

**White Papers for: *“Toward Zero Deaths: A  
National Strategy on Highway Safety***

**—White Paper No. 8—**

**Data Systems and Analysis  
Tools**

**Prepared by:**

Barbara Hilger DeLucia  
Data Nexus, Inc.

Geni Bahar, P.E.  
NAVIGATS Inc.

**Under Subcontract to:**

Vanasse Hangen Brustlin, Inc.

**Prepared for:**

Federal Highway Administration  
Office of Safety

**Under:**

Contract DTFH61-05-D-00024

Task Order T-10-001

**July 16, 2010**

## **FOREWORD**

**(To be prepared by FHWA)**

## **NOTICE**

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The contents of this report reflect the views of the author, who is responsible for the accuracy of the data presented herein. The contents do not necessarily reflect the official policy of the Department of Transportation.

## PREFACE

While many highway safety stakeholder organizations have their own strategic highway safety plans, there is not a singular strategy that unites all of these common efforts. FHWA began the dialogue towards creating a national strategic highway safety plan at a workshop in Savannah, Georgia, on September 2-3, 2009. The majority of participants expressed that there should be a highway safety vision to which the nation aspire, even if at that point in the process it was not clear how or when it could be realized. The Savannah group concluded that the elimination of highway deaths is the appropriate goal, as even one death is unacceptable. With this input from over 70 workshop participants and further discussions with the Steering Committee following the workshop, the name of this effort became “Toward Zero Deaths: A National Strategy on Highway Safety.” The National Strategy on Highway Safety is to be data-driven and incorporate education, enforcement, engineering, and emergency medical services. It can be used as a guide and framework by safety stakeholder organizations to enhance current national, state, and local safety planning and implementation efforts.

One of the initial efforts in the process for developing a National Strategy on Highway Safety is the preparation of white papers that highlight the key issue areas that may be addressed as part of the process for developing a National Strategy on Highway Safety. Vanasse Hangen Brustlin was awarded a task order under the Office of Safety contract (DTFH61-05-D-00024) to prepare nine white papers on the following topics:

1. Future View of Transportation: Implications for Safety
2. Safety Culture
3. Safer Drivers
4. Safer Vehicles
5. Safer Vulnerable Users
6. Safer Infrastructure
7. Emergency Medical Services
8. Data Systems and Analysis Tools
9. Lessons Learned from Other Countries

Good data and good tools to assess the data are the foundation for safety decision makers. The more important determinants of success for data systems are collecting timely, accurate, and complete data efficiently, coupled with the ease of integrating (or linkages) and accessing the data for reporting and analysis. Co-authors Barbara Hilger Delucia and Geni Bahar examine the importance and future of data systems and analysis tools and the role of each in working towards zero deaths.

Hugh W. McGee, Ph.D., P.E.  
Principal Investigator

## TABLE OF CONTENTS

2020 VISION OF DATA SYSTEMS AND ANALYSIS .....	1
INTRODUCTION .....	2
STAKEHOLDERS .....	2
DATA SYSTEMS .....	3
ANALYTIC TOOLS .....	11
Information Sources.....	12
Analytical Tools.....	19
STRATEGIES AND INITIATIVES .....	27
Data Systems Strategies and Initiatives .....	27
Data Analysis Strategies and Initiatives .....	29
REFERENCES .....	38

## **2020 VISION OF DATA SYSTEMS AND ANALYSIS**

*Imagine the day when a crash occurs, the location is known by its geographic position immediately, the driver, passengers, and other road users are issued an incident number that will allow us to follow up on the impact of the crash using data from other systems, facilitating adjudication, medical care, training, licensing, vehicle use, and other key safety aspects of transportation.*

*Imagine the day when crash data are transmitted from the vehicle, accurately located by GPS to link with roadway and traffic conditions. The event data recorder from the vehicle transfers information about the moments before the crash to a data warehouse or knowledge base of analysts, thereby providing linkage to further data sources for safety analysis.*

*Imagine the day when traffic movements are continuously assessed at real time and these data are analyzed for instant response and prevention of collisions.*

*Imagine the day when data systems and analysis tools are available to evaluate the strategies and initiatives discussed in the white papers for the other key areas, as well as, for assessing progress in the implementation of the national strategy for highway safety Toward Zero Deaths and significant decreases in seriously injured persons.*

*These analyses and the frequent dissemination of their results to experts and decision makers are fundamental to gain continuous support for the advancements and innovations in safety, and develop confidence in strategies for new implementations. These include infrastructure treatments, driver-based vehicle tools, changes in emergency medical services, etc.*

## INTRODUCTION

Moving effectively *Toward Zero Deaths: A National Strategy in Highway Safety* requires that serious thought be given to the data systems and analysis tools that will be required to measure the efficacy and progress toward achieving that strategy. New data sources, yet unidentified or available, maybe needed to facilitate more effective safety data collection, quality, and completeness. All the while, fewer resources will be available to the multitude of jurisdictions that continue to replicate data collection and management of systems available from other jurisdictions or agencies. Past President of AASHTO and Director of the Missouri Department of Transportation (DOT), Peter Rahn, described the “challenges that state DOTs face in doing more with less” and he recommends using a “practical design” during tight budget times.<sup>1</sup>

Making data-driven decisions to move toward strategic goals and key emphasis areas requires integrating information from numerous data systems from, at a minimum, the 4Es (engineering, education, enforcement, and emergency medical services). Activities and decisions for each of the 4Es occur in all jurisdictions and often for other primary strategic functions; e.g., titling vehicles, licensing drivers, performing medical procedures. In recent years, regional fusion centers are using much of the same data to perform activities for homeland security. Agency leaders are beginning to understand the fundamental need for allocating attention and resources to data collection and management, data processing, and to developing cooperation among related agencies. Better communication of intra- and interagency data needs and business requirements, along with modern systems development, management processes, and applicable technologies will pave the way for providing data and analysis for decisions made to accomplish the Toward Zero Deaths strategy.

