that provides background on the relationship of design criteria to performance and offers insights on design decision-making in reconstruction.

Application of the HSM in day-to-day activities should follow training as soon as possible. Direction and technical assistance may be necessary during these initial efforts to use the HSM.

The extent to which the HSM can be immediately used following training to inform the design process depends on several factors. With state-specific calibration factors or state-specific SPFs already available, designers can quantify actual long-term expected safety performance of a facility, considering both the number and severity of crashes.

Several states are currently in the process of calibrating HSM Safety Performance Functions (SPF) and the development of state or region-specific SPFs. During this development period, designers can still use the HSM Part C to assess *relative* differences among alternatives within the same facility type and control type. However, the output from an HSM SPF cannot be used or described as an actual prediction, as it lacks the necessary calibration factor. Calibration of the HSM SPFs is necessary for full predictive capability because the SPFs in the HSM are based on the data from a subset of states. Differences in crash data quality, roadway inventory data, traffic volume counts and estimations, minimum crash reporting thresholds, topography and weather conditions are but some of the factors that vary among states that may impact the number and severity of crashes.

Managers will need to weigh the advantages and disadvantages of promoting the immediate use of the HSM and the timing of delivery of training for staff in states with SPF or calibration development efforts that may take some time. Rather than hold off on training or any use of the HSM, the identification of implementation opportunities before the training would be useful. The training can then include some discussion of the particular approach that the agency will take in terms of implementation of the HSM in the project development process.

Design and Context Sensitive Solutions

In many projects, conflicts can occur between what a designer may perceive as the best design (i.e., one that is nominally safe) and what may be achievable due to environmental constraints or conditions, public acceptability and availability of right-of-way. Context Sensitive Solutions as outlined by AASHTO and NCHRP Report 480 addresses these four critical success factors:

- Employ effective decision-making;
- Reflect community values;
- Achieve environmental sensitivity; and
- Deliver safe and feasible solutions.

Virtually all aspects of project development have evolved to state in which DOTs can provide quantitative, high-quality data on the performance of an alternative, with the exception until now of safety performance. Indeed, the extent of safety analysis frequently applied to contentious or difficult projects is the nominal safety model. With HSM methods and approaches, agencies can better fill in the missing piece and not only make better decisions but have the basis for explaining and defending their decisions.

The final step in the initial planning part of the project development process is identification of a preferred design alternative. This is typically done when design is about 30 percent complete, i.e., when the alignment and cross section are established. The HSM can then be used to perform predictions of safety performance compared to other alternatives, or to a "no-build" option.

Preliminary and Final Engineering

As the selected concept is detailed, changes may occur. Other major design decisions such as maintenance of traffic plans are developed. During preliminary engineering the design documentation is prepared and approvals sought. It is during this stage that design exceptions may be fully outlined, studied, and approved.

Design exceptions – the use of a design value outside the established criteria for the project, are a common and indeed routine part of project development. A design exception represents an acceptance that the design will not be "nominally safe." Some designers and some agencies resist design exceptions either because of tort liability fears or their genuine belief that safety performance (substantive safety) will be compromised.

The HSM offers concepts and methods for design engineers to understand the implications of their actions and thus improve decision-making. Insights evident in applying the predictive methods and CMFs, include the following:

- Traffic volume is an important determinant of relative risk. A design exception on a road with 1,000 vpd will clearly have less risk than one with a volume of 10,000 vpd;
- The length of highway over which the exception occurs strongly influences relative risk; and
- The design element or feature in question (lane width, shoulder width, superelevation, curvature, grade) will have differing expected sensitivities based on the type of facility.

