SUMMARY **REPORT**

Crash Modification Factors Needs Assessment Workshop

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Executive Summary

The Federal Highway Administration (FHWA) hosted a Crash Modification Factor (CMF) Stakeholder Meeting to provide a forum for CMF stakeholders to communicate ongoing efforts and identify opportunities for future collaboration. CMF stakeholders represent two primary groups: the CMF user community (transportation agencies and practitioners) and the CMF research and development community (individuals and agencies who plan, fund, direct, and carry out CMF research). Bringing these stakeholders together provided an opportunity to share insights and resources to further advance the research and development of CMFs and related activities.

The meeting was arranged around five primary topic areas. The first was current CMF-related activities, which allowed time for each stakeholder to identify their roles, responsibilities, and current efforts with respect to the development and application of CMFs. The second topic of discussion was CMF research needs, which included a summary of the results of a CMF gap analysis. The third topic focused on resources (e.g., data) to support the development of CMFs. The fourth topic, advancing highway safety, focused on research methods, technologies, and innovation. The final discussion was a recap of the overarching themes and focused on future opportunities to advance the state of the practice. The remainder of this section provides further details on each of the topic areas, summarizing current CMF development efforts and highlighting key opportunities for the future.

FHWA, the Transportation Research Board (TRB), and State transportation departments are the primary sponsors of research to develop CMFs. CMFs are developed through individual research projects, such as those under the National Cooperative Highway Research Program (NCHRP), which is a division of TRB. CMFs are also developed under a large FHWA effort, the Development of Crash Modification Factors (DCMF) Program. Most individual projects are subject-specific; CMFs are developed for a particular strategy or set of strategies. The objective of the DCMF Program is to develop numerous CMFs for diverse strategies. There is an opportunity for better coordination among these groups to avoid duplication of efforts.

Several other groups conduct crash-based research that may or may not result in the development of CMFs. These groups include the AAA Foundation for Traffic Safety (AAA-FTS), Insurance Institute for Highway Safety (IIHS), National Highway Traffic Safety Administration (NHTSA), and Federal Motor Carrier Safety Administration (FMCSA). For example, the IIHS has conducted several studies to estimate the safety effectiveness (i.e., CMFs) of strategies such as speed enforcement cameras, roundabouts, centerline rumble strips, and red-light-running cameras. The AAA-FTS developed the U.S. Road Assessment Program (usRAP), which includes "risk factors" to estimate the safety performance of a roadway based on the design and operational characteristics of that specific road.

CMFs serve a similar function as the risk factors in usRAP. There may be future opportunities to coordinate efforts with these groups to develop CMFs. There may also be opportunities to coordinate with or use the results of other safety or operational effectiveness studies to develop specific CMFs. The ultimate goal is for these groups to develop CMFs as part of their research to expand the use of their results.

Outreach to safety stakeholders, particularly decisionmakers for planning and funding research, was identified as a critical component to advancing the development, use, and understanding of the importance of CMFs. FHWA, TRB, the Institute of Transportation Engineers (ITE), the Roadway Safety Foundation (RSF), and others currently play an active role in stakeholder outreach through various initiatives such as conferences, journals, webinars, and workshops. For example, ITE leadership has identified CMF needs through informal conversations with their members. There is an opportunity to expand and formalize ITE's efforts, including coordination with FHWA and TRB. There is also a need to coordinate the prioritization of CMF needs, identification of training needs, identification of proper training mechanisms, and dissemination of results. RSF could be engaged to coordinate with decisionmakers on the need for and importance of CMFs.

The development and advancement of CMFs is dependent on the availability of quality data. Several databases are currently used to develop CMFs, including the Highway Safety Information System (HSIS), the Fatality Analysis Reporting System (FARS), and State and local roadway and crash databases. Other existing data sets may serve as resources, including the FMCSA analysis and information (A&I) online database and IIHS insurance data. There are also new and forthcoming databases that hold promise for developing CMFs, such as the Strategic Highway Research Program 2 (SHRP2) roadway information database and naturalistic driving data. In addition to current databases, there is a need for databases to support CMF development, including a mechanism to track new strategies and innovations so that CMFs can be developed in a timely manner.

In summary, there are many opportunities to advance the development, use, and understanding of CMFs by fostering partnerships with national organizations, other Federal agencies, and State and local partners. These partners provide an opportunity to better understand CMF needs, a source of data and sponsorship for research, and a mechanism for outreach to the vast CMF community.

Preface

The CMF Stakeholder Meeting was sponsored by FHWA's DCMF Program. The DCMF Program was established in 2012 to address highway safety research needs for evaluating new and innovative strategies by developing reliable quantitative estimates of their effect on crash frequency and severity.

The ultimate goal of the DCMF Program is to save lives and reduce injuries by identifying new safety strategies that effectively reduce the frequency and severity of crashes and promote them for nationwide installation by providing measures of their safety effectiveness and benefit-cost ratios through research. As the first step toward this goal, a DCMF task, *New Statistical Methodologies and Improving the Current Ones for Highway Safety Research,* was conducted in cooperation with the American Statistical Association (ASA) in December 2012 to build a foundation for advancing research. This task will be continued through follow-up studies and by implementing a Marketing, Communication, and Outreach Plan targeting the statistician community for developing new expertise, technical tools, and innovative highway transportation specific methodologies.

The DCMF task *CMF Gap Analysis, Research Needs, and Stakeholder Meeting* presents the second step toward the overall goal of the DCMF Program. This effort included a gap analysis of CMFs, identification and prioritization of current and future CMF research needs, and a CMF Stakeholder Meeting to communicate ongoing efforts and identify opportunities for future collaboration.

Background

FHWA hosted a CMF Stakeholder Meeting on May 28, 2014, at the Turner-Fairbank Highway Research Center. The objectives of the CMF stakeholder meeting were as follows:

- Brief stakeholders about the DCMF Program, Evaluation of Low Cost Safety Improvements Pooled Fund Study (ELCSI-PFS), and CMF Clearinghouse, including activities, products, and how they are used.
- Brief CMF stakeholders on the FHWA findings of the DCMF task for identifying CMF gaps and research needs and seek feedback on these findings, current/near future related activities, and how stakeholders may partner and/or share resources with FHWA for meeting current CMF research needs for selected high priority safety areas.
- Brief CMF stakeholders on the FHWA findings of the DCMF task *New Statistical Methodologies and Improving the Current Ones for Highway Safety Research* for building a sound foundation for advancing highway safety research and seek feedback on these needs and activities and how they may partner and/or share resources with FHWA for meeting future CMF research needs.
- Obtain information on CMF-related efforts being conducted by stakeholders, including: 1) safety concerns and how they are/were measured or validated through data, 2) innovative approaches and tools/technologies implemented to address their safety concerns, and 3) possible future efforts and partnerships for advancing highway safetyresearch, new strategy developments, and technology innovations.
- Identify action items to prepare solid ground for future CMF research in separate categories (e.g., data collection and improvements, statistical methodologies, new strategy developments, innovative science and technologies, and technology transfers), and identify partners for carrying these identified actions forward. This objective may include an introduction to planned future DCMF and stakeholder activities.
- Encourage CMF-related communications and partnering that will advance these objectives, and include an action item for direct communication and its frequency for stakeholder's updates/exchange to FHWA.

Working toward these objectives, the project team, in consultation with FHWA, planned a 1-day CMF stakeholder meeting to bring together members from both the CMF user community and CMF research and development community, which are described as follows:

- **CMF User Community:** This group includes the practitioners who incorporate CMFs into their safety analyses and apply them to their projects; personnel from State transportation departments are key members of this group. There are 38 State transportation departments that provide technical feedback on safety improvements to the DCMF Program and implement new safety improvements to facilitate evaluations. These States are members of the ELCSI-PFS that functions under the DCMF Program. The list of participating State transportation departments and their primary contact is provided in table 4 in appendix A.
- **CMF Research and Development Community:** This group includes the agencies and individuals who plan, fund, direct, and carry out the research and development of CMFs and activities related to their application and prioritization. Each community has insight and resources that may be shared to further advance the research and development of CMFs and related activities. A list of United States Department of

Transportation (USDOT) and partner agencies is provided in table 6 in appendix A, along with their primary contact.

Enhancing communication and collaboration among these groups will help streamline future safety efforts related to the research, development, and application of CMFs. Table 4 and table 6 in appendix A represent an initial list of CMF stakeholders. The intent is to help facilitate communication and coordination among CMF stakeholders. The contact lists in table 4 and table 6 in appendix A should be updated regularly and expanded over time as other stakeholders are identified.

Organization of White Paper

This summary report focuses on the outcomes and feedback from the CMF stakeholder meeting. The detailed agenda is included in appendix B. The meeting was arranged around the following topics, and this summary report follows a similar flow:

- CMF-related activities.
- CMF gap analysis and research needs.
- Resources to support DCMF efforts.
- Advancing highway safety—research methods, technologies, innovation.
- Looking to the future.

CMF-Related Activities

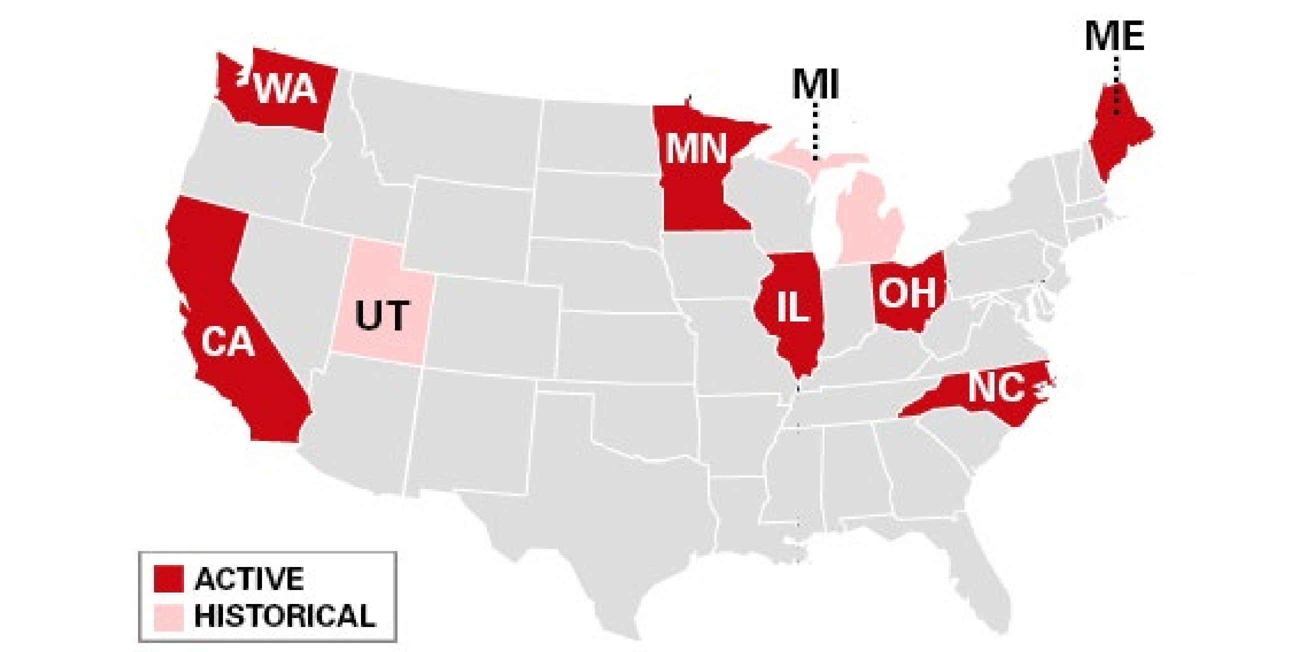
This section provides a brief summary of information exchange and related activities conducted by the various CMF stakeholders in the CMF Stakeholders Meeting.

FHWA Office of Safety Research & Development (R&D)

Roya Amjadi provided an overview of the CMF-related activities conducted by the FHWA Office of Safety R&D. The primary efforts include hosting data, conducting CMF research, and encouraging innovation. A summary of these efforts is as follows:

- **Data:** The FHWA Office of Safety R&D sponsors and houses HSIS, a multistate database of select States that contains crash, roadway, and traffic volume data. Figure 1 identifies the active and historical States contributing data to HSIS. CMF researchers can request data from HSIS in support of their efforts to develop

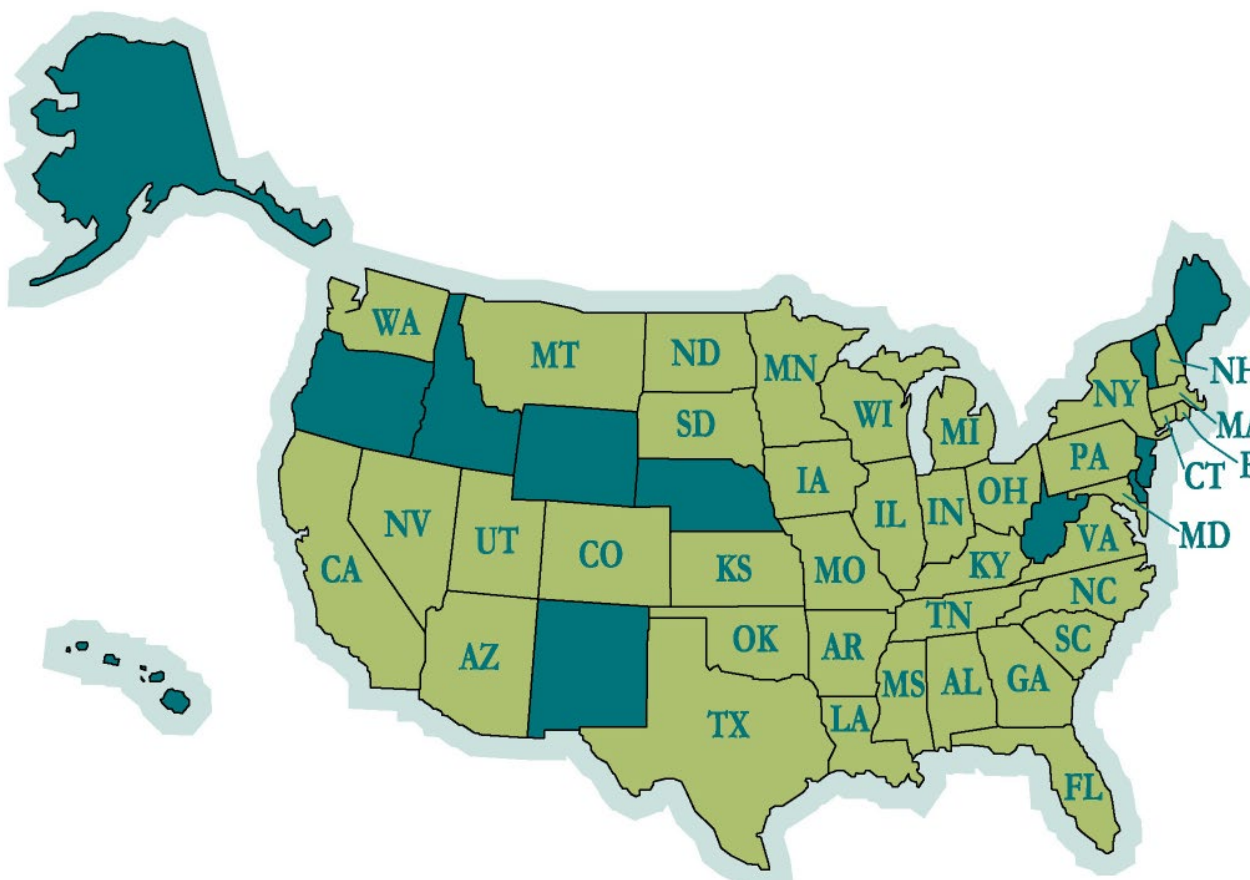
Figure 1. HSIS States.