## STAKEHOLDERS

Current sources of safety-related data and an example of the breadth of stakeholders are outlined in material used to develop FHWA’s Strategic Highway Safety Planning.<sup>2</sup> Each locality, region, and state may have these stakeholders in common, as well as unique stakeholders that are a specific concern for that jurisdiction.

- Department of Motor Vehicles
- Fire and Rescue Community
- Governor’s Highway Safety Office
- Highway Safety Advocates
- Insurance Industry
- Judicial Community
- Law Enforcement Community

- Motor Carrier Agencies
- Municipal Planning Organizations
- Public Health Agencies
- State Department of Transportation
- State and Local Transportation Agencies
- Railroad Community

The issue of improving data systems to support the TZD strategy becomes very complex because these stakeholders collect and use their data systems for regulatory purposes, as well as provide data from their systems to other stakeholders for their safety analyses. A great deal of progress has been made toward removing institutional barriers and in understanding the relevant problems in obtaining adequate safety-related data for analysis. Safety-LU legislation has required certain state improvements in communication in order to qualify for Section 408 Safety Data Grants.<sup>3</sup> For example, most states now have a traffic records coordinating committee, or its equivalent, to provide a forum for communications about data projects among stakeholders. The legislation further requires peer assessments of traffic records and strategic plans for improving traffic records.

## DATA SYSTEMS

*Figure 1* is an overview of the types of data typically used to support strategic planning and analysis for highway safety improvements<sup>4</sup>. Throughout the years of analyzing safety data, sources of data have expanded and will likely do so in the future. Within these components and among various jurisdictions, these systems come in numerous configurations and are maintained through many different methods.

While it is useful to identify progress toward reduced fatalities by analyzing data from the Fatality Analysis Reporting System (FARS)<sup>5</sup>, it is even more important to be able to analyze non-fatal data to identify crashes that previously might have resulted in fatalities, but instead resulted in lower levels of injury or no injuries at all. In terms of measuring success for the TZD strategy, no single set of databases will be ideal to identify progress in all jurisdictions and all agencies. The more important determinant of success will be effectively



**Figure 1. Safety data components.**

collecting timely, accurate, and complete data, coupled with the facility of linking these data for reporting and analysis.

Each of the following is an example of currently available data resources for safety analysis. Each data resource is presented with its website address and a short description.

### **FARS (Fatality Analysis Reporting System) (on-going)**

**Links:** <http://www-fars.nhtsa.dot.gov>, <ftp://ftp.nhtsa.dot.gov/FARS/data>

**Description:** Created by NHTSA to provide an accurate and complete depository of data about crashes involving fatalities. This data repository is a measure for evaluating safety standards and programs. Includes data from all United States, including District of Columbia and Puerto Rico. This database only includes crashes that happened in publicly accessible roads that resulted in a fatality within 30 days of collision time. Total fatalities information exceeds 1 million incidents.

#### **Capabilities:**

- Data in Hypertext Transfer Protocol (HTTP) site for 1994-2008.
- Data in File Transfer Protocol (FTP) site for 1975-2008.
- Data cubes (trends in time) for all variables are available.
- Custom queries for single years.
- Over 100 variables related to vehicles, people, speed, conditions, States, etc.
- Export query results as flat text file, MS Excel file and graphs.
- FARS Query System and FARS Encyclopedia
- Can download publications and reports.
- Can get all data through FTP protocol.
- Can perform special requests for reports.
- Can map all queries to GIS maps per state at the county level.
- Can view crash locations with Google Earth browser plug-in.
- Training and help is available.

### **NASS GES (National Automotive Sampling System - General Estimates System) (on-going)**

**Link:** [http://www.nhtsa.gov/people/ncsa/nass\\_ges.html](http://www.nhtsa.gov/people/ncsa/nass_ges.html), <ftp://ftp.nhtsa.dot.gov/GES/>

**Description:** Created by the NHTSA to provide an accurate and complete depository of information. Data in this database come from a representative sample nationwide. The country is divided in about 1,200 sampling units and grouped in different categories by geographic location and type (urban, suburban, and rural). This database includes crashes



for which a police accident report has been completed, at least one vehicle was involved and there was property damage, injury or fatality. The sample pool is about 50,000 police accident reports per year and only data from these police reports are included. NHTSA produces an annual report (*Traffic Safety Facts*) which combines these data with data from FARS (Item #1).

**Capabilities:**

- FTP site data 1988-2008.
- NHTSA provides pre-built reports in the annual publications.
- FTP site provides flat text files as well as SAS database files per year.

**NASS CDS (National Automotive Sampling System--Crashworthiness Data System) (on-going)**

**Link:** [http://www.nhtsa.gov/people/ncsa/nass\\_cds.html](http://www.nhtsa.gov/people/ncsa/nass_cds.html), <ftp://ftp.nhtsa.dot.gov/NASS/>

**Description:** Created by the NHTSA in 1979 as part of an effort to reduce motor vehicle crashes. This system is operated by the National Center for Statistics and Analysis (NCSA) part of the NHTSA operating under the U.S. Department of Transportation. NASS consists of about 5,000 crashes per year from everywhere in the spectrum of severity. Twenty-four field research teams investigate the crashes and study evidence such as skid marks, guardrails, glass, air bags, in an effort to understand the nature and consequences of the crashes. The teams are involved in a thorough investigation including photographs, interviews, and medical records. All private information is treated according to the law.