Designers attuned to the nominal safety model but not to the contents of the HSM may have a mindset that any change of a standard design parameter would result in a significant change in the safety performance of the facility. For example, a reduction in lane width from 12 feet to 11 feet may thought to be reducing safety performance substantially in an abrupt and immediate manner, i.e., the change makes the facility *unsafe* and 12 feet made the facility *safe.* Actual or substantive safety performance is, however, does not represent such an absolute change in safety but rather a gradual change in safety. It is important to keep in mind that such a relationship with substantive safety may not even exist. Designers who have learned about substantive safety, and marginal or incremental changes in safety performance suggested by CMFs and predictive models, will understand the change in safety is likely gradual and be able to act accordingly. Several states that started with the implementation of the HSM reported that the HSM adds value to the evaluation of design exceptions and the documentation process.

Besides allowing designers to quantify the impact of design exceptions, the HSM also offers the opportunity to quantify potential safety performance benefits of mitigation strategies at locations where design exceptions are considered. The FHWA *Mitigation Strategies for Design Exceptions* (FHWA 2007) offers a resource to design managers.

Operations and Maintenance

The HSM includes information to inform those charged with operating and maintaining the system. Full knowledge and application of the HSM contents in this area may lead agencies to rethink or revise their operating strategies. Examples may include incorporating quantitative safety consideration when timing of signals (provision for protected only left-turn phasing), considering access management strategies, decides when to allow or prohibit of on-street parking, and even maintenance in adverse weather conditions: snow removal strategies.

Managers studying the HSM may find that the 1st edition of the HSM is limited in offering quantitative safety information for all operations and maintenance activities. As with the first edition of the Highway Capacity Manual (HCM), the expectation is that over time, the HSM will be updated to reflect the growing body of research on the impact of maintenance and operational effects on crash frequency and crash severity.

4. Summary

Agency officials often cite safety as their top priority. With the adoption and use of the HSM, states may be in a position to evaluate, program, design, and construct facilities with an understanding of their quantitative safety performance. The investment by AASHTO and FHWA in the development the HSM was driven by a belief that improved scientific knowledge of safety performance would produce significant benefits. Such benefits go well beyond projects or programs that are “safety-based,” but rather all projects and all activities.

Deriving full value from the HSM will only occur if states and other agencies adapt their organizations and business processes to enable its implementation. Careful planning and management of an implementation effort is necessary. In addition to completing obvious tasks such as training, database development and management, agencies will want to examine their internal program and project development policies and risk management procedures. Finally, states should anticipate the need to engage their project delivery staff in a dialogue on the reasons for implementation, with specific emphasis on the benefits that will be achieved for the agency and their customers.

DOT managers charged with policy and program development, staff development, and ultimately accountability to their customers should make every effort to assist their agency and partner agencies in the development and execution of an HSM implementation program.

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6. Resources

On-Line

HSM – http://www.highwaysafetymanual.org.

IHSDM – http://www.ihsdm.org.

SafetyAnalyst – http://www.safetyanalyst.org/.

Introduction to the HSM Video produced by AASHTO: http://bcove.me/hbct8mxu.

FHWA Crash Modification Factors Clearinghouse: http://cmfclearinghouse.org.

Publications

FHWA, 2011. *HSM Training Guide*, Federal Highway Administration: Office of Safety, http://safety.fhwa.dot.gov/hsm/training.

NCHRP Synthesis 316, *Design Exception Practices*, http://trb.org/publications/nchrp/nchrp_syn316.pdf.

NCHRP Research Results Digest 306, *Identification of Liability-Related Impediments to Sharing Section 409 Safety Data Among Transportation Agencies and A Synthesis of Best Practices*, http://trb.org/publications/nchrp/nchrp_rrd_306.pdf.

7. List of Acronyms

AASHTO	American Association of State Highway Transportation Officials
CMF	Crash Modification Factors
DOT	State Department of Transportation (a general term used to describe the state agency that is responsible for the design and maintenance of the state transportation highway network)
FHWA	Federal Highway Administration
HCM	Highway Capacity Manual
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
IHSDM	Interactive Highway Safety Design Model
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
RSAP	Roadside Safety Analysis Program
SPF	Safety Performance Functions
SPR	State Planning and Research
TRB	Transportation Research Board
VPD	Vehicles per Day

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