CMFs or advance the science of CMFs. The data are available free of charge, and additional information about HSIS can be found at http://www.hsisinfo.org. The FHWA Office of Safety R&D is also establishing the Safety Training and Analysis Center (STAC), which will provide support to the research community and State transportation departments in using data from SHRP2. The SHRP2 data will be available in two components: 1) a Roadway Information Database (RID), and 2) a Naturalistic Driving Study (NDS) database. Additional information on the STAC is available at http://www.fhwa.dot.gov/research/resources/stac.cfm.

- **CMF Research:** The FHWA Office of Safety R&D encourages and facilitates communication, coordination, and collaboration with and among State transportation departments and other stakeholders to conduct CMF and related research. Specifically, they sponsor research to evaluate the safety effect (i.e., develop CMFs) of existing, new, and innovative strategies by working with the State transportation departments and researchers to collect data for existing strategies (retro-respective study), or install new safety strategies and then collect data for evaluations (build-to-evaluate study). They are the lead agency for the DCMF Program as well as the ELCSI-PFS, which includes 38 State members as shown in figure 2. At the time of this report, the FHWA Office of Safety R&D had sponsored the evaluation and development of CMFs for more than 40 strategies. Under efforts such as the DCMF Program, the FHWA Office of Safety R&D also sponsors research and efforts

Figure 2. ELCSI-PFS participants.



to improve statistical analysis methods used to develop CMFs and efforts to network and cooperate with CMF stakeholders to advance safety research.

- **Encourage Innovation:** The FHWA Office of Safety R&D encourages innovation by supporting research and development of strategies before large-scale deployment. This is facilitated through their human factor labs, including a large-scale highway driving simulator, a mini-sim driving simulator, and a sign lab. The human factors lab is able to support research that originates within and outside the FHWA Office of Safety R&D. Additional information on the human factors lab is available at http://www.fhwa.dot.gov/research/tfhrc/labs/humanfactors/index.cfm.

FHWA Office of Safety

Karen Scurry provided an overview of the CMF-related activities conducted by the FHWA Office of Safety. In general, the FHWA Office of Safety sponsors activities related to both the application and development of CMFs, including the development of the CMF Clearinghouse, CMF-related guidance, and CMF-related training. They are also working to coordinate outreach efforts to improve the quality of CMFs. A summary of these efforts is as follows:

CMF Application Efforts

- **CMF Clearinghouse:** This is a one-stop shop for CMFs and related resources. The Web site shown in figure 3 was established to provide a regularly updated online repository of CMFs. It serves as a search engine, allowing users to search for CMFs for a specific countermeasure. The CMF Clearinghouse summarizes published information on each CMF, including how it was developed (e.g., study design, sample size, and source of data) and what its statistical properties are (e.g., standard error). In addition to the CMFs, 10 there are several CMF-related

Figure 3. CMF Clearinghouse (http://www.cmfclearinghouse.org).

resources linked from the CMF Clearinghouse at http://www.cmfclearinghouse.org.

- **CMFs in Practice:** This is a series of guides that illustrate the value and demonstrate the practical application of CMFs in the project development process. The *CMFs in Practice* series includes five separate guides that identify opportunities to consider and quantify safety in specific activities, including: 1) Roadway Safety Management Processes, 2) Road Safety Audits, 3) Design Decisions and Exceptions, 4) Development and Analysis of Alternatives, and 5) Value Engineering. Each guide includes a step-by-step demonstration of how CMFs can be applied in the specific activity, a case study to show real-world application of CMFs, discussion of potential challenges in applying CMFs, and opportunities to overcome those challenges. Additional information is available at http://safety.fhwa.dot.gov/tools/crf/resources/cmfs.

- **National Highway Institute (NHI) Course 380093 (Application of CMFs):** The FHWA Office of Safety partnered with NHI to develop this introductory course on CMFs. After completing the course, participants should be able to do the following:
    - Explain how CMFs are used to estimate the safety effects of highway improvements.
    - Apply CMFs to compare and select highway safety improvements.

  Additional information is available at http://www.nhi.fhwa.dot.gov.

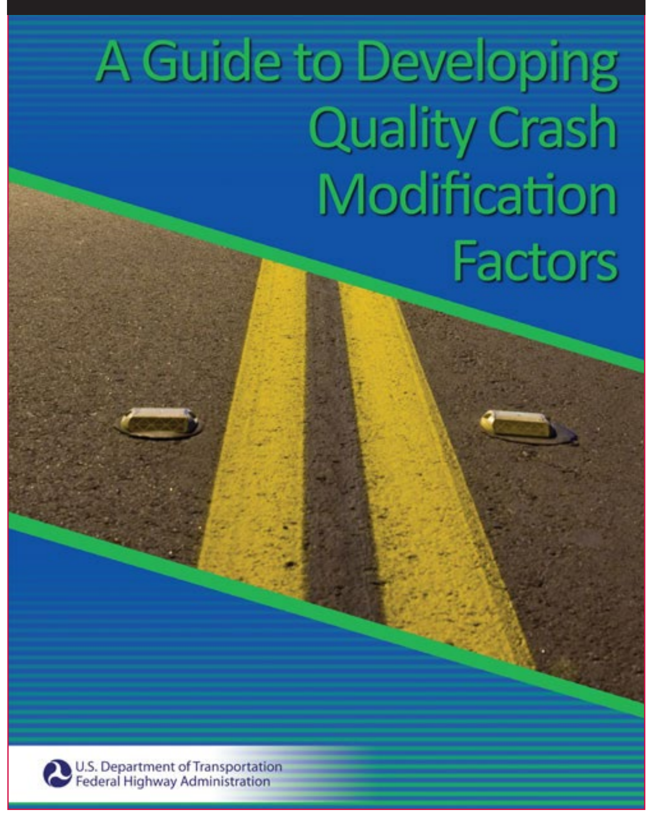
- **NHI Course 380094 (Science of CMFs):** The FHWA Office of Safety partnered with NHI to develop this advanced course on CMFs. After completing the course, participants should be able to do the following:
    - Explain the concepts of CMFs and the measurement of safety.
    - List and describe important statistical issues that affect safety research.
    - Describe and compare three methodologies for evaluating the safety effect of a countermeasure.
    - Select the most appropriate CMF for a given application.

  Additional information is available at: http://www.nhi.fhwa.dot.gov.

CMF Development Efforts

- **A Guide to Developing Quality CMFs:** This guide provides direction to those interested in developing CMFs. It opens with a general discussion of CMFs, including definitions, purpose and application, and general issues related to CMFs. The document identifies several methodologies for developing CMFs, including an overview of each method, sample size considerations, strengths, and weaknesses. It also provides a process for selecting the most appropriate method. The guide is shown in figure 4, and additional information is available at http://www.cmfclearinghouse.org/collateral/CMFGuide.pdf.[1]

Figure 4. *A Guide to Developing Quality Crash Modification Factors.*



- **CMF Development Training:** The FHWA Office of Safety is again partnering with NHI to develop a course that will guide participants through the CMF development process. At the time of this report, the course development had just started, and the final course is expected by June 2015. After completing the course, participants should be able to do the following:
    - Identify the various study designs used to develop CMFs, their data needs, and associated strengths and limitations.
    - Select an appropriate study design based on the resources and quantity/quality of data available.
    - Apply various methodologies to develop CMFs and assess the quality of the results.
    - Document the appropriate elements of a CMF development effort.
- **Coordinating Outreach Efforts:** The FHWA Office of Safety is currently working to improve the quality of CMFs by coordinating outreach efforts. In support of this effort, they are working to develop a draft outreach strategy that will include standardized Request for Proposal (RFP) language for CMF research sponsors, sharing guidelines for developing CMFs, sharing information on paper reviewers and research sponsors, hosting TRB/NCHRP webinars, and providing training and technical assistance.

FHWA Resource Center

Patrick Hasson provided an overview of the CMF-related activities conducted by the FHWA Resource Center Safety and Design Technical Service Team. In general, the FHWA Resource Center assists with technology deployment and provides technical assistance. The following is a summary of these efforts:

- **Technology Deployment:** This includes packaging new information and delivering it to customers and partners. Examples include Highway Safety Manual (HSM) training courses such as the HSM for locals, incorporating CMFs into existing courses, and promoting technologies and strategies such as roundabouts.
- **Technical Assistance:** This involves responding to requests and special needs of customers and partners. For example, the Resource Center may be called upon to help examine alternatives that will provide the best safety results from investment.

The FHWA Resource Center works in close partnership with FHWA Headquarters and Office of Safety R&D to develop and deliver the best products and services possible to meet the safety challenges in the United States. Examples of coordination efforts include the Joint Strategic Plan and tactical roadmaps and spending plans.

FMCSA

William Bannister provided an overview of the CMF-related activities conducted by the FMCSA. In general, the FMCSA has not developed CMFs in the past because their safety initiatives are not roadway-specific but company-, vehicle-, and driver operation-related. They do, however, collect and analyze data to evaluate crash risk factors. The following is a summary of their efforts:

- **Data:** There are more than 500,000 interstate freight carriers, 12,000 interstate passenger carriers, and 15,000 intrastate hazardous materials carriers registered with FMCSA, with more than 3 million drivers and 4 million trucks and buses. Data are collected annually from nearly 4 million annual roadside inspections, mostly by State personnel; 10,000 to 30,000 warning letters and 18,000 to 20,000 motor carrier investigations, mostly done by FMCSA safety investigators; and 130,000 FMCSA-reportable crashes, submitted by States from police accident reports. They have established a robust data quality program to continually evaluate and improve the data, including a State Safety Data Quality (SSDQ) map. Specifically, FMCSA uses nine data quality performance measures to assess the timeliness, completeness, and accuracy of inspection and crash data reported by the States. The SSDQ map has been a real incentive to the States to achieve and maintain "green" status.

- **Data Analysis:** FMCSA uses data to identify individual commercial motor carriers (companies) who present a safety risk. Their enforcement program—Compliance, Safety, Accountability (CSA)—uses data to prioritize individual carriers for inspections or investigations. FMCSA also conducts extensive analysis to determine which violations of the Federal Motor Carrier Safety Regulations have the strongest relationship to crash risk, as well as the relationship between past crashes and future crash risk. Similar to safety performance functions, they have developed algorithms with weights assigned to each violation or crash type and further weighting based on how "old" the data are to produce a scoring system to rank carrier safety performance with respect to their "peers." The data analysis is used to support rulemaking, performance measurement, and outreach programs.

- **Reporting:** FMCSA compiles data in their Safety Measurement System (SMS) and publishes analysis results on their A&I Web site, where it is publicly available. The motor carriers have access to their respective detailed data, including personal identifying information such as driver license numbers. Other users such as shippers, freight brokers, insurance companies, safety advocacy groups, the press, and the general public can view the SMS data on all carriers in the system.

More in line with CMFs, FMCSA has developed the following two models to assess the effectiveness of its safety programs:

- **Roadside Intervention Effectiveness Model:** For all motor carriers that received a roadside inspection, this model estimates crash reduction to determine the impact of the intervention. Different types of violations are assigned different crash risks, time periods of effectiveness, and correction rates based on a violation severity assessment. The reductions in crashes are combined for all carriers, and an estimate of crashes avoided, injuries prevented, and lives saved are calculated.

- **Carrier Intervention Effectiveness Model:** This model employs a before-after comparison of crash rates for motor carriers receiving any one of the types of CSA enforcement investigations or warning letters employed by FMCSA. The carriers are grouped by size to account for differences in operations. All data are assessed for errors and outliers, which are removed. Results are then tested for statistical significance. The model calculates the change in crash rates for all carriers not receiving an intervention and subtracts any improvement in crash rates for this comparison group from the change calculated for those getting an intervention in an attempt to isolate the change attributable to the interventions. This modified change in crash rates for those receiving an intervention is used to then calculate crashes avoided, injuries prevented, and lives saved.