**Capabilities:**

- FTP site data 1979-2008.
- FTP site provides flat text files as well as SAS database files per year.

**HSIS (Highway Safety Information System) (on-going)**

**Link:** <http://www.hsisinfo.org/>

**Description:** HSIS is database that contains crash, roadway inventory, and traffic volume data for California, Minnesota, Illinois, North Carolina, Maine, Ohio, Michigan, Utah and Washington. The years of data available and data types vary according to State; usually include crash, road and traffic information. The HSIS is operated by the University of North Carolina Highway Safety Research Center (HSRC) and LENDIS Corporation, under contract with Federal Highway Administration (FHWA).

**Capabilities:**

- Multiple reports and publications.
- Pedestrian and bicycle GIS safety analysis tools (refer to tool #24).
- GIS safety analysis tools.
- Pedestrian and bicycle crash analysis tool.
- Guidebooks available for each State.
- Data are available upon electronic request.

**LTCCS (Large Truck Crash Causation Study) (single timeframe)**

**Link:** <http://ai.fmcsa.dot.gov/ltccs/default.asp?page=about>

**Description:** LTCCS was a one-time study completed in 2006 which investigated crashes involving large trucks between 2001 and 2003. The aim of the study was to identify the critical events and associated factors that contribute to serious large truck crashes. Therefore, leading the way into implementing effective countermeasures in order to reduce the occurrence and severity of these crashes. Sampling from 17 States was the collection method and qualifying crashes involved at least one large truck and resulted to at least one fatality or injury. A total of 1,000 elements per crash were recorded for 967 crashes.

**Capabilities:**

- Data files available in MS Excel, SAS database and flat text file. (<http://ai.fmcsa.dot.gov/ltccs/default.asp?page=data>)
- Report available.
- Summary tables available.

**CODES (Crash Outcome Data Evaluation System) (on-going)**

**Link:** <http://icsw.nhtsa.gov/people/ncsa/codes/>

**Description:** CODES is an effort to develop hospital-level crash cost data. A report is documents information about medical cost and funding agencies; it is meant to create a link between motor vehicle crashes, injuries, and medical costs toward improved highway safety and injury control decision making. To measure benefits in terms of reducing death, disability, and medical costs, NHTSA determined that State-wide data were needed that included all persons involved in police-reported crashes, regardless of injury. In this manner, comparisons between those using and not using safety belts or motorcycle helmets could be made by identifying and contrasting the characteristics of

the injured and uninjured persons within each of the restraint use groups. This report was delivered to Congress in 1996.

**Capabilities:**

- Data are not available in a unified place, only in a report.
- State level data are available on some Web sites with pre-determined reporting capability, while other participating States do not share the data or information openly.

**NHTSA Vehicle Crash Test Database (on-going)**

**Link:** <http://www-nrd.nhtsa.dot.gov/database/veh/veh.htm>

**Description:** The NHTSA Vehicle Crash Test Database contains engineering data measured during various types of research, the New Car Assessment Program (NCAP), and compliance crash tests. Information in this database refers to the performance and response of vehicles and other structures they impact. New cars and tests are included as they are available after they have been reviewed for quality. The database is comprised of 6 tables that capture all relevant information about the car and the test.

**Capabilities:**

- Query by: test, vehicle and barrier parameters.
- Browse all available tests
- Photos of results of tests
- View sorted catalogues of vehicles, tests and events.
- Export the database to flat text file

**DDACTS (Data-driven Approaches to Crime and Traffic Safety) (on-going)**

**Link:** <http://stko.maryland.gov/DDACTS/tabid/127/Default.aspx>

**Description:** DDACTS is a geo-mapping tool that integrates location-based crime, crash and traffic data. GIS mapping of localized problems can graphically represent where issues are occurring. Often crime and crashes occur in the same location; the tool identifies these correlations visually as hot-spots. Further, the crime, crash and traffic data is coded for type of incident, time of day and week, and location. Additional data may include citizen complaints, dangerous driving behaviors, information about suspended or revoked licenses, and wanted persons. NHTSA, Department of Justice, Bureau of Justice Assistance and National Institute of Justice, along with their national partners, help

technical assistance teams work with local law enforcement agencies on DDACTS, serve as intermediaries to identify local partnerships, and obtain technical assistance from local affiliates and State agencies.

**Capabilities:**

- Reports
- GIS integrated maps that overlay crime, crash, and traffic data
- Distinguish causation factors, delineate time elements, and considers environmental influences on crime and crashes.

**Potential Expansions / Modifications:** Integrate other data sources such as emergency department information.

**Plan4Safety – New Jersey DOT (on-going)**

**Link:** <http://cait.rutgers.edu/tsrc/plan4safety>

**Description:** Plan4Safety is a multilayered decision support tool created for the New Jersey Department of Transportation (NJDOT). Through the tool, state-wide crash data can be analyzed in geospatial and tabular forms. The analysis also includes roadway characteristic data, calculates statistical analyses, incorporates network screening layers and models, and includes visual analytical tools (GIS). The software also contains essential tools for examining incident patterns and properties. The database has crash data from January 1, 2003 to current release. The Plan4Safety team is working with NJDOT and NJ OIT to develop a crash data warehouse that will merge many sources of data (including crash data) to answer questions we have been unable to ask in the past. When this system goes online, Plan4Safety will be sitting on top of a warehouse that will update nightly. This means that all crashes that have been put into the system up to the day before will be available. The current time lapse is approximately 3 weeks to input crash data. With the electronic data transfer initiative, the goal is to shorten that lapse to 3 days.