NHTSA

Kristie Johnson provided input for the meeting, highlighting NHTSA's related efforts. In general, NHTSA focuses on countermeasures to address driver behavior issues. While they do not develop CMFs per se, there is an opportunity to coordinate efforts and promote effective strategies along with the associated safety impact (CMF or otherwise). The following is a summary of NHTSA's related efforts:

- **Countermeasures that Work:** This guide is published biennially and serves as a basic reference to assist State Highway Safety Offices (SHSO) in selecting effective, evidence-based behavioral countermeasures for traffic safety problem areas. The safety problem areas include alcohol-impaired and drugged driving; seat belts and child restraints; aggressive driving and speeding; distracted and drowsy driving; motorcycle safety; young drivers; older drivers; pedestrians; and bicycles. The guide serves the following purposes:
    - Describes major strategies and countermeasures that are relevant to SHSOs.
    - Summarizes countermeasure use, effectiveness, costs, and implementation time.

- Provides references to the most important research summaries and individual studies.

- **Pedestrian and Bicyclist Countermeasure Primer for SHSOs:** *Countermeasures that Work* is limited to behavior-focused countermeasures that States can fund with grant funds distributed by NHTSA. While it is appropriate for SHSOs to focus on behavior-based countermeasures eligible for funding, the most effective safety programs are comprehensive, integrating infrastructure and engineering countermeasures with outreach, education, and enforcement. This guide helps raise awareness of engineering strategies targeting pedestrians and bicyclists that are proven to be effective at reducing pedestrian and bicyclist injuries and fatalities. Having a basic knowledge and awareness of engineering countermeasures and relevant jargon allows decision makers to be mindful of what is already in place in their community and permits more effective communication among safety professionals.

- **Effect of Electronic Device Use on Pedestrian Safety:** This study will quantify the impacts of electronic device use on pedestrian safety. At the time of this report, the study was underway and included the following tasks:
    - Review literature on pedestrian and driver device use and distraction as it relates to pedestrians' risk of injury or death in traffic conflicts with motor vehicles.
    - Collect naturalistic observations to quantify distraction related to drivers' and pedestrians' use of electronic devices during pedestrian-vehicle interactions.
    - Collect and analyze data from pedestrian-vehicle crashes to quantify the frequency and severity of crashes that involve pedestrians' and drivers' use of electronic devices.

National Academies of Sciences (NAS)

Bernardo Kleiner and David Plazak provided an overview of the CMF-related activities conducted by NAS. TRB is the primary division associated with CMF-related activities within NAS. TRB provides leadership in transportation innovation and progress through research and information exchange. TRB is supported by State transportation departments, Federal agencies, and other organizations and individuals interested in the development of transportation. The following is a summary of TRB's CMF-related efforts:

- **Technical Activities:** The TRB Technical Activities Division supports standing committees and task forces, organizes the TRB Annual Meeting and other conferences and workshops, and conducts field visits to transportation agencies, organizations, and research institutions. There are two standing committees that are heavily involved in CMF-related activities: 1) ANB20: Safety Data, Analysis, and Evaluation, and 2) ANB25: Highway Safety Performance. These committees are involved in the identification and prioritization of research needs, the development of research needs statements, and the marketing of completed research.

- **Studies and Special Programs:** The TRB Studies and Special Programs Division convenes specially appointed expert committees to conduct policy studies and program reviews, maintains the Transportation Research Information Services database, provides library services, prepares synthesis reports on behalf of the Cooperative Research Programs, and manages the Innovations Deserving Exploratory Analysis programs.

- **Cooperative Research Programs:** The TRB Cooperative Research Programs Division manages NCHRP, the Transit Cooperative Research Program (TCRP), the Airport Cooperative Research Program, the National Cooperative Freight Research Program, and the Hazardous Materials Cooperative Research Program. Many CMF development efforts and related research are funded through NCHRP projects.

- **SHRP2:** The TRB SHRP2 Division manages a targeted, short-term, results-oriented program of contract research, designed to advance highway performance and safety for U.S. highway users. Two databases are being developed under SHRP2: the RID and the NDS databases. The RID contains existing data taken from Esri and State roadway inventories, as well as data recently collected on approximately 12,500 centerline mi from six study States. The NDS database includes data representing normal driving habits from more than 3,100 participants of various ages across the country. Included in the NDS database are more than 5 million trips, 49 million travel miles, and 1.4 million driving hours, making this the largest naturalistic driving study ever undertaken. These databases are further described in table 6 through table 9 in appendix C and will be used to support future research related to CMF development and improvement.

American Association of State Highway Transportation Officials (AASHTO)

Kelly Hardy provided an overview of the CMF-related activities conducted by AASHTO. In general, AASHTO represents highway and transportation departments in the 50 States, the District of Columbia, and Puerto Rico, serving as a liaison between State transportation departments and the Federal government. AASHTO is a standards-setting body that publishes specifications, test protocols, and guidelines that are used in highway design and construction throughout the United States. The following is a summary of CMF-related efforts:

- **HSM:** The HSM is an AASHTO publication, but AASHTO works closely with the FHWA Office of Safety and the TRB Highway Safety Performance Committee on issues related to the HSM. The HSM presents a variety of methods for quantitatively estimating crash frequency or severity on various facility types. CMFs are used in the predictive methods from part C of the HSM, and there is an entire section of the HSM (part D) that presents CMFs for various countermeasures. Part D is divided into five chapters, presenting CMFs separately for roadway segments, intersections, interchanges, special facilities, and road networks.
- **Standing Committee on Highway Traffic Safety (SCOHTS):** SCOHTS and the associated Subcommittee on Safety Management (SCOSM) identify and prioritize safety research needs, including research related to CMF development. Specifically, research needs statements are developed by members of the research community (within and outside of SCOHTS), and members of SCOSM review and assess the merit of those statements. The top-ranking statements are then submitted to the AASHTO Standing Committee on Research for funding. Those statements selected for funding are then included in the next cycle of NCHRP projects.
- **AASHTO Innovation Initiative:** This initiative was formerly known as the Technology Implementation Group (TIG). Members involved in this initiative identify products or processes likely to yield significant economic or qualitative benefits. It is a systematic approach for putting new technologies into day-to-day practice, similar to the FHWA Every Day Counts (EDC) initiative and FHWA Proven Countermeasures. Specifically, this initiative designates "champions" to promote technologies, which can then be implemented and evaluated. Examples of technologies promoted under the former TIG include severe-duty crash attenuators, sequential flashing warning lights for work zones, grade crossing electronic document management systems, linear referencing systems, cable median barriers, road safety audits, and intelligent transportation systems in work zones.

AAA-FTS

Doug Hardwood, MRI Global, provided an overview of AAA-FTS's efforts on behalf of Peter Kissinger from AAA-FTS. While AAA-FTS has not developed CMFs by name, they have developed usRAP, which is a planning-level tool to help highway agencies better understand the risk of crashes on specific road segments. The usRAP tool incorporates risk factors, which are equated to CMFs, to quantify the change in risk associated with a change in a given roadway characteristic. The following is a summary of two components of the usRAP tool:

- **Risk Mapping:** The usRAP risk mapping protocol assists highway agencies in characterizing the risk of crashes on specific road segments based on crash and traffic volume data. Agencies can use the usRAP risk maps to see how well their road system is performing and direct resources rationally toward systematic improvement of their road system.
- **Safer Roads Investment Protocol:** The usRAP safer roads investment protocol is available to help plan a cost-effective program of highway infrastructure improvements to enhance safety. The safer roads investment plan provides preliminary recommendations of countermeasures for implementation at specific locations to improve safety. An advantage of the usRAP Tools software is that the safety plans are based on roadway characteristics data and do not require detailed, site-specific crash data.

IIHS

Wen Hu provided an overview of the CMF-related activities conducted by IIHS. In general, IIHS is dedicated to reducing losses—deaths, injuries, and property damage—from crashes on the Nation's highways. Their sister organization, the Highway Loss Data Institute, shares and supports the mission through scientific studies of insurance data representing the human and economic losses resulting from the ownership and operation of different types of vehicles and by publishing insurance loss results by vehicle make and model. Both organizations are wholly supported by auto insurers and guided by the Haddon Matrix, which identifies interactions among the driver, vehicle, and environment during pre-crash, crash, and post-crash events. CMFs are most directly applicable to the environment during the pre-crash and crash stages. For example, roundabouts, posted speeds, and other design features affect the likelihood of a crash. Roadside features such as breakaway devices and roadside barriers affect the severity of a crash. The following is a summary of CMF-related efforts:

- **Roundabouts:** IIHS conducted a comprehensive safety evaluation of roundabouts and concluded that the conversion of stop- and signal-controlled intersections to roundabouts could result in a 40 percent reduction in all crashes, an 80 percent reduction in injury crashes, and a 90 percent reduction in fatal and incapacitating injury crashes at the treated locations. Furthermore, they noted that if 10 percent of signalized intersections in the United States were converted to roundabouts, then the following changes would occur:
  - Approximately 46,000 crashes would have been prevented in 2012, including 184 fatal crashes and 31,000 injury crashes.
  - Vehicle delays would have been reduced by more than 900 million h.
  - Fuel consumption would have been reduced by more than 600 million gal.
- **Red Light Cameras:** IIHS conducted a study of red-light cameras in Arlington, VA, to evaluate their safety effectiveness. They observed large reductions in red-light violations that occur late in the red interval (i.e., 1.5 s or longer after onset of red light) compared to the number of expected violations without cameras. They also conducted a study of red-light cameras in Oxnard, CA. They reported reductions in total, injury, and right-angle crashes, with substantial reductions (nearly 70 percent) in right-angle injury crashes.
- **Speed Cameras:** IIHS studied the safety effects of speed cameras in 2003 and 2008, including the cities of Scottsdale, AZ;

Montgomery County, MD; and Washington, DC. In all three locations, they observed reductions in the proportion of vehicles exceeding the speed limit by more than 10 mi/h after camera enforcement. Compared to other sites, there was an 88 percent reduction in Scottsdale, a 70 percent reduction in Montgomery County, and an 82 percent reduction in Washington, DC.

- **Speed Limits:** In 1999, IIHS published a study on the safety impacts of the repeal of the national maximum speed limit.
- **Ongoing Research:** Other ongoing research topics related to the roadway environment include the following:
  - A national study of the effects of speed limit changes on fatal crash rates.
  - A study of the effects of stop-sign cameras and crosswalk cameras on violations.

ITE

Ed Stollof provided an overview of the CMF-related activities conducted by ITE, an international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. Its members represent a wide cross-section of CMF stakeholders, including academia/education, consultants, the Federal government, State governments, and local governments. These members conduct CMF-related research, develop and distribute CMFs, and use CMFs on a daily basis. The following is a summary of CMF-related efforts:

- **Education:** Through surveys and existing professional development/training, ITE has determined that many practitioners and younger members lack knowledge of basic statistics, appropriate methodologies, and how to use CMFs.
- **CMF Distribution:** ITE shares information on CMFs through *ITE Journal* articles and HSIS supplements; the *Journal of Transportation of the Institute of Transportation of Engineers;* training and workshops; professional development; district, section and chapter meetings; and its annual meetings. Examples include the following:
  - ITE Alaska Section Transportation Safety Committee: Focuses on best practices that incorporate the HSM, CMF development, and safety performance function calibration. This provides a forum for discussion.
  - FHWA-MODOT-LTAP-KCITE-OCITE-CMCITE: Workshop on the Missouri Guidebook updating *Introduction to Traffic Practices: A Guidebook for Local Agencies* (2013). Included section on HSM and use of CMFs.
  - CITE Chapter (Toronto, Canada, Workshop): University of Manitoba ITE Chapter hosted a CMF Clearinghouse seminar.
- **Everyday Practice:** ITE members use CMFs in all phases of the project development process, including transportation planning, environmental documentation, alternatives analysis, investment decisions and cost benefit/analysis, preliminary engineering and design, and road safety audits.
- **Identifying CMF Needs:** ITE has compiled a list of CMF needs based on years of member conversations. The following is a summary of identified CMF-related needs.
  - Context matters: CMF users are not only designing curves or alternative intersections. They are planning, designing, and operating facilities within the context of communities. They are designing for Complete Streets and Sustainable Communities. Therefore, CMFs with appropriate detail to describe the context would be most beneficial. Applicable context may include area-type (e.g., urban/downtown core, urban, suburban town center, suburban low density, rural/suburban transition, and rural), land use patterns, regional differences, traffic safety culture/cultural differences (e.g., differences

in seatbelt laws, alcohol laws, and posted speeds), and sociodemographic factors.

- CMFs are needed for many more pedestrian, bicycle, and multimodal strategies, including bicycle lanes, cycle tracks (one- and two-way), mid-block pedestrian crossings, by area-type, by type (e.g., basic painted crosswalk, pedestrian hybrid beacon, median refuges), addition of "x" bus stops with safe pedestrian crossings within "x" mile segment, and transit signal priority systems (intelligent transportation systems (ITS) operations).
- CMFs are needed for design elements related to Complete Streets and Sustainable Communities.
- CMFs are needed for additional traffic engineering/operational features, including adaptive signal control technology, traffic signal optimization/retiming, illumination by area type (e.g., increase from base to point 1 or increase from base to point 2), speed reduction (by area type) such as urban centers on main streets (e.g., from 30 to 20 mi/h, from 35 to 25 mi/h), and access management (e.g., reduction in density of unprotected left turns or reduction in density of driveways).
- CMFs are needed for ITS/technology strategies, including speed cameras by area type (e.g., schools versus other urban, suburban, freeways, arterials), red-light cameras, road weather information/management systems, and dynamic message signs.
- Future research may include the development of CMFs for vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) technologies. Cooperative Intersection Collision Avoidance Systems is an example of V2I technology. Examples of V2V include blind-spot warnings, do-not-pass warnings, intersection warnings, forward-collision warnings, and rollover warnings.