**Capabilities:**

- Geospatial and tabular forms crash data analysis
- Statistical analyses

**NITS (Not-In-Traffic Surveillance System) (on-going)**

**Link:** <ftp://ftp.nhtsa.dot.gov/NiTS/>

**Description:** The Not-in-Traffic Surveillance (NiTS) system developed for the National Centre for Statistics and Analysis (NCSA) is a virtual data collection system designed to provide counts and details regarding fatalities and injuries that occur in non-traffic crashes and in non-crash incidents. It is comprised of four major components: three databases and one collection of investigations. The first database contains information on fatal and injury non-traffic crashes extracted from police reports. The second database is based upon death certificate information for non-crash fatalities. The third database is comprised of non-crash injuries information from a nationally representative sample of emergency department records. The fourth element is a collection of detailed investigations of particular types of incidents conducted by NHTSA's Special Crash Investigations (SCI) program. Since the statistical sample of non-traffic crash fatalities from police jurisdictions is not complete, an adjustment factor was developed; it accounts for the difference between the expected number of fatalities based on death certificates and the number of fatalities in the police sample. For non-traffic injuries, information from three States in the State Data System is used to adjust for the expected number of non-traffic crash injuries and the number received.

**Capabilities:**

- Microsoft Excel files for aggregate information about the age of the victims, the injury mechanisms, and the locations of the incidents (non-crash fatalities and injuries).
- SAS analysis file.
- Case searching system (<http://www-nass.nhtsa.dot.gov/BIN/logon.exe/airmislogon>).

**NEMSIS (National Emergency Medical Services Information System) (on-going)**

**Link:** <http://www.nemsis.org/>

**Description:** This system is a step towards the direction of a nationwide Emergency Medical Services (EMS) database. NEMSIS is helping States collect and standardize data and eventually submit these data to the national EMS database. NEMSIS is using the eXtensible Markup Language (XML) and XML Schema Definition (XSD) standards to move data from and to multiple systems. The system is comprised of different datasets such as EMS and Demographics and numerous professional organizations are involved.

**Capabilities:**

- Database scripts are available for Microsoft and Oracle products.
- User manual and help are available.
- Data submission center to be used to include data in NEMSIS.
- Articles, publications, presentations, data dictionaries.
- Querying and dynamic reports are available.
- Can request dataset electronically.

**NMVCCS (National Motor Vehicle Crash Causation Survey) (single timeframe)****Link:**

[http://www.nhtsa.dot.gov/portal/nhtsa\\_static\\_file\\_downloader.jsp?file=/staticfiles/DOT/NHTSA/NCSA/Content/NMVCCS/811052.pdf](http://www.nhtsa.dot.gov/portal/nhtsa_static_file_downloader.jsp?file=/staticfiles/DOT/NHTSA/NCSA/Content/NMVCCS/811052.pdf)

**Description:** NHTSA conducted this survey under orders from the Congress in order to investigate 6,949 crashes that occurred between 2005 and 2007. The results of this survey were to be used in developing vehicle-related crash avoidance technologies. Crashes that qualified for this survey involved at least one light passenger vehicle that was towed due to damage. At least 600 data elements were collected for each crash including information about the drivers, vehicles, roads, environment, photos, narratives, diagrams, and other data recorders’.

**Capabilities:**

- Frequency distributions and percentages (weighted and un-weighted).
- Online search capability for a case.
- Can download an archive file with per case information: photos, schematics, etc.

**NOPUS (National Occupant Protection Use Survey) (single timeframe)**

**Link:** <http://www-nrd.nhtsa.dot.gov/Pubs/811254.PDF>

**Description:** NOPUS was a one-time study completed in 2009 which investigated the use of helmets by motorcyclists in USA. The data used were probability-based observation data at sampled roadways. Observers were either stationary or moving with traffic, during day-light hours. Data were collected for 3 weeks in June for 2008 and 2009.

**Capabilities:**

- Predefined charts and tables available only in PDF format.

**NSUBS (National Survey of the Use of Booster Seats) (single timeframe)**

**Link:** <http://www-nrd.nhtsa.dot.gov/Pubs/811121.pdf>

**Description:** NSUBS was a one-time survey completed in 2008 which investigated the use of child booster seats in passenger vehicles. Data were collected by sending trained data collectors to a probability sample of gas stations, day care centers, recreation centers, and restaurants in five national fast food chains across the United States. This was necessary in order to observe restraint use from a close range in a slow-moving or stopped vehicle. After the observation interviews were conducted in order to inform the passengers and capture additional data (heights, ages, ethnicity, etc). A total of 6,200 vehicles were observed and 7,632 children were covered in the interviews.

**Capabilities:**

- Predefined charts and table available only in PDF format.

**ANALYTIC TOOLS**

State and local highway agencies are faced with the challenge to prove that the countermeasures they select and implement are the “right” ones, and that, once implemented, they have had the desired impact on safety. The days of simplistic analyses comparing before- and after-implementation periods and claiming success whenever the number of crashes dropped between these two slices in time is rapidly drawing to a close. The release of the Highway Safety Manual<sup>6</sup> is a signpost on the road to a more scientific approach. It gives practitioners the guidance they need to do a better job of using the available data to make highway safety decisions. To aid in this transition, FHWA, AASHTO, TRB, university-based researchers, and DOTs are all working to develop, release and maintain a series of tools and electronic resources. This section of the white paper describes the existing tools and resources and provides a view of the near future in which these aids are in common use throughout the US.

The primary information resources, including the HSM itself, provide guidance on how to conduct valid data analyses in support of Problem Identification, Countermeasure Selection, and Program/Project Evaluation. The associated analytic tools aid practitioners in analyzing their own data or, where necessary, applying nationally-representative data to a local- or state-specific problem or implementation.