International Efforts

Patrick Hasson provided an overview of international CMF-related activities. In general, the international community is actively developing CMFs and conducting CMF-related research. Many countries are facing similar issues in terms of methodology, transferability, and applicability of CMFs. The following is a summary of CMF-related efforts:

- **International Transport Forum (ITF):** The ITF is a forum at the Organization for Economic Cooperation and Development, an intergovernmental organization with 54 member countries. ITF acts as a strategic think tank that convenes at an annual summit of ministers along with leading representatives from industry, government, and academia. ITF's Research Centre gathers statistics and conducts cooperative research programs, and the research findings are discussed at the annual summit and widely disseminated to support policymaking in member countries. In 2012, ITF published *Sharing Road Safety: Developing an International Framework for Crash Modification Functions.*[2] This report focuses on international collaboration to promote the rigorous development of CMFs and increase the potential for transferability of CMFs among countries. The report does the following: 1) identifies issues related to the development and application of CMFs, 2) evaluates obstacles related to international collaboration on the development of CMFs, 3) identifies opportunities to promote collaboration, 4) examines the international transferability of CMFs, and 5) presents a theoretical basis for assessing countermeasure effectiveness in a framework that is based on the quality and consistency of individual studies.
- **International CMF Clearinghouse:** Hasson noted that the international safety community is interested in developing an International CMF Clearinghouse, similar to the one developed in the United States.

State Transportation Department Efforts

State transportation departments are actively involved in the entire spectrum of CMF-related activities. The following is a high-level overview of State transportation department involvement in CMF-related activities:

- State transportation departments help identify and prioritize CMF development needs.
- State transportation departments implement strategies and collect data that can then be used to support the development of CMFs and CMF-related research.
- State transportation departments provide funding through their Strategic Planning and Research funds to support NCHRP projects to develop national CMFs and conduct CMF-related research.
- State transportation departments serve on NCHRP panels to oversee and guide CMF-related research projects.
- State transportation departments fund other research projects to develop state-specific CMFs.
- State transportation departments develop CMFs in-house.
- State transportation departments apply CMFs throughout the project development process to support decisionmaking.

CMF Gap Analysis and Research-Needs Prioritization

Daniel Carter and Frank Gross presented the results of a CMF gap analysis and research-needs prioritization. The gap analysis and prioritization was a multistep process, including an inventory of existing CMFs and ongoing research, the identification of research needs, and the prioritization of research needs. These three steps are described below.

Inventory of Existing CMFs and Ongoing Research

In order to identify the gaps in CMF research, it is crucial to begin with a firm understanding of what CMF knowledge currently exists and what research is in progress to develop additional CMFs. This effort included a detailed query of the CMF Clearinghouse and TRB's Research in Progress (RiP) database. Using these two sources, a comprehensive database of existing and forthcoming CMF knowledge was developed.

The applicability of CMFs is an important consideration in the identification of knowledge gaps. For example, a CMF may be available for roundabouts, but if that CMF only applies to the conversion of rural, stop-controlled intersections to roundabouts, then there are clear gaps (e.g., a CMF would be needed for urban, stop-controlled conversions as well as rural and urban signalized conversions). As such, the inventory of existing and ongoing CMF research included several details related to the applicability. Where available and applicable, the following details were identified and included in the inventory:

- CMF identification number.
- Star quality rating.
- Countermeasure category.
- Countermeasure subcategory.
- Countermeasure name.
- Combined countermeasure name.
- CMF or CMFunction.
- Cost/benefit ratio or other benefit.
- Crash type.
- Crash severity.
- Crash time of day.
- Roadway type.
- Number of lanes.
- Area type.
- Intersection type.
- Intersection geometry.
- Traffic control type.
- Prior condition.
- Inclusion in HSM.

- State/municipality.
- Country.
- Type of study methodology.
- Standard error.
- Sample size (total).
- Sample size (before).
- Sample size (after).

In total, more than 4,700 existing/forthcoming CMFs were identified for the inventory. The inventory provided a starting point for identifying and prioritizing CMF research needs. Beyond this effort, the inventory of CMFs provides a structure and template for tracking ongoing CMF-related research. It will be important to update this resource periodically to assist with future CMF prioritization efforts.

Identification of Research Needs and Gaps

Current CMF research needs were identified by examining a variety of sources. A recent NCHRP study, *NCHRP Project 17-48: Highway Infrastructure and Operations Safety Research Needs*, provided a starting point.[3] The NCHRP study developed a list of general safety research needs, including CMF research needs, based on a review of the sources identified in table 1. Note that several of the sources have not been updated since the time of the study, while others had to be re-reviewed for the latest CMF-related needs.

The CMF-related research needs were extracted from the list developed under NCHRP Project 17-48 and supplemented with additional needs based on a review of the following sources:

- CMF Most Wanted List (based on searches made on the CMF Clearinghouse Web site).
- Feedback from CMF Clearinghouse focus groups and webinars.
- Emails from CMF Clearinghouse users.
- Lists of experimental installations (*Manual on Uniform Traffic Control Devices* (MUTCD) and the National Association of City Transportation Officials).
- Countermeasures not evaluated in research studies (i.e., NCHRP 17-56 had 10 countermeasures on their initial list but only sufficient budget to evaluate 4).
- States using CMFs that have little or no research backing (i.e., investigate State Web sites for their published list of CMFs used in the State).
- Past input and questions from practitioners (National Safety Engineers Listserv, AASHTO/HSM online forum).
- International CMF-related research needs based on input from Pat Hassan.

In the future, there is a need to consult ITE for a list of CMF needs. Ed Stollof presented a list of CMF needs based on input from ITE members.

The CMF research needs identified from these various sources were compiled into a database for comparison with the inventory of existing/forthcoming CMFs. This step was necessary to identify and remove research needs that were already addressed or are being addressed through ongoing research. Table 2 illustrates the general structure for comparing identified CMF research needs with the existing/forthcoming CMFs. In this way, potential gaps were identified and carried forward for prioritization. The columns under "Perceived Need" identify the countermeasure category, specific countermeasures, and applicable scenario based on the identified research needs. The "Source" notes where the CMF research need was identified, and it is possible that multiple sources identified the same research need. The final set of columns under "Comparison to Resource Database" indicates whether existing/forthcoming CMFs are available to address the need. Note again the importance of proper details to define the specific CMF gap as indicated by the applicable crash type, crash severity, and area type. The star quality rating is also noted for reasons explained previously.

Prioritization of Research Needs

The final step included a preliminary prioritization of research needs to identify high-priority countermeasure categories and individual countermeasures within the categories. A prioritization scheme was

Table 1. Sources of research needs for NCHRP Project 17-48.	
Source of Research Topics	**Mechanism for Extracting Topics**
Research needs, as defined in *Toward Zero Deaths: A National Strategy on Highway Safety.*[4]	Review of plan and review of topic-area white papers.
Knowledge gaps identified in the HSM.	At end of each chapter in part D of the HSM, there is a section on treatments where more research is needed. In addition, several CMFs in the HSM are not supported by details about their source studies such as exposure, target crash, site and roadway specification, and area type. These were also considered and developed for different scenarios of applications (e.g., two lane-rural roads and urban arterials).
Knowledge gaps identified in work plan for 2nd edition of the HSM (NCHRP 20-07(279))	Contact Dr. Dan Turner, principal investigator.
High-priority knowledge gaps identified in NCHRP Report 617, *Accident Modification Factors for Traffic Engineering and ITS Improvements.*[5]	Review of report. Note that this project included a survey of State transportation department safety engineers for research topic ideas. Responses were from 34 States.
Research needs identified by States.	Ballot results from previous ELCSI-PFS Technical Advisory Committee ballots.
Research Problem Statements from key TRB Committees.	Problem statements from committees are located at http://rns.trb.org/.
Unfunded high-priority NCHRP projects.	Obtain from TRB staff (e.g., Mark Bush).
Input from FHWA's EAR Program.	Contact David Kuehn (david.kuehn@dot.gov), EAR program manager, and Kunik Lee (kunik.lee@dot.gov), EAR program coordinator in Safety R&D.
Input from FHWA Office of Safety and Office of Safety R&D on unfunded needs.	Contact FHWA Safety R&D and FHWA Office of Safety for information and additional contacts.
Input from FHWA Safety R&D ITS Safety Program on unfunded needs.	Contact Greg Davis (gregory.davis@dot.gov), ITS Safety Program Manager.
Research topics identified in FHWA's Pedestrian Strategic Safety Plan (draft).[6]	Obtain report from author (and 17-48 principal investigator) Charlie Zegeer.
Topics identified by the National Highway Research and Technology Partnership.[7]	*Review of Highway Research and Technology—The Need for Greater Investment* (2002), including "Highway Infrastructure and Operations" section of appendix, available at http://onlinepubs.trb.org/onlinepubs/rtforum/safety_agenda_july_2001.pdf.
AAA-FTS's Traffic Safety Issues of the Future: A Long Range Research Agenda, (2006).[8]	Review of report, available at http://www.aaafoundation.org/pdf/FuturesReport.pdf.
Knowledge gaps identified in Special Report 292 review of white papers.[9]	Review appendix B, Comments on Individual Projects Described in White Papers Commissioned by the Federal Highway Administration.
Research needs identified in FHWA's HSIS project for potential internal research (unpublished).	Review listing prepared by HSIS project staff.
SHRP2 prioritized listing of run-off-road and intersection research topics.	Review draft report: *S02 Integration of Analysis Methods and Development of Analysis Plan. Phase 1 Report.*[10]
Knowledge gaps identified by international research organizations.	Contact staff at institutes in Australia, Canada, France, Germany, Netherlands, New Zealand, Norway, Sweden, and the United Kingdom. Contact staff at multinational sites—OECD, International Transport Forum/ Joint Transport Research Centre), World Health Organization, others.

EAR = Exploratory Advanced Research.
OECD = Office of Economic Development.

Table 2. General structure for identifying gaps.

Perceived Need				Comparison to Resource Database				
Category	Countermeasure	Applicable Scenario	Source	Existing/ Forth-coming CMFs	Applicability			Star Rating
					Crash Type	Crash Severity	Area Type	
Pedestrian	Rectangular rapid flashing beacons	Urban and Rural	CMF Most Wanted List	Yes	Unknown	Unknown	Unknown	Unknown
	Countdown signals	Urban	CMF Most Wanted List	Yes	Unknown	Unknown	Unknown	Unknown

developed based on how many sources identified a particular need and whether there is existing/forthcoming information on the topic. The prioritization also considered the quality of existing CMFs.

For example, a gap may be identified where the only available CMF is based on a simple before-after study with limited data. This type of gap, however, would be less of a priority than a gap in which there are no CMFs currently available. The preliminary prioritization scheme is represented by a simple tiered structure, arranging the research needs as follows:

- Research needs identified by multiple sources and have no existing/forthcoming CMFs.
- Research needs identified by multiple sources and have limited existing/forthcoming CMFs.
- Research needs identified by one source and have no existing/forthcoming CMFs.
- Research needs identified by one source and have limited existing/forthcoming CMFs.
- Research needs that have fairly complete or high quality existing/forthcoming CMFs.

The high-level results of the gap analysis and prioritization were shared with the participants during the CMF stakeholder meeting. The results were also shared with those involved with the international effort on the joint transferability of CMFs.

Resources to Support DCMF Efforts

In addition to CMF-related research needs, it is important to understand the availability of resources to support CMF development efforts. As such, several safety databases were identified that could be used to help CMF stakeholders accomplish the following tasks:

- Identify and prioritize current CMF research needs (i.e., those already proposed).
- Identify, prioritize, and coordinate future CMF research that will yield more reliable CMFs and may be more cost-effective than current practices. The relevant questions for future research needs include the following:
    - What resources are available and how can they be used?
    - What parties can be involved?
    - What tools are available and do better ones exist or can improvements be made to existing tools?
    - What are the methodological needs and what efforts are needed or underway to meet those needs?
- Support and advance innovation in safety countermeasures to further reduce crash

fatalities and severe injuries associated with prioritized safety needs.

- Identify current FHWA efforts and emerging statistical methodologies (e.g., those discussed at the recent Technical Experts Meeting for statisticians held under a separate DCMF task) that may support current needs, identify appropriate stakeholders that could be involved in promoting this effort, and determine priority research needs that have not been identified.

There are several existing databases to support the development of CMFs, but most provide crash-based data. The following databases were identified, under the DCMF task to identify CMF research needs, as relevant to supporting the four tasks listed previously:

- FARS.
- General Estimates System.
- Crashworthiness Data System.
- National Motor Vehicles Crash Causation Study (NMVCCS).
- Crash Injury Research and Engineering Network.
- Motor Carriers Management Information System.
- Federal Transit Administration National Transit Database.
- National Emergency Medical Services Information System.
- SHRP2 RID and NDS.
- National Park Service Service-wide Traffic Accident Reporting System.
- HSIS.

Table 6 through table 9 in appendix C provide a summary of these databases, including critical aspects of each database with respect to CMF development. Specifically, table 6 through table 9 in appendix C provide summary information such as the sponsoring agency, data coverage, data years, data availability, and database content. The last row of each table identifies the applicability to Tasks A–D.

Advancing Highway Safety

The majority of the discussion during the CMF Stakeholder Meeting was focused on sharing current efforts in the interest of advancing highway safety. Specific discussions on advancing highway safety included research methods, technologies, and innovations. The following is a summary of the related presentations and discussion.

Current Predominant Methodologies for CMF Development

Study designs can be classified as experimental or observational studies based on cross-sectional or before-after data. In an experimental study, sites are identified for some treatment and randomly assigned to either a treatment or control group that is left untreated. The treatment and control groups are identified before implementation of the treatment. In an observational study, the treatment is implemented at some sites, not on the basis of a planned experiment but on engineering considerations, including safety. While experimental studies are common in other fields such as medicine, observational studies are more common in road safety research in view of the ethical concerns with experimentation in road safety.

For both experimental and observational studies, a before-after design is usually preferred to a cross-sectional design. For the before-after design, the CMF is estimated from the change in crash frequency between the periods before and after the implementation of a treatment at a given site or group or sites. For the cross-sectional design, the CMF is estimated by comparing crash frequency across sites with different characteristics (i.e., with and without treatments). In either case, there is a need to account for changes in safety due to factors other than the treatment of interest.

There are several types of potential bias that may arise in before-after and cross-sectional studies. In a before-after study, it is necessary to account for other changes over time (e.g., changes in traffic volume, weather, demographics, and vehicle characteristics). It is also necessary to either dismiss or account for changes related to regression-to-the-mean, which is related to the random variation in crashes over time. In a cross-sectional study, it is necessary to account for differences among the sites with and without treatment. Potential biases related to before-after and cross-sectional studies are described in the NCHRP 20-7(314) Final Report, *Recommended Protocols for Developing Crash Modification Factors.*[11]

FHWA's *A Guide to Developing Quality CMFs* further describes the variations of before-after and cross-sectional methods that are commonly used to develop CMFs.[1] Types of before-after studies include the simple, comparison group, and Empirical Bayes before-after methods. Cross-sectional methods include simple cross-tabulation and regression-based modeling. The key takeaway is that not all methods are created equal, where some are better than others at accounting for potential biases. For example, the simple before-after method does not account for changes in traffic volume, regression-to-the-mean, or other temporal trends. In general, the Empirical Bayes (or Full Bayes) before-after method is the current gold standard for developing CMFs.

Identifying Opportunities to Advance Current Methods

The TRB Annual Meeting provides a forum for researchers and practitioners from all sectors (public, private, industry, and academia) to share their research needs and latest advancements. In total, there are 480 committees and panels with 4,600 committee members. Several standing committees work to advance the science of highway safety, including ANB10 (Transportation Safety Management), ANB20 (Safety Data, Analysis, and Evaluation), and ANB25 (Highway Safety Performance). Other committees support the advancement of the science of safety (e.g., ABJ80: Statistical Methods) although their primary mission is not focused on highway safety. These committees and their members work to identify research needs, conduct research, and disseminate research findings through the TRB annual and mid-year meetings.

There is an opportunity to develop a compendium of TRB papers that focus on statistical methodologies applicable to highway safety evaluations under the DCMF program in the near future. In 2015, it is expected that more than 4,500 papers will be presented at the TRB Annual Meeting. These papers, some seemingly unrelated, represent incremental advances in the science of safety. Advances may include refinements to an existing process, testing of statistical distributions, and specific applications to data. The compendium of TRB papers on statistical methodologies for highway safety evaluations would identify and make recommendations for reliable and advanced methodologies, and highlight opportunities and areas of need so that CMF stakeholders, researchers, academics, and other interested parties can advance highway safety research.

Advancing Methods in Transportation Statistics

The use of statistics has advanced in highway safety over the last 20 years. Methodologies have been borrowed from various statistical fields and adapted for use in highway safety analysis. Some methods have very specific and limited applications (e.g., Empirical Bayes before-after method) while others are applied more generally (e.g., tests of proportions and significance). While there have been substantial advancements in the science of safety, many of these methods have limitations in capability and applicability when used for highway safety research.

There is a need to develop new highway-specific statistical methodologies and to further tailor existing statistical methodologies to highway safety application. Specifically, there is an immediate need for methodologies to advance the development of CMFs, CMFunctions, and safety performance functions (SPF). Another short- to long-term need is to develop more statistical tools for effective use of available data resources.

Until recently, limited data have been a primary challenge in highway safety analysis. In response, FHWA and others have worked to improve data capabilities through guidance such as the Model Minimum Uniform Crash Criteria and the Model Inventory of Roadway Elements, as well as technical assistance efforts such as the crash data improvement program, roadway data improvement program, and the roadway safety data program. As data become more robust, reliable, and readily available, there will be a similar advancement in the development and improvement of analytical tools.

FHWA is making a concerted effort to enhance statistical methodologies for highway safety research. Roya Amjadi presented on the related FHWA efforts, including the assessment and use of statistical methodologies under the DCMF Program. As part of the DCMF Program, FHWA hosted a technical experts meeting of statisticians from various fields to help assess existing methods in highway safety analysis. FHWA is also working to sustain this effort through better coordination with ASA. The results of the technical experts meeting is documented in a separate white paper, *Enhancing Statistical Methodologies for Highway Safety Research—Impetus from FHWA.*[12]

Tracking Technologies and New Strategies

The acceptance and implementation of a new strategy is not a trivial process. To accept a new strategy, practitioners must have sufficient knowledge of the strategy and confidence that it will result in a safety benefit (i.e., credible CMF). Practitioners must also have approval, funds, and expertise to implement a new strategy. The lifecycle of a strategy includes the following steps:

1. **Early Development:** In the early development phase, a concept or initial product is developed based on an expressed need or idea. This may result in simulator testing or closed environment deployment (i.e., test track).
2. **Introduction to Market:** The introduction to market includes pilot field implementations, analysis of small-scale implementations based on safety surrogate measures (e.g., speed, lane keeping, road user opinion surveys), and anecdotal evidence (e.g., discussions with agencies to collect information on ease of implementation, treatment cost, durability, and level of effectiveness). The limited introduction to market helps to verify acceptance before deploying on a larger scale.
3. **Evolution of Knowledge:** The evolution of knowledge begins with the analysis of small-scale implementations when the strategy is introduced to the market. As a strategy gains acceptance, there may be additional implementations by the pilot agency with additional analysis to update the previous results. Over time, implementations may spread to other agencies and provide an opportunity to evaluate the effectiveness under different conditions (e.g., urban/rural, different traffic volumes). Eventually, the goal is to conduct a statistically rigorous evaluation of the safety performance of the strategy based on multiple sites in multiple States/regions. The evolution of knowledge is satisfied when the safety performance is quantified with confidence.
4. **Dissemination of Knowledge:** The lifecycle does not end with evaluation. Instead, it is important to communicate the results of the evaluation so that others can use the information to improve future decisions.

The speed at which a strategy progresses through the lifecycle depends on a number of factors, including how well the strategy is tracked. For example, the early development depends on how well an idea or need is conveyed to those responsible for further developing those ideas. The introduction to market depends on how well the strategy performs in the pilot tests and how well the results of those tests are communicated. The evolution of knowledge depends on data from sites where the strategy is implemented, so it is critical for agencies to track where and when they implement safety improvements.

To increase the speed at which a strategy progresses through the lifecycle, there is a need for increased information sharing throughout the process. Specifically, a method is needed to track new strategies and technologies as they are developed and deployed on the Nation's roadways. The recommended process for tracking new strategies and technologies would include a single entity performing the search and maintaining a database, but in cooperation and coordination with other stakeholders. The leadership of a single entity will help avoid duplication of efforts. Table 3 presents a simplified layout for a recommended tracking mechanism.

Table 3. Potential structure for tracking mechanism.

Strategy	Potential Opportunity	Implementation Status	Current Monitoring
Strategy A	Strategy is designed to prevent run-off-road crashes.	Strategy implemented in one State (NC) at five sites.	NCDOT is conducting a before-after study of the impact of the strategy on speeds. Results expected in August 2014.
Strategy B	Strategy is designed to increase the visibility of pedestrians at midblock crossings.	Strategy was demonstrated at ATSSA meeting. It has not been installed in the United States.	Vendor has kept in communication with FHWA regarding U.S. installations.
Strategy C	Strategy is designed to increase the conspicuity of traffic signals.	Strategy is installed in five States (TX, NC, SC, PA, and MI), totaling 450 deployments.	Wayne State University is conducting a rigorous EB evaluation. Results expected in January 2015.

ATSSA = American Traffic Safety Services Association.
EB = Empirical Bayes.
NCDOT = North Carolina Department of Transportation.

The recommended tracking mechanism would identify each new strategy or technology along with specific information related to the potential opportunity, implementation status, and current monitoring. The potential opportunity describes the intended use of the strategy (targeted safety issue). The implementation status helps define the point at which the strategy is in the lifecycle process (e.g., idea, concept, pilot, wide-scale deployment, or acceptance). Information related to current monitoring would help identify the level of evaluation and recent/ongoing efforts to evaluate and disseminate the results.

Information on the current state of new strategies and technologies is held by somewhat disparate groups, including vendors, State and local practitioners, university researchers, private consultants, and several Federal agencies. A successful tracking process must access and assemble information from this wide range of sources. Again, it is recommended that a single entity lead the tracking effort with support from other stakeholders.

Potential venues or sources of information to populate the tracking database include the following:

- Trade shows and expositions at major conferences, including the American Traffic Safety Services Association (ATSSA) meeting, TRB annual meeting, and ITE annual meeting, among others. There is great potential for future coordination with ATSSA, and it may be possible to initiate conversations regarding a roundtable discussion at the ATSSA 2015 annual meeting. ATSSA has an invited the Circle of Innovation portion to their annual meeting that may be appropriate.
- Listservs that are used by practitioners to discuss their experiences with safety strategies and technologies.
- FHWA Request to Experiment Database maintained by the FHWA MUTCD Team.
- Vendor product and technology marketing material made publicly available for marketing purposes.
- Annual Highway Safety Improvement Program (HSIP) reports. HSIP reports are submitted annually by each State to describe progress in implementing highway safety improvement projects, including project effectiveness. The reports include a general listing of projects, such as the improvement category/subcategory, project output (e.g., miles of rumble strips), project cost (HSIP cost and total cost), funding category, roadway characteristics (e.g., functional classification, annual average

daily traffic, and posted speed), roadway ownership, and relationship to the State's strategic highway safety plan. Benefits include the collection of all HSIP projects in one location, and the States are required to report projects that have been funded. Potential challenges are that only HSIP projects are reported, projects are only associated with one improvement category, and improvement categories are not specific enough to identify specific strategies.

- Anecdotal information reported by States on their experiences and media requests.
- Research findings presented at conferences or published in leading journals. Because the tracking is focused on new technology, these findings would not include CMF research. Instead, the research of interest would include non-crash-based studies of the new technology, such as studies of the effect on operations (e.g., speed) and other surrogate measures (e.g., conflicts) through simulation, pilot demonstrations, or limited field implementation.

The tracking mechanism could be populated with the information from the following sources using one or more methods (e.g., having a single entity provide oversight and quality control of the database and employing crowdsourcing to help input strategies and using technical support contractors to track known strategies and implementations):

- **DCMF Program:** The selected project team would explore each of the potential sources to identify this information. For example, a member of the project team would attend one or more national trade shows (such as ATSSA) and actively pursue this information from the exhibit floor, visiting vendors to discuss their new strategies and technologies and collecting ancillary product material. The findings would be populated into the tracking mechanism and date stamped. This could be supplemented by reviews of publicly available vendor marketing materials such as Web sites and product brochures. Implementation information would be collected concurrently from practitioners by querying listservs or conducting surveys. The advantages of this method are that there is an existing contract mechanism in place, the task is related to the overall goals of the contract, and the contract team has extensive contacts in the community that would support this work. The disadvantage is that it might need to include a survey, which would require Office of Management and Budget approval. Additionally, the information collected would need to be maintained after the task and contract ended.
- **FHWA or NCHPR Initiative:** Similar to the DCMF method, another FHWA contract or NCHRP initiative could be used to collect the information using a similar method. The advantage of this approach is that there may be an opportunity to tie into other related efforts. The disadvantages are that it might require a new contract mechanism, a survey may also be needed, and, again, the information will need to be maintained after the contract ends.
- **Crowdsourcing:** Crowdsourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people (especially from an online community) rather than from traditional employees or suppliers. Using this method, an editable version of the tracking table would be posted in a publicly available location such as on a Wikipage or similar. The advantages of this method are that it casts the widest possible net and may be very inexpensive. The disadvantages are that the quality of the information may be lower and there is no incentive to populate the data.

Looking to the Future

Through the course of the CMF stakeholder meeting, there were several underlying themes around which the conversation revolved. Four specific themes were included: 1) CMF Opportunities, 2) Data and Methods, 3) Coordination and Training, and 4) Innovation, Technology, and Other. The remainder of this section provides a summary of the discussion related to the four overarching themes, focusing on short- and long-term efforts to advance CMF developments.

CMF Opportunities

The following is a summary of existing CMF efforts and future opportunities:

- **Identifying CMF Needs:** The CMF Needs Assessment and Gap Analysis identified and prioritized CMFs for future development. The primary needs were related to pedestrians, access management, alignment, bicyclists, intersection geometry, and on-street parking. The following are additional CMF needs and opportunities:
  - These needs were confirmed by Ed Stollof of ITE, who presented the CMF needs from the ITE community. Other high-priority CMF needs identified by the ITE community include CMFs for multi-modal, complete streets, and ITS/technology-related strategies. Beyond specific CMFs, there is a need to identify and consider the context in the CMF development process. For example, there could be CMFs for various land use and area types (e.g., urban central business district, low-density suburban, high-density suburban). It may be possible to get this information now if there is a concerted effort to promote the proper documentation of CMFs. There is an opportunity to incorporate advice from the ITE community in future CMF needs assessments and prioritization efforts.
  - Topics of interest identified by the HSM community include speed, vulnerable users, and roadside hazards (trees). Behavioral countermeasures will also be included in the next edition of the HSM. There is a need for more comprehensive outreach to help with the prioritization of CMF research needs. Specifically, the AASHTO SCOHTS, Subcommittee on Traffic Engineering, and Subcommittee on Design would likely have input on CMF needs and priorities.
  - There is the potential to incorporate CMF needs from FMCSA. FMCSA would like to develop a priority list of needs after seeing the list created under this effort, including the safety effects of a Smart Park truck parking tool (i.e., what is the safety risk associated with large trucks parked at the on/off ramps at rest areas or other highway locations?). In conjunction with the Smart Park initiative, another CMF could potentially be developed for crashes involving large, parked trucks and buses. More research is needed to determine the feasibility of this CMF, as well as coordination to identify potential partners and funding sources.
- **Disseminating CMF Needs:** There were several sources of CMF needs identified in this paper. Beyond the identification and prioritization of CMF needs, there is a need to communicate the prioritized list to the CMF stakeholder community. There is an opportunity to post the results of the CMF Needs Assessment and Gap Analysis to the CMF Clearinghouse. This would help researchers and research sponsors as they allocate funding to various research programs and projects. A related effort is needed to communicate the status and details of ongoing CMF research to minimize duplication of efforts.
- **Tracking Ongoing CMF Research:** There is a need for researchers, research sponsors, and other CMF stakeholders to understand ongoing efforts with respect to advancing the science of CMFs. Better tracking and coordination of efforts will help minimize redundancies and duplication of effort, allowing funding to be spent to address other CMF needs. The TRB RiP database is an existing resource that could help with this issue. One limitation of the RiP database is that it relies on stakeholders to enter and update information on their respective studies. As such, the completeness and quality of the database is dependent on the participation and thoroughness of stakeholders.
- **Improving CMF Research:** The FHWA Office of Safety is currently working to improve the quality of CMFs by coordinating outreach efforts. In support of this effort, they are working to develop a draft outreach strategy as discussed previously. It will be important to

target the potential audiences with the correct message. CMF research sponsors will need to be informed of the standardized RFP language and the advantages of including it in their scope of work. CMF developers will need to be aware of the various guidelines and training courses for developing CMFs. There may be an opportunity to change the layout and/or functionality of the Clearinghouse to raise awareness of the situational use of CMFs. Specifically, the user would be asked to identify the specific context of their scenario (e.g., area type, intersection type) to help convey the importance of context.