When the tools and resources are used correctly, the practitioner is guaranteed of two things:

- 1) That the analytic results are valid and “state-of-the-practice” with respect to emerging standards in highway safety, and,

- 2) That over time the decisions made using those analytic results will be of generally higher quality, more easily verified, and more defensible.

It is expected that as more DOTs adopt the methods described in the Highway Safety Manual the need for analytic expertise (including high level statistical data analysis) and for expansion of the available tools will become a growing issue. It is with that eventual expansion in mind that the following descriptions of tools and resources are provided.

This section provides examples of state-of the-practice resources and analytical tools. Each resource or tool is presented with its Web link address, a short description and capabilities, and brief suggestions for future modifications/expansions to meet current or likely future needs. The items are grouped by their functionality; i.e., resource or analytical tool. These are defined as:

- Resources – provide static information or guidance that users may consult when designing an analysis or gathering national data for potential application to a state or local problem.
- Analytic tools – provide database, analysis and reporting functions for use by practitioners in completing Problem Identification, Countermeasure Selection and Program/Project Evaluation.

In addition, each resource is recognized as *on-going* meaning that data or information are entered periodically or *single timeframe* meaning that data were entered for a single time period only. Each tool is recognized as *completed* or *under-development* (as of June 2010).

## ***Information Sources***

### **HSM knowledge base (single timeframe)**

**Link:** [http://www.cmfclearinghouse.org/collateral/HSM\\_knowledge\\_document.pdf](http://www.cmfclearinghouse.org/collateral/HSM_knowledge_document.pdf)

**Description:** This knowledge base is an extensive literature review that was created for the development of chapters for the AASHTO Highway Safety Manual (Tool #19). The version found on the clearinghouse was updated in 2008. The information in the report is structured by themes: Roadway Segments, Intersections, Interchanges, Special Facilities and Geometric Situations, and Road Networks. The safety effects of implementing specific treatments are presented as Accident Modification Factors (AMF, also known as Crash Modification Factors, CMF) varying by severity, traffic volume, urban/rural, etc. Each AMF/CMF is accompanied by a measure of accuracy in terms of its standard error.

### **Capabilities:**

- The largest literature review ever completed and available for all professionals seeking to find the knowledge base about a particular treatment



**Potential Expansions / Modifications:** Create an on-going mechanism to keep the knowledge base updated with new research and evaluation of treatments; it could also be changed to a hyperlinked document for ease of access.

### **CMF Clearinghouse (on-going)**

**Link:** <http://www.cmfclearinghouse.org/>

**Description:** This website was established in order to provide a regularly updated, online repository of CMFs. 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 are its statistical properties (e.g., standard error). Where available, a link is provided to the publication from which the CMF was extracted. The CMFs that passed the inclusion rule and are found in the AASHTO HSM are noted as such here. The CMFs are graded with a star quality rating depending on the study quality or methodology used to estimate the CMF.

**Capabilities:**

- CMF search engine.

**Potential Expansions / Modifications:** Develop a SPF Clearinghouse to similarly support the users of the HSM with national and locally calibrated models.

### **Pedestrian and Bicycle Clearinghouse (on-going)**

**Link:** <http://www.pedbikeinfo.org/>

**Description:** The pedestrian and bicycle clearinghouse is PBIC is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center, in cooperation with the Association of Pedestrian and Bicycle Professionals. It is an umbrella project that includes: [walkinginfo.org](http://walkinginfo.org), a website dedicated to pedestrian safety that also hosts PEDSAFE (tool #26); [bicyclinginfo.org](http://bicyclinginfo.org) a similar site for bicycle safety that also hosts BIKESAFE (tool #27); and [pedbikeimages.org](http://pedbikeimages.org) a website hosting a depository of images related to these areas.

**Capabilities:**

- The first two sites offer a broad and in-depth source of information in the areas of pedestrian and bicycle safety: Guides, assistance, plans, education, law information, library, training information, speaker search, news, email lists, etc.

- The image depository offers free to use images as long as the source is mentioned and individuals can contribute their own related images.

**Potential Expansions / Modifications:** NA (or continue to update the clearinghouse, if this is not the current situation)

### **AASHTO (American Association of State Highway and Transportation Officials) 500 Series Reports (single timeframe)**

**Link:** <http://safety.transportation.org/guides.aspx>

**Description:** The 500 series is a group of reports in which relevant information is assembled into single concise volumes, each pertaining to emphasis areas, specific types of crashes, or contributing factors. All volumes include possible countermeasures for dealing with particular areas. There are plans for future volumes and currently the volumes available are:

Volume 01: A Guide for Addressing Aggressive-Driving Collisions

Volume 02: A Guide for Addressing Collisions Involving Unlicensed Drivers and Drivers with Suspended or Revoked Licenses

Volume 03: A Guide for Addressing Collisions with Trees in Hazardous Locations

Volume 04: A Guide for Addressing Head-On Collisions

Volume 05: A Guide for Addressing Unsignalized Intersection Collisions

Volume 06: A Guide for Addressing Run-Off-Road Collisions

Volume 07: A Guide for Reducing Collisions on Horizontal Curves

Volume 08: A Guide for Reducing Collisions Involving Utility Poles

Volume 09: A Guide for Reducing Collisions Involving Older Drivers

Volume 10: A Guide for Reducing Collisions Involving Pedestrians

Volume 11: A Guide for Increasing Seat Belt Use

Volume 12: A Guide for Reducing Collisions at Signalized Intersections

Volume 13: A Guide for Reducing Collisions Involving Heavy Trucks

Volume 14: Reducing Crashes Involving Drowsy and Distracted Drivers

Volume 15: A Guide for Enhancing Rural Emergency Medical Services

Volume 16: A Guide for Reducing Crashes Involving Alcohol

Volume 17: A Guide for Reducing Work Zone Collisions

Volume 18: A Guide for Reducing Head-On Crashes on Freeways

Volume 19: A Guide for Collecting and Analyzing Safety Highway Safety Data

Volume 20: A Guide for Reducing Head-on Crashes on Freeways

Volume 21: Safety Data and Analysis in Developing Emphasis Area Plans

Volume 22: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan

Volume 23: A Guide for Reducing Speeding-Related Crashes

Two companion documents complement the series; they are:

- NCHRP Report 501 – Integrated Safety Management Process (2003) – provides a detailed outline of an integrated safety management system, required to effectively develop and implement a strategic highway safety program; it also provides detailed descriptions of tools such as methodologies for identification of crash concerns for and developing combinations of strategies for supporting jurisdictional goals (such as TZD); methodologies for estimating the effectiveness of promising or innovative strategies that have insufficient information; and methodologies for evaluating performance measures to determine the level of implementation and success in meeting of the goals of a SHSP.
- Updated *Transportation Planner's Safety Desk Reference* (February 2010) includes strategies derived from the NCHRP Report 500 Series volumes. All 22 emphasis areas are covered, as well as sections on collecting and analyzing highway safety data and developing emphasis area plans. This document discusses the planner's role in transportation safety and the incorporation of safety into the transportation planning process.

**Capabilities:**

- Volumes are available in PDF format and free for online download; alternatively copies are available at NCHRP.

**Potential Expansions / Modifications:** Create hyperlinked documents online with relevant CMFs for the treatments as found in the HSM or CMFClearinghouse.

**USRAP (United States Road Assessment Program) (on-going)**

**Link:** <http://www.usrap.us/home/>

**Description:** This program was initiated as a pilot program by the American Automobile Association Foundation for Traffic Safety (AAAFTS). The primary objectives are: to reduce fatalities by identifying major safety shortcomings; promote assessment of risk as a major part of strategic decisions on route improvements; and forge partnerships among all participants in road safety. Risk maps have been produced for the four initial pilot States. States have joined in subsequent phases, currently on Phase 3.

**Capabilities:**

- Predefined risk assessment maps for participating States.

**Potential Expansions / Modifications:** Create a user interface allowing the creation of subsets of the complete maps, in other words, users to create their own maps or extract from the existing maps. Develop a system of interaction between historical crash and annual statistics; revision of risk rankings with modifications to road networks etc.

**CAMP (Crash Avoidance Metrics Partnership) (single timeframe)****Link:**

<http://www.nhtsa.gov/Research/Crash+Avoidance/Office+of+Crash+Avoidance+Research+Technical+Publications+2000-2010>

**Description:** An initial partnership was formed between Ford and General Motors in 1995 in order to accelerate the implementation of crash avoidance measures in passenger vehicles. In later years, more companies joined the effort, such as BMW, Nissan, Volkswagen and more. This larger partnership created the CAMP Light Vehicle Enabling Research Program, a 3-year program which produced several reports in this area as well as annual progress reports. The partners collaborated in various projects including: Forward Crash Warning Requirements, Driver Workload Metrics, Enhanced Digital Maps for Safety, and Vehicle Safety Communications.

**Capabilities:**

- Data only available through reports.

**Potential Expansions / Modifications:** Encourage this and similar partnerships to work with the public agencies to integrate vehicle and road sensor/ readers for future traffic and road management (crash avoidance and traffic conditions; driver performance and vehicle response; location of vehicle and speed limiters, etc).

**Data Systems: A Road Safety Manual for Decision-Makers and Practitioners (single timeframe)**

**Link:** <http://www.who.int/roadsafety/projects/manuals/data/en/>

**Description:** This manual was drafted by the World Health Organization with collaboration with other partners. It provides guidelines on data collection for road safety management. What data elements are required for effective planning and monitoring? It helps identify relevant stakeholders, existing data sources and systems as well as strategies for improving data quality. It provides guidance to users on how to disseminate data and maximize the likelihood of its use and how to use the data in order to improve road safety, monitor results and assess the impact of interventions. Several case studies have been drawn from around the world.

**Capabilities:**

- Well presented guidelines in identifying the topics listed in the description above.

**Potential Expansions / Modifications:** Include in the HSM Knowledge base.

**HSM (Highway Safety Manual) First Edition (on-going)**

**Link:** <http://www.highwaysafetymanual.org>

**Description:** This manual was published on June 30, 2010 by the AASHTO. It will assist highway agencies as they consider improvements to existing roadways or as they are planning, designing, or constructing new roadways. The HSM will present information on roadway safety fundamentals, the safety management process, models for estimating the expected safety performance of a specific facility, and crash modification factors for estimating the expected effectiveness of individual infrastructure-based countermeasures. The publication of the Manual is the result of a decade of research and development efforts of AASHTO, the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB).

**Capabilities:**

- Fundamentals of highway safety
- Methods for developing and evaluating a roadway safety program
- Predictive methods to estimate crash frequency and severity
- Catalogue of crash modification factors for a variety of situations

**Potential Expansions / Modifications:** Develop a Web-based document that allows easy access and searching, and is updated timely with new research findings.

**Human Factors Guidelines for Road Systems - National Cooperative Highway Research Program (NCHRP) - Report 600A (under development – single timeframe)**

**Link:** [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_600A.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600A.pdf)

**Description:** This report published in 2008 is complimentary to the HSM. It contains guidelines that provide human factors principles and findings for consideration by highway designers and traffic engineers. The guidelines allow the non-expert in human factors to more effectively consider the roadway user's capabilities and limitations in the design and operation of highway facilities.