- **Relationship between Speed and Safety:** There is a need to incorporate or better account for speed in the development of CMFs. Specifically, there is the potential for some strategies to affect vehicle speeds either positively or negatively, which can affect the potential safety effectiveness. For example, traffic-calming measures are intended to reduce traffic speeds and volumes. As vehicle speeds are reduced, there is a potential safety benefit related to increased time for recovery, reduced stopping distances, and improved survivability (i.e., reduced risk of injury/fatality given a crash). In other cases, there is the potential for vehicle speeds to increase with the installation of certain strategies due to increased driver comfort and confidence. For example, repaving roadways and the installation of raised pavement markers would be expected to improve safety, but studies have shown safety disbenefits in some cases. There is a need to better quantify the relationship between speed and safety and how this relationship translates to the safety effectiveness of strategies that can affect speed.
- **Combining Multiple CMFs:** There is a need for a method to combine individual CMFs to better understand the safety effectiveness of multiple treatments. A current study is underway (NCHRP Project 17-63) to develop such a method, but further research may be necessary to fully understand or separate individual effects of multiple treatments.
- **Transferability of CMFs:** There is a need to better understand the transferability of CMFs within and among States. CMFs are developed for specific scenarios (e.g., urban, four-legged, signalized intersections). It is necessary to understand if the CMF value would change if the specific scenario changes. It is also necessary to understand if CMFs change among States where there are other notable differences in characteristics such as climate, terrain, driver populations, and overall safety culture (e.g., seatbelt laws, alcohol laws, and posted speeds). A related question that may deserve further exploration is the development and use of CMFs for different purposes (e.g., planning versus design). There is a current study underway (NCHRP Project 17-63) to better understand the transferability of CMFs, including the typical roadway characteristics and other factors that would affect transferability. One component of transferability is understanding the specific scenario under which the CMF was developed. As such, proper documentation is a critical first step toward understanding transferability. Guidance on the proper documentation of CMF development efforts is provided in the NCHRP report *Recommended Protocols for Developing CMFs.*[11] Further effort is needed to promote the use of that guidance.

Data and Methods

The following is a summary of issues and opportunities related to data and methods used in the development of CMFs:

- **Quality Data:** There is a need for new sources of data and more complete and higher-quality data across the board, including better data for local roads and better tracking of safety improvements. The quality of CMFs and potential to develop more advanced statistical methods depends on the quality and completeness of the underlying data. Many of the CMF stakeholders confirmed the need for data, including FMCSA, which uses microdata (i.e., detailed information about drivers, vehicles, and companies) to support day-to-day operational decision-making. William Bannister of FMCSA noted that high-quality data are necessary to ensure the correct identification of motor carriers and drivers who present the greatest safety risk. The same can be said with respect to the identification of road segments, curves, and intersections.

- **Supplemental and Emerging Databases:** Several data resources were identified and summarized as part of this effort (see appendix C). Additional databases and potential resources were identified during the CMF stakeholder meeting, including the SHRP2 data and FMCSA databases (i.e., SMS and A&I online), which were described previously. Other potential databases include the following:
  - **Large Truck Crash Causation Study:** This study was the predecessor to NMVCCS, and there is the potential for an update to these databases in the near future.
  - **NHTSA's State Data System (SDS):** SDS is maintained by NHTSA's National Center for Statistics and Analysis. There are currently 32 States providing electronic crash data files to NHTSA for SDS. The objective of SDS is to fully develop the analytic potential of all State data of relevance to highway safety. A potential limitation of this dataset is that there is no quality control; SDS is based on data reported directly from the States.
  - **Nationwide Inpatient Sample (NIS):** The NIS database is part of a family of databases and software tools developed for the Healthcare Cost and Utilization Project (HCUP). NIS is the largest all-payer inpatient health care database in the United States, yielding national estimates of hospital inpatient stays. Sampled from the State Inpatient Databases, HCUP's NIS contains all discharge data from more than 1,000 short-term and non-Federal hospitals each year, which approximates a 20 percent stratified sample of U.S. community hospitals. It contains data from approximately 8 million hospital stays each year. Specific data include charge information on all patients, including individuals covered by Medicare, Medicaid, or private insurance, as well as those who are uninsured. These data can be used to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes.
  - **National Trauma Data Bank (NTDB):** NTDB is the largest aggregation of trauma registry data ever assembled. The data may be obtained and used for informational and research purposes with approval from the American College of Surgeons Committee on Trauma. The goal of NTDB is to inform the medical community, the public, and decisionmakers about issues that characterize the current state of care for injured persons. Additional information is available at http://www.facs.org/trauma/ntdb/index.html.
  - **IIHS:** There is the potential to use insurance data to obtain information such as exposure by various groups.
- **Assessment Methods:** There are various methods to assess and evaluate the safety performance of a roadway facility, vehicle, or driver. Some methods are site-specific while others are more systemic. Some methods are crash-based and rely on the crash history from specific sites to help estimate future safety performance. Others are risk-based and rely on the site characteristics to estimate potential crash risk. There is value to all of these methods, and they are not mutually exclusive. In some cases, an agency may combine output from all of the methods to develop a safety program. In other cases, an agency may be confined to specific methods based on the availability of data. The following is a brief summary of some of the methods discussed during the CMF Stakeholder Meeting:
  - **usRAP:** One of the objectives of this program is to promote the assessment of risk as a major part of strategic decisions on roadway improvements. One aspect

of the program is crash-based, while the other is risk-based. The crash-based component uses crash data to develop risk maps, which can be used to document the risk of fatal and serious injury crashes and show where risk is high and low. The risk-based component uses roadway characteristics to determine star ratings and examine how well they protect users from crashes and from deaths and serious injuries when crashes occur.

- ○ **FMCSA Risk Models:** FMCSA develops models to assist in various aspects of their safety program. For example, they develop algorithms to relate risk factors (e.g., hours of service, vehicle type) to crash risks. These models are essentially SPFs that can be used to identify high-risk drivers and carriers. FMCSA is also developing models to assess the benefits of their programs and determine the success of their interventions, similar to CMFs.
- ○ **Systemic Safety Analysis:** FHWA has developed the Systemic Safety Project Selection Tool, but there is an opportunity to further advance the state of the practice in systemic safety analysis. One opportunity is to identify States that are currently implementing systemic treatments to fast-track the evaluation of those treatments and dissemination of results. (Note that Louisiana is implementing systemic treatments and would be happy to share data.) Another opportunity is to apply the systemic approach to support the FHWA Focused Approach to Safety. The objective would be to conduct an analysis of nationally representative data and provide the results to the FHWA focus States to support their safety efforts. The analysis would help State and local agencies better understand how risk factors relate to specific crash types and how these relationships may differ across various facility types. One product of this effort could be a matrix of risk factors by focus group (i.e., roadway departure, intersections, and pedestrians) by facility type (e.g., 2-lane rural, multilane rural, urban/suburban arterial).

- **Value of Advanced Methods:** There is a need to promote the use of scientifically rigorous methods by demonstrating the value of these methods compared to traditional methods. There is a current effort underway through the FHWA Office of Safety to develop a Safety Data and Analysis Toolbox. As part of this effort, select new tools will be developed, including a tool (i.e., guide) to articulate and hopefully demonstrate the value of rigorous methods throughout the safety management process (from network screening to project evaluation).

Communication and Coordination

There is a need to enhance communication and coordination among CMF stakeholders. In general, the message and content should be appropriate for the target audience. For example, decisionmakers are not likely to read a research report. Instead, TechBriefs are appropriate to inform decisionmakers and communities of the safety effects of new and innovative strategies. The following is a list of potential opportunities to enhance communication and coordination of CMF-related efforts through new and existing mechanisms:

- **CMF Clearinghouse:** The CMF Clearinghouse is one opportunity to facilitate enhanced communication. Currently, the CMF Clearinghouse is the go-to resource for CMFs and CMF-related resources. As such, it might be a natural choice for providing information related to CMF needs, ongoing CMF research, and a forum for collecting CMF-related research needs (in addition to the Most Wanted List). As identified by Ed Stollof from ITE, users will want to obtain the majority of CMF information from a single source; they will not click multiple links to search multiple sites.
- **RiP Database:** There is the potential to utilize the existing TRB RiP database to track ongoing research. A benefit of this option is that the

database is already established. A potential limitation is that the database is underutilized, and it may continue to be underutilized unless there is an effort to improve the functionality or increase awareness to encourage consistent use.

- **TRB Annual and Midyear Meetings:** TRB committee meetings, particularly ANB20 and ANB25, provide an opportunity to advance CMF-related research needs as well as ideas developed in the CMF Stakeholder Meeting. In general, TRB is an opportunity to coordinate research surrounding a given topic. For example, roundabouts are a cross-cutting issue that could touch safety, operations, design, pedestrians, and bicyclists. TRB hosts regular meetings, workshops, and webinars to allow communities to communicate and coordinate.
- **SHRP2:** There is an opportunity to communicate the list of CMF needs and priorities on the SHRP2 Web site. Researchers could then use the SHRP2 data to address the pressing needs. These data may also provide an opportunity for students looking for research topics for their thesis or dissertation. There is also a potential to list or identify common pitfalls and potential issues related to the use of the SHRP2 data, which will allow users to learn from others' past experiences and help advance the methods and analysis.
- **ITE:** ITE could serve as a forum or distribution network at the grass roots level because their membership includes all levels of CMF stakeholders and users.
- **AASHTO Innovation Initiative (former TIG):** This initiative designates "champions" to promote technologies, which can then be implemented and evaluated. It will be important for the CMF community at large to understand which technologies the AASHTO group is promoting. It will also be important for the AASHTO group to understand the safety effectiveness (i.e., CMFs) related to the technologies they are promoting. The AASHTO group could also establish a formal link with other similar efforts such as the FHWA EDC initiative, FHWA Proven Countermeasures, and the ATSSA Circle of Innovation. Currently, FHWA develops a list of technologies that could/should be accelerated and sends the list to AASHTO asking for feedback on priorities.
- **Review of Research:** Despite the development of several guides related to development of CMFs (e.g., FHWA's A Guide to Developing Quality CMFs and NCHRP's Recommended Protocols for Developing CMFs), the quality of CMFs continues to be an issue. One challenge to improving the quality of CMFs is the need to inform all CMF research sponsors and developers. This report has outlined several different CMF development efforts and funding agencies. The next step is to promote the use of existing guides to improve the quality of CMFs. There is also the potential to establish a mechanism to cross-examine CMF-related research. For example, IIHS is planning to conduct a study on the safety effects of changes in speed limits. Other CMF stakeholders may have suggestions on factors to consider during the research, but there is not currently a forum or mechanism to provide that feedback. There may be an opportunity to investigate how the CMF stakeholder community can help guide research from both a needs perspective and an existing knowledge perspective.

Training

There were several training-related needs and opportunities identified during the CMF Stakeholder Meeting. The primary concern was that CMFs are crucial components of the decisionmaking process, but there is still a lack of understanding and proper use of CMFs, particularly at the local level. Training opportunities include:

- **Promotion:** There is the potential to increase attendance in existing CMF-related courses by better promoting these events and opening the training to all safety stakeholders rather than focusing on States (if this is in fact the current practice). One hook to promote training is with professional development hours.
- **Expansion:** There is a need to integrate transportation-specific exercises and

assignments in existing statistics courses. Universities across the country offer both transportation and statistics courses, which present opportunities to cross-educate transportation engineers and statisticians.

- **Refreshers:** Training is not a "one-and-done" exercise; it is an ongoing process. As the science and practice of CMFs develop, it will be important to convey any changes to the CMF community, particularly those that have already been trained. There is a need to reinforce old concepts and identify recent developments. For some users, it will be necessary to understand the statistics and methodologies, but for most, it will be sufficient to understand the selection and appropriate use of CMFs.

There were also several potential training-related challenges identified during the meeting. The primary challenge is that CMF users come from all strata, from the local level practitioner to consultants to the Federal government. In this regard, not all individuals have the same technical or time capacity to understand and apply CMFs. In some cases, users may be tempted to rely solely on the CMF Clearinghouse as a quick reference tool because of resources, immediate responses needed for investment, and other decisions or other factors. It is important for CMF stakeholders to understand that CMFs are just one component of a quantitative safety management process.

Innovation, Technology, and Other

The following programs and tools will be useful for individuals developing CMFs:

- **usRAP and International Road Assessment Program (iRAP):** The new version of usRAP (version 3.0) is about to be released. This version will include a video tool for data coding. iRAP has also released information on the underlying methods and risk factors incorporated in the tool. This information is available at http://www.irap.net/en/about-irap-3/methodology. There is the potential to link to usRAP and iRAP from the CMF Clearinghouse. The common link between the CMF Clearinghouse and usRAP is the section on risk factors. While usRAP is more complex than the CMF Clearinghouse, it would position agencies for longer-term investment decisions. It also includes a method for assessing risk to pedestrians and bicyclists, which is not well-covered in other tools.
- **FMCSA Tools and Technology:** FMCSA has continued to innovate in the name of safety by developing the following tools and technology:
  - **Smart Infrared Inspection System (SIRIS):** FMCSA launched a project to demonstrate SIRIS, which uses state-of-the-art thermal imagery technology, integrated with signature recognition software, to identify faults and impending failures in tires, brakes, and bearings mounted on large trucks and motor coaches and to alert roadside inspectors in real time.
  - **Wireless Roadside Inspections:** FMCSA is testing a wireless roadside inspection system that will automatically gather information about trucks, drivers, and carriers without stopping vehicles. The goal is to use commercial mobile radio service technology to conduct inspections as trucks travel along the highway.
  - **Bus Safety App:** FMCSA has developed the Saferbus mobile app to help consumers identify the risk and track record of a carrier. This app could be used by insurance companies or the general public.
- **AASHTO Innovation Initiative:** This initiative is a systematic approach for moving new technology into day-to-day practice. Opportunities to track and coordinate efforts were discussed previously in this report.
- **Strategy Tracking:** There is a need for better mechanisms to track strategies from concept to CMF. A potential framework for a tracking mechanism was described in this report, but further research is needed to refine and populate such a tool.

Appendix A: CMF Stakeholders

Table 4. State transportation department and partner members of ELCSI-PFS.

State	Contact	Organization	Email
Alabama	Timothy Barnett	Alabama Department of Transportation	barnettt@dot.state.al.us
	Linda Guin	FHWA Alabama Division	linda.guin@dot.gov
	Sonya Baker	Alabama Department of Transportation	bakers@dot.state.al.us
Arizona	Kohinoor Kar	Arizona Department of Transportation	kkar@azdot.gov
Arkansas	Adnan Qazi	Arkansas State Highway and Transportation Department	adnan.oazi@ahtd.ar.gov
California	Thomas Schriber	California Department of Transportation	thomas.schriber@dot.ca.gov
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Connecticut	Joe Ouellette	Connecticut Department of Transportation	joseph.ouellette@ct.gov
Florida	Joe Santos	Florida Department of Transportation	joseph.santos@dot.state.fl.us
Georgia	Michael Turpeau	Georgia Department of Transportation	mturpeau@dot.ga.gov
Ilinois	Priscilla Tobias	Strategy A Illinois Department of Transportation	priscilla.tobias@illinois.gov
	Tim Sheehan		tim.sheehan@Illinois.gov
	Riyad Wahab		riyad.wahab@illinois.gov
Indiana	Mike Holowaty	Indiana Department of Transportation	mholowaty@indot.in.gov
Iowa	Jan Laaser-Webb	Iowa Department of Transportation	jan.laaser-webb@dot.iowa.gov
Kansas	Steven Buckley	Kansas Department of Transportation	buckley@ksdot.org
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Maryland	Eric Tabacek	Maryland State Highway Administration	etabacek@sha.state.md.us
	Ruihua Tao		rtao@sha.state.md.us
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Michigan	Mark Bott	Michigan Department of Transportation	bottm@michigan.gov
Minnesota	Brad Estochen	Minnesota Department of Transportation	bradley.estochen@state.mn.us
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	Mark Thomas		mthomas@mdot.ms.gov

Table 4. State transportation department and partner members of ELCSI-PFS (continued).			
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North Dakota	Shawn Kuntz	Planning & Programming Division, North Dakota Department of Transportation	skuntz@nd.gov
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	Chris Speese		chspeese@pa.gov
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South Dakota	Michael Behm	South Dakota Department of Transportation	michael.behm@state.sd.us
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Washington	John Milton	Washington State Department of Transportation	miltonj@wsdot.wa.gov
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Wisconsin	John Bridwell	Wisconsin Department of Transportation	john.bridwell@dot.wi.gov
	Brian Porter		brian.porter@dot.wi.govv
	Andrea Bill	University of Wisconsin-Madison	bill@wisc.edu

Table 5. USDOT and partner agency contacts.

Agency	Contact	Email/Phone
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	Monique Evans	monique.evans@dot.gov 202-493-3074
	James Pol	james.pol@dot.gov
FHWA Office of Safety	Karen Scurry	karen.scurry@dot.gov 609-637-4207
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	Cathy Satterfield	cathy.satterfield@dot.gov 708-283-3552
	Brian Fouch	brian.fouch@dot.gov
	Joseph Cheung	joseph.cheung@dot.gov
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	Andy Mergenmeier	andy.mergenmeier@dot.gov
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	Richard Compton	richard.compton@dot.gov 202-366-2699
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Table 5. USDOT and partner agency contacts (continued).		
Agency	**Contact**	**Email/Phone**
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NCHRP	Mark Bush	mbush@nas.edu
TRB	Bernardo Kleiner	bkleiner@nas.edu
TRB Transportation Safety Management Committee (ANB10)	Frank Gross (Research Coor.) Robert Hull (Co-Chair) Jake Kononov (Co-Chair)	fgross@vhb.com
TRB Safety Data, Analysis, and Evaluation Committee (ANB20)	Kim Eccles (Secretary) Bhagwant Persaud (Co-Chair) Chris Monsere (Co-Chair)	keccles@vhb.com
TRB Highway Safety Workforce Development Committee (ANB23)	Frank Gross (Research Coor.) Barbara Harsha (Co-Chair) Terecia Wilson (Co-Chair)	fgross@vhb.com
TRB Highway Safety Performance Committee (ANB25)	John Milton	miltonj@wsdot.wa.gov
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IIHS	Anne McCartt	amccartt@iihs.org 703-247-1534
ITE	Douglas Noble	dnoble@ite.org 202-785-0060 x 148
ENTERPRISE	Bill Legg	kleggb@wsdot.wa.gov 360-705-7994
	Ginny Crowsont	crowson@acconsultants.org 651-600-3338

CVSA = Commercial Vehicle Safety Alliance.
GHSA = Governors Highway Safety Association.
JPO = Joint Program Office.

USDOT and Partner Agencies

CMF researchers and developers include individuals from the following key partnering agencies and bodies:

- FHWA.
    - Office of Safety.
    - Office of Safety Research, Development, and Technology.
    - Other FHWA Offices (e.g., Operations).
    - Resource Center.
    - Division Offices.
- NHTSA.
- Governors Highway Safety Association.
- Research and Innovative Technology Administration.
    - ITS Joint Program Office.
- FMCSA.
- AASHTO.
    - SCOHTS.
    - SCOSM.
- TRB (e.g., representatives from related TRB committees and NCHRP senior program officers).
    - ANB10–Transportation Safety Management.
    - ANB20–Safety Data, Analysis, and Evaluation.
    - ANB23–Highway Safety Workforce Development.
    - ANB25–Highway Safety Performance.
    - NCHRP.
    - TCRP.
    - SHRP2.
- AAA-FTS.
- TSSA.
- IIHS.
- ITE.
- Commercial Vehicle Safety Alliance.
- Other pooled fund studies (e.g., ENTERPRISE, Traffic Control Devices, All Roads Network Of Linear-referenced Data).

The contacts from each group are listed in table 5.

Appendix B: CMF Stakeholder Meeting Agenda

- 9:00 AM: Welcome, FHWA, *Monique Evans and Patrick Hasson.*
    - Introductions.
    - Meeting objectives and overview of agenda.
    - Brief introduction to CMFs—application, market, and demand.
- 9:30 AM: USDOT Partners CMF-Related Efforts and Perspectives
    - FHWA Office of Safety R&D, *Roya Amjadi.*
    - FHWA Office of Safety, *Karen Scurry*.
    - FHWA Resource Center, *Patrick Hasson.*
    - FMCSA, *William Bannister.*
    - NHTSA, *Kristie Johnson (remote).*
    - Other USDOT efforts.
- 10:30 AM: Break.
- 10:45 AM: Partner CMF-Related Efforts and Opportunities.
    - Partner presentations.
        - AAA-FTS, *Doug Hardwood, MRI Global.*
        - AASHTO, *Kelly Hardy.*
            - SCOHTS and SCOSM.
            - HSM Efforts.
        - IIHS, *Wen Hu.*
        - ITE, *Ed Stollof.*
        - NAS, *Bernardo Kleiner and David Plazak.*
        - TRB.
            - ANB20 Safety Data, Analysis, and Evaluation Committee.
            - ANB25 Highway Safety Performance Committee.
        - NCHRP.
        - SHRP2.
    - International efforts.
    - State transportation department efforts.
    - Other partners and related efforts.
        - Partner discussion.
- 12:00 PM: Lunch.
- 1:00 PM: Partner CMF-related efforts and opportunities (cont'd).
- 2:00 PM: CMF Gap Analysis and Research Needs, *Frank Gross (VHB)* and *Daniel Carter (North Carolina Highway Safety Research Center).*
    - Summary of gap analysis and ongoing research.
    - Summary of identified CMF research needs.
    - Partner discussion.
- 2:45 PM: Break.
- 3:00 PM: Advancing Highway Safety—Research Methods, Technologies, Innovation.
    - Research methods.
        - Overview of current predominant methodologies, *Frank Gross (VHB).*
        - Compendium of TRB papers for statistical methodologies applicable to highway safety evaluations, *Kim Eccles (VHB).*
        - Transportation Statistics, *Roya Amjadi (FHWA).*
            - FHWA Technical Experts Mtg—white paper and marketing.
            - Coordination with ASA.
        - Methodologies, Technologies, and Innovation.
            - Tracking technologies and new strategies, *Kim Eccles (VHB)* and *Karen Scurry.*
            - FHWA database focus State approach to systemic safety, *Karen Scurry.*
        - Partner discussion.
- 4:00 PM: Looking to the Future, *Pat Hasson.*
    - Future Needs for Advancing CMF Development.
    - Communicating and Coordinating Efforts.
    - Others.
- 4:30 PM: Wrap-up and Next Step.

Table 6. Resource databases to support DCMF efforts (FARS, GES, CDS, NMVCCS).

	FARS	GES	CDS	NMVCCS
Who houses and maintains the data?	NASS; directed by NCSA, which is a component of Policy and Operations in NHTSA.	NASS; directed by NCSA, a component of Policy and Operations in NHTSA.	NASS; directed by NCSA, a component of Policy and Operations in NHTSA.	NASS; directed by NCSA, a component of Policy and Operations in NHTSA.
What is the spatial coverage of the data?	All qualifying fatal crashes within the 50 States, the District of Columbia, and Puerto Rico.	Obtained from 60 geographic sites that reflect the geography, roadway mileage, population, and traffic density of the United States; approximately 400 police jurisdictions included in the sampling.	Obtained from 24 geographic sites that reflect the geography, roadway mileage, population, and traffic density of the United States.	Sample of crashes in 24 PSUs, centered on large cities/counties/metro areas; include cities and counties in AL, AZ, CA, CO, FL, IL, IN, MD, MI, NE, NJ, NY, NC, PA, TN, TX, WA.
What years of data are in the database?	1975 to 2012	1988 to 2012	1979 to 2012	January 2005 to December 2007
What is the general availability of the data?	FTP site: ftp://ftp.nhtsa.dot.gov/fars/	FTP site: ftp://ftp.nhtsa.dot.gov/GES/	FTP site: ftp://ftp.nhtsa.dot.gov/NASS/	FTP site: ftp://ftp.nhtsa.dot.gov/NASS/NMVCCS/
How are the data collected? How are the data coded?	Cooperative agreement with agency in each State to provide information in standard format on fatal crashes in the State; data collected, coded and submitted into database. The data are coded for: • Crash variables. • Vehicle variables. • Person variables.	Data collectors make weekly, biweekly, or monthly visits to selected police agencies, and randomly sample about 50,000 PARs each year; approximately 90 data elements; for privacy reasons, no personal information nor specific crash location is coded.	24 research teams at PSUs study between 3,000 and 5,000 crashes a year involving passenger cars, light trucks, vans, and utility vehicles; investigators obtain data from selected police agencies, crash sites, and study all available evidence; interview crash victims and review medical records; more than 600 elements coded; for privacy reasons, no personal information nor specific crash location is coded.	Investigated crash locations while first responders were still on-site; reconstruct crash by collecting all available data and interviewing witnesses; identify critical pre-crash event, critical reason for crash event, and other associated factors; over 500 elements coded.
Does the database include all crashes for the coverage area (i.e., the population) or just a portion of the crashes (i.e., a sample)?	Includes population of crashes with fatal outcome; fatalities are defined as a death to an individual occurring within 30 days of a crash due to injuries sustained in the crash.	Includes only portion of crashes, sampled randomly from 60 geographic sites and some 400 police agencies across the United States.	Includes only portion of crashes, sampled randomly from 24 geographic sites across the United States.	Sample of crashes from each PSU.
How are crash severity levels defined?	KABCO	KABCO	KABCO and sometimes Abbreviated Injury Scale	KABCO, plus: • Died prior to crash • Unknown if injured
What is the vehicle type coverage?	All vehicle types.	All vehicle types.	Crashes involving at least one light vehicle < 10,000 lbs.	Crashes involving at least one light vehicle < 10,000 lbs.
If data is just a sample, how was the sampling done?	NA	(1) Selection of primary sampling units (PSUs). (2) Selection of police jurisdictions. (3) Selection of crashes.	(1) Selection of primary sampling units (PSUs). (2) Selection of police jurisdictions. (3) Selection of crashes.	Six-hour sampling time period (between 6AM and midnight) selected each week; then divided into sampling days with tendency to maximize probability of observing crash during selected sampling periods.
If just a sample, what (if any) guidance is given to incorporate the sampling procedure into data analysis?	NA	A national weight has been added to the file for each PAR and is called "WEIGHT." This weight is the product of the inverse of the probabilities of selection at each of the three stages in the sampling process.	Data are weighted to represent all police reported motor vehicle crashes occurring in the United States during the year involving passenger cars, light trucks and vans that were towed due to damage.	A comprehensive weighting procedure, that makes the NMVCCS sample nationally representative, consists of mainly two phases, the design weight and its appropriate adjustment.

Table 6. Resource databases to support DCMF efforts (FARS, GES, CDS, NMVCCS) (continued).