**Capabilities:**

- Data, charts, tables in report.
- Case studies

**Potential Expansions / Modifications:** It will be expanded as the next research projects develop additional materials.

**PEDSAFE (single timeframe)**

**Link:** <http://www.walkinginfo.org/pedsafe/>

**Description:** The Pedestrian Safety Guide and Countermeasure Selection System is intended to provide practitioners with the latest information available for improving the safety and mobility of those who walk. The online tools provide the user with a list of possible engineering, education, or enforcement treatments to improve pedestrian safety and/or mobility based on user input about a specific location.

**Capabilities:**

- Selection Tool – find, through questionnaire the appropriate countermeasures on the basis of desired objectives and specific location information. Can output to excel.
- Interactive Matrices – view the countermeasures associated with crash types and performance objectives.
- Countermeasures – read descriptions of the 49 engineering, education, and enforcement treatments.
- Case Studies – review real-world examples of implemented treatments.

**Potential Expansions / Modifications:** No comment

**BIKESAFE (single timeframe)**

**Link:** <http://www.bicyclinginfo.org/bikesafe/>

**Description:** As per PEDSAFE, only for bicycle related countermeasures.

**Capabilities:** Same as PEDSAFE

**Potential Expansions / Modifications:** Refer to PEDSAFE

***Analytical Tools*****SafetyAnalyst (completed)**

**Link:** <http://www.safetyanalyst.org/>

**Description:** SafetyAnalyst provides a set of software tools to be used by State and local highway agencies for highway safety management. SafetyAnalyst can be used by highway agencies to improve their programming of site-specific highway safety improvements. SafetyAnalyst incorporates state-of-the-art safety management approaches into computerized analytical tools for guiding the decision-making process to identify safety improvement needs and develop a systemwide program of site-specific improvement projects. SafetyAnalyst has a strong basis in cost-effectiveness analysis; thus, SafetyAnalyst has an important role in ensuring that highway agencies get the greatest possible safety benefit from each dollar spent in the name of safety.

**Capabilities:**

- Licensed tools
- The Network Screening Tool identifies sites with potential for safety improvements.
- The Diagnosis Tool is used to diagnose the nature of safety problems at specific sites.
- The Countermeasure Selection Tool assists users in the selection of countermeasures to reduce accident frequency and severity at specific sites.
- The Economic Appraisal Tool performs an economic appraisal of a specific countermeasure or several alternative countermeasures for a specific site.
- The Priority Ranking Tool provides a priority ranking of sites and proposed improvement projects based on the benefit and cost estimates determined by the economic appraisal tool.
- The Countermeasure Evaluation Tool provides the capability to conduct before/after evaluations of implemented safety improvements.

**Potential Expansions / Modifications:** Additional road types and facilities to be added to all tools.

**IHSDM (Interactive Highway Safety Design Model) (on-going)**

**Link:** <http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm>

**Description:** IHSDM is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways. IHSDM is a decision-support tool. It checks existing or proposed highway designs against relevant design policy values and provides estimates of a design's expected safety and operational performance. IHSDM results support decision making in the highway design process. Intended users include highway project managers, designers, and traffic and safety reviewers in State and local highway agencies and engineering consulting firms. IHSDM currently includes six evaluation modules (Crash Prediction, Design Consistency, Intersection Review, Policy Review, Traffic Analysis, and Driver/Vehicle).

**Capabilities:**

- Designed in collaboration with the HSM
- Fully compatible with prediction models found in the HSM

**Potential Expansions / Modifications:** Continue expanding with the new SPFs and CMFs under development for interchange and freeways, etc.

**PLANSAFE (under-development)**

**Link:** [http://trb.org/publications/nchrp/nchrp\\_rpt\\_546.pdf](http://trb.org/publications/nchrp/nchrp_rpt_546.pdf), Appendix C and D

**Description:** PLANSAFE is a tool developed but not yet released, that intends to forecast safety effects at the level of the traffic analysis zone (TAZ) or higher. PLANSAFE is expected to be useful for evaluating transportation and safety-related policies and area-wide solutions. It will forecast the safety impacts of socio-demographic changes and alternative future growth and transportation investment scenarios. This proactive safety tool will enable planners to consider the safety impacts of transportation and infrastructure investments, alongside congestion and air quality impacts.

**Capabilities:**

- GIS, census, roadway information and countermeasure input giving forecast results as map and tables.
- Product will be available to the public, no pricing information is available.

**Potential Expansions / Modifications:** Application has not been released yet for evaluation.



**FHWA GIS Safety Analysis Tools v4.0 (completed)**

**Link:** <http://www.hsisinfo.org/hsis.cfm?num=9&page=1>

**Description:** Part of HSIS (Tool #4). This suite of pedestrian and bicycle safety tools is a set of GIS based analytical techniques have been applied to a series of pedestrian and bicycle safety issues. They can only be used in conjunction with the ESRI ArcGIS suite, MS Access and Crystal Reports. Requires data from other source.

**Capabilities:**

- Can calculate high pedestrian crash zones.
- Can draw safe routes for walking to school.
- Can draw safe bicycle routes.

**Potential Expansions / Modifications:** Redevelopment for easier access as it is very restricting because it requires several other licensed software; and data.

**PBCAT (Pedestrian and Bicycle Crash Analysis Tool) (completed)**

**Link:** <http://www.walkinginfo.org/facts/pbcats/index.cfm?/pc/pbcats.htm>

**Description:** PBCAT is a crash manual-entry software product intended to assist state and local pedestrian/bicycle coordinators, planners and engineers with improving walking and bicycling safety through the development and analysis of a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists.

**Capabilities:**

- Free Windows application.
- Can design forms that resemble police reports that are used locally.
- Can enter location information.
- Can generate crash reports.
- Can enter countermeasures.
- Links to other countermeasure systems: PEDSAFE (#26) and BIKESAFE (#27).
- Can export data to MS Excel and SAS formats.

**Potential Expansions / Modifications:** Interconnection of applications is a step in the right direction. This stand alone application needs to be transformed to a web based application that all police reports (assuming that they will also become electronic everywhere) involving pedestrians or bicyclists be automatically included for analysis.

**Pedestrian and Bicycle GIS Safety Tools (completed)**

**Link:** <http://www.tfhr.gov/safety/pedbike/pubs/05085/chapt3.htm>

**Description:** Geographic information system (GIS) software turns statistical data (e.g., crashes) and geographic data (e.g., roads and crash locations) into meaningful information for spatial analysis and mapping. GIS is an invaluable tool being applied to many pedestrian and bicycle safety issues. It assists in mapping crashes to identify hot spots, planning the safest route to walk or bike based on roadway and traffic elements (sidewalk, curb lane width, crosswalk locations, traffic volume, etc.), and illustrating the relationships between land use, traffic patterns, and bicycle and pedestrian safety. This tool is valuable in helping visualize the data accumulated in crash and roadway databases.

**Capabilities:**

- Mapping in GIS pedestrian and bicycle data
- Mapping relationships between data

**Potential Expansions / Modifications:** No comment

**ISAT (Interchange Safety Analysis Tool) (on-going)**

**Link:** [http://safety.fhwa.dot.gov/tools/data\\_tools/iisat.cfm](http://safety.fhwa.dot.gov/tools/data_tools/iisat.cfm)

**Description:** ISAT provides design and safety engineers with an automated tool for assessing the safety effects of basic geometric design at typical existing interchange and adjacent roadway network. ISAT can also be used to predict the safety performance of design alternatives for new interchanges and prior to reconstruction of existing interchanges. The primary outputs from an analysis include: the number of predicted crashes for the entire interchange area, the number of predicted crashes by interchange element type, the number of predicted crashes by year, and the number of predicted crashes by collision type.

**Capabilities:**

Types of Analysis applications:

- Application 1—Estimating the Safety Performance of an Existing Interchange
- Application 2—Predicting the Safety Performance of Design Alternatives for a New Interchange
- Application 3—Predicting the Safety Performance of Design Alternatives for an Existing Interchange
- Application of ISAT to Specific Interchange Configurations
- Full Diamond Interchange
- Partial Cloverleaf Interchange

- Full Cloverleaf Interchange
- Directional Interchange
- Extended Roadway Networks Near Interchanges

**Potential Expansions / Modifications:** develop a more robust tool; expand with better SPFs and create more reliable CMFs (NCHRP 17-48 is developing the SPFs and CMFs – and these will be used in this tool and the HSM)

### **SSAM (Surrogate Safety Assessment Model) (completed)**

**Link:** <http://www.fhwa.dot.gov/publications/research/safety/08049/index.cfm>

**Description:** To assess a traffic facility with SSAM, the facility is first modeled in VISSIM, AIMSUN, Paramics, and TEXAS simulation models and then simulated with desired traffic conditions (typically simulating several replications with different random number seeds). Each simulation run results in a corresponding trajectory file, referred to as a TRJ file corresponding to the .trj filename extension. Then, SSAM is used as a post-processor to analyze the batch of TRJ files. SSAM analyzes vehicle-to-vehicle interactions to identify conflict events; it catalogs all events found. For each such event, SSAM also calculates several surrogate safety measures, including the following:

- Minimum time-to-collision (TTC).
- Minimum post-encroachment (PET).
- Initial deceleration rate (DR).
- Maximum deceleration rate (MaxD).
- Maximum speed (MaxS).
- Maximum speed differential (DeltaS).
- Classification as lane-change, rear-end, or path-crossing event type.
- Vehicle velocity change had the event proceeded to a crash (DeltaV).

#### **Capabilities:**

- A table of all conflicts identified in the batch of analyzed TRJ files, including file, time, location, vehicles identifications, and several measures of conflict severity.
- A summary of conflict counts by type and file, with average values of surrogate measures over all conflicts.

- A filtering mechanism that allows the isolation of subsets of conflicts by ranges of surrogate safety measures, conflict type, network link, or a rectangular region of the network.
- A facility for statistical comparisons of the conflict frequencies and values of surrogate safety measures for two alternative cases or designs using the Student  $t$  distribution for hypothesis testing.
- A display of the location of conflicts on the network map, with icons of different shapes and colors assignable to different conflict types or severities.

**Potential Expansions / Modifications:** Real life testing

### **FEA (Finite Element Analysis) (completed)**

**Link:** <http://www.tfhr.gov/safety/crash/index.htm>

**Description:** Finite element analysis (FEA) is an efficient and cost-effective tool to assist in the design of safer highway guardrails, bridge supports, signposts, and other roadside structures. It can be used to predict the outcome of a crash test. FEA of roadside safety features involves analyzing the computer-generated impact of two bodies (a model of a specific motor vehicle colliding into a model of a specific roadside safety structure). Computer models of many motor vehicles that are currently in the national fleet are ready for use with this tool. These include models of specific vehicles that meet the NCHRP Report 350 vehicle criteria: a Geo Metro sedan, a Chevrolet C-2500 pickup truck, and an 18,000-lb. single-unit Ford truck. A model of a tractor-trailer is currently under development.

#### **Capabilities:**

- Predict outcome of crash test.

**Potential Expansions / Modifications:** Add different models (both motor vehicle and roadside safety structure)

### **VDA (Vehicle Dynamics Analysis) (completed)**

**Link:** [http://safety.