	FARS	GES	CDS	NMVCCS
To which Tasks (A–D) is the database applicable?	A: Prioritize current CMF research needs based on magnitude of fatalities. B: Prioritize future CMF research based on magnitude of fatalities. C: Support and advance innovation in safety countermeasures by demonstrating the magnitude of related fatalities. D: Determine priority research needs that have not been identified based on magnitude of fatalities and related factors.	A: Prioritize current CMF research needs based on magnitude and severity of crashes. B: Prioritize future CMF research based on magnitude and severity of crashes. C: Support and advance innovation in safety countermeasures by demonstrating the magnitude and severity of related crashes. D: Determine priority research needs that have not been identified based on magnitude and severity of crashes and related factors.	C: Support and advance innovation in safety countermeasures by identifying the underlying crash contributing factors related to light vehicle crashes. D: Determine priority research needs that have not been identified based on the investigation of crash contributing factors.	C: Support and advance innovation in safety countermeasures by identifying the underlying crash contributing factors related to light vehicle crashes. D: Determine priority research needs that have not been identified based on the investigation of crash contributing factors.

CDS = Crashworthiness Data System.
FTP = File Transfer Protocol.
GES = General Estimates System.
KABCO = KABCO injury severity scale, where K = killed, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, and O = no apparent injury.
NA = Not applicable.
NASS = National Automotive Sampling System.
NCSA = National Center for Statistics and Analysis.
PAR = Police accident report.
PSU = Primary sampling unit.

Table 7. Resource databases to support DCMF efforts (CIREN, MCMIS, STARS).

	CIREN	MC	STARS
Who houses and maintains the data?	NHTSA	FMCSA	NPS
What is the spatial coverage of the data?	Sample of crashes collected by CIREN teams, which consist of three medical centers and three engineering centers in Washington, Wisconsin, Virginia, Maryland, and Alabama.	All registrations, inspections, investigations, and qualifying crashes involving motor carriers with USDOT numbers within the 50 States, the District of Columbia, and Puerto Rico.	All motor vehicle collisions that occur within NPS jurisdiction.
What years of data are in the database?	1996 to 2011	1989 to present	1990 to 2005
What is the general availability of the data?	Online: http://www.nhtsa.gov/Research/Crash+Injury+Research+(CIREN)/Data	Available to the general public through the MCMIS Data Dissemination Program with a fee, formal request needed. Selected data available online at http://ai.fmcsa.dot.gov/default.aspx.	No direct access online, formal request needed.
How are the data collected? How are the data coded?	Each Center collects detailed crash and medical data on about 50 crashes per year. Personal and location identifiers and highly sensitive medical information have been removed from the public files to protect patient confidentiality; 650 NASS CDS data elements and 250 medical and injury data elements coded.	Daily updates from State and FMCSA field offices through the microcomputer system SAFETYNET, CAPRI, and other sources. The data are coded for: crash variables, census variables, and inspection variables. Inspection data is primarily conducted at the roadside by State personnel under MCSAP.	Obtained from Motor Vehicle Accident Report. The data is coded for crash variables.
Does the database include all crashes for the coverage area (i.e., the population) or just a portion of the crashes (i.e., a sample)?	Includes only crashes with serious injury.	Includes only reported crashes involving commercial motor carriers (large truck & bus) and hazardous material carriers.	All reported crashes.
How are crash severity levels defined?	ISS/MAIS Scale	National Governors' Association crash thresholds. Injury crashes: person injured is immediately taken to a medical facility. Tow-away crashes: at least one vehicle is towed from the scene as a result of disabling damage suffered in the crash.	Fatal, Injury, PDO
What is the vehicle type coverage?	All vehicle types.	Large trucks, buses, and any vehicle with a hazmat placard.	All vehicle types.
If data is just a sample, how was the sampling done?	Admission to participating CIREN Center. Severely injured and transported to Level 1 trauma center. Injury required: 1) at least one AIS3+ injury, 2) AIS2 injury in two different AIS body regions, 3) significant particular injury to a lower extremity (AIS2). Vehicle model no older than 6 years. Restraint: 1) frontal crash–air bag and/or belt required, 2) side impact–unbelted is acceptable, 3) rollover–eject occupants are excluded.	NA	NA
If just a sample, what (if any) guidance is given to incorporate the sampling procedure into data analysis?	None	NA	NA

Table 7. Resource databases to support DCMF efforts (CIREN, MCMIS, STARS) (continued).			
	CIREN	**MC**	**STARS**
To which Tasks (A–D) is the database applicable?	General: Conduct research related to vehicles, occupants, and non-motorized road users involved in a crash (e.g., identify motor vehicle design features that offer maximum occupant protection). C: Support and advance innovation in safety countermeasures to further reduce crash fatalities and severe injuries associated with prioritized safety needs. D: Determine priority research needs that have not been identified	General: Support and evaluate motor carrier safety programs and regulations. C: Support and advance innovation in motor carrier-related safety countermeasures to further reduce crash fatalities and severe injuries associated with prioritized safety needs. D: Determine priority research needs related to motor carriers that have not been identified.	General: Support and evaluate motor carrier safety programs and regulations. C: Support and advance innovation in motor carrier-related safety countermeasures to further reduce crash fatalities and severe injuries associated with prioritized safety needs. D: Determine priority research needs related to motor carriers that have not been identified. Note: the NPS STARS database may have limited potential for the DCMF project and future efforts to advance CMF development.

AIS = Abbreviated injury scale.
CAPRI = Compliance analysis and performance review information.
CIREN = Crash Injury Research and Engineering Network.
ISS = Injury severity score.
MAIS = Modified abbreviated injury scale.
MCMIS = Motor Carriers Management Information System.
MCSAP = Motor Carrier Safety Assistance Program.
NPS = National Park Service.
PDO = Property damage only.
STARS = Service-wide Traffic Accident Reporting System.

Table 8. Resource databases to support DCMF efforts (NTD, NEMSIS, SHRP2).			
	NTD	**NEMSIS**	**SHRP2**
Who houses and maintains the data?	FTA	NHTSA Office of Emergency Medical Services	TRB
What is the spatial coverage of the data?	National transit-related reportable incidents.	National repository for EMS data. As of 2012, there are 42 States and territories that are contributing to the dataset.	The NDS data and roadway information database (RID) were based on data gathered in six States (FL, IN, NY, NC, PA, and WA).
What years of data are in the database?	2002 to 2013	2008 to 2012	2010 to 2013
What is the general availability of the data?	Online: http://www.ntdprogram.gov/ntdprogram/data.htm	Online request: http://www.nemsis.org/reportingTools/requestNEMSISData.html	To be determined
How are the data collected? How are the data coded?	The system derives data from transit providers, States, or MPOs that are recipients and beneficiaries of grants. There are 55 data fields that are collected from six different forms for safety and security.	The NEMSIS project was developed to help States collect more standardized elements and eventually submit the data to a national EMS database.	The NDS data were collected by instrumenting vehicles to record vehicle location, forward radar, vehicle control positions (e.g., turn signals, brake pedal activation, ABS, gear position, speed, horn, and steering wheel angle), acceleration, alcohol use, cell phone use, and video of the forward roadway and of the driver's face and hands. Crash investigations were conducted after some crashes to gather detailed data. The RID contains new roadway data gathered by automated data collection vehicles and existing data provided by agencies (i.e., State transportation departments, MPOs, and counties). The roadway data includes roadway inventory information, crash histories, traffic, weather, roadway improvements, work zones, safety laws, and enforcement campaigns.
Does the database include all crashes for the coverage area (i.e., the population) or just a portion of the crashes (i.e., a sample)?	The database includes transit-related reportable incidents. Note that not all incidents are considered to be reportable. If an incident is not related to and does not affect revenue operations, then it is considered to be non-reportable.	Includes only reported crashes involving commercial motor carriers (large truck & bus) and hazardous material carriers.	The NDS database includes detailed data on more than 5 million trips, 49 million travel miles, and 1.4 million driving hours from more than 3,100 participants of various ages across the country. The database represents continuous data from all trips taken by volunteer participants over one to two years. The RID contains approximately 12,500 centerline miles and the existing data contains more than 200,000 centerline miles.
How are crash severity levels defined?	Incidents, injuries, fatalities	Possible injury (yes/no)	Unknown
What is the vehicle type coverage?	Transit vehicles, including the following modes: Automated Guideway, Commuter Bus, Cable Car, Demand Response, Demand Response-Taxi, Ferryboat, Inclined Plane, Heavy Rail, Jitney, Light Rail, Motor Bus, Monorail/Guideway, Monorail, Público, Bus Rapid Transit, Streetcar Rail, Trolleybus, Aerial Tramway, Vanpool, and Hybrid Rail.	All vehicle types.	Passenger vehicles, including passenger cars, minivans, SUVs, and pickup trucks.
If data is just a sample, how was the sampling done?	NA	States vary in criteria used to determine the types of EMS events submitted to the NEMSIS dataset.	Six locations were selected in the United States to represent geographic diversity and to provide a range of driver, vehicle, and roadway conditions.

Table 8. Resource databases to support DCMF efforts (NTD, NEMSIS, SHRP2) (continued).			
	NTD	**NEMSIS**	**SHRP2**
If just a sample, what (if any) guidance is given to incorporate the sampling procedure into data analysis?	NA	No	No
To which Tasks (A–D) is the database applicable?	General: United States' primary source of transit system information and statistics. Investigate transit-related crashes, including the injuries and fatalities by type and mode. C: Support and advance innovation in transit-related safety countermeasures to further reduce fatalities and severe injuries associated with prioritized safety needs. D: Determine priority research needs related to transit that have not been identified.	General: Evaluate patient and EMS system outcomes.	General (Note: the following list provides examples of potential uses of SHRP2 data): • Understand the contributing and causal factors in crashes. • Understand how the driver interacts with and adapts to the vehicle, traffic, roadway characteristics, traffic control devices, and the environment. • Identify the relationship between crashes, conflicts, and crash surrogates. • Formulate exposure-based risk measures using surrogate measures. • Investigate the potential for new countermeasures related to the design of the roadway and vehicles as well as public policy and enforcement. • Enhance driver training programs to demonstrate appropriate and inappropriate driver behavior. • The RID provides a model for developing linked data sets for asset management purposes.

ABS = Anti-lock braking system.
EMS = Emergency medical services.
FTA = Federal Transit Administration.
MPO = Metropolitan Planning Organization.
NEMSIS = National Emergency Medical Services Information System.
NTD = National Transit Database.
SUV = Sport utility vehicle.

Table 9. Resource databases to support DCMF efforts (HSIS).

	HSIS						
	California	Illinois	Maine	Minnesota	North Carolina	Ohio	Washington
Who houses and maintains the data?	University of North Carolina HSRC under contract with FHWA.						
What is the spatial coverage of the data?	Statewide						
What years of data are in the database?	1991 to present (data typically lag by 1–2 years)	1985 to present (data typically lag by 1–2 years)	1985 to present (data typically lag by 1–2 years)	1985 to present (data typically lag by 1–2 years)	1991 to present (data typically lag by 1–2 years)	1997 to present (data typically lag by 1–2 years)	1993 to present (data typically lag by 1–2 years); 1997 and 1998 crash data are not included
What is the general availability of the data?	Data can be provided via different mediums (CD-ROM, FTP, email). The data can be requested by filling out an HSIS data request form online at the HSIS Web site.						
How are the data collected? How are the data coded?	Annually derived from California TASAS. The data are coded for: crash variables, roadway variables, intersection variables, interchange variables, and traffic variables.	Annually derived from Illinois safety information system, which includes a number of data edits and quality checks. The data are coded for: crash variables, roadway variables, interchange variables, curve/grade variables, and traffic variables.	Annually derived from Maine TINIS. The data are coded for: crash variables, roadway variables, intersection variables, interchange variables, and traffic variables.	Annually derived from Minnesota data system. The data are coded for: crash variables, roadway variables, intersection variables, interchange variables, and traffic variables.	Annually derived from an Oracle database on the NCDMV system. Before 2000, it was derived from a mainframe database maintained by the NCDOT. The data are coded for: crash variables, roadway variables, and traffic variables.	Annually derived from Ohio data system. The data are coded for: crash variables, roadway variables, curve and grade variables, and traffic variables.	Annually derived from Washington TRIPS system. The data are coded for: crash variables, roadway variables, interchange variables, curve/grade variables, and traffic variables.
Does the database include all crashes for the coverage area (i.e., the population) or just a portion of the crashes (i.e., a sample)?	All reported crashes, primarily on the State-maintained system. This varies slightly by State.						
How are crash severity levels defined?	KABCO/five-point scale, plus error/other codes	KABCO, plus: not coded, error codes	KABCO, plus: unknown, error/other codes	KABCO, plus: not applicable, unknown if injured	KABCO, plus: unknown	KABCO	Nine-point scale
What is the vehicle type coverage?	All vehicle types, distinguished between vehicle makes, types and model years.	All vehicle types.	All vehicle types.	All vehicle types.	All vehicle types.	All vehicle types.	All vehicle types.
If data is just a sample, how was the sampling done?	NA	NA	NA	NA	NA	NA	NA

Table 9. Resource databases to support DCMF efforts (HSIS) (continued).							
	HSIS						
	California	**Illinois**	**Maine**	**Minnesota**	**North Carolina**	**Ohio**	**Washington**
If just a sample, what (if any) guidance is given to incorporate the sampling procedure into data analysis?	NA	NA	NA	NA	NA	NA	NA
To which Tasks (A–D) is the database applicable?	General: The HSIS database has numerous general applications, as do many of the databases listed in this document. A: Prioritize current CMF research needs based on the magnitude and severity of crashes at specific locations (e.g., curves, intersections, segments). B: Prioritize future CMF research needs based on the magnitude and severity of crashes at specific locations (e.g., curves, intersections, segments). C: Support and advance innovation in safety countermeasures to further reduce crash fatalities and severe injuries associated with prioritized safety needs. D: Determine priority research needs that have not been identified based on the investigation of crashes and crash severity at specific locations (e.g., curves, intersections, segments).						

CD-ROM = Compact disc, read-only-memory.
HSRC = Highway Safety Research Center.
NCDMV = North Carolina Department of Motor Vehicles.
TASAS = Traffic Accident Surveillance and Analysis System.
TINIS = Transportation Integrated Network Information System.
TRIPS = Transportation Information and Planning Support System.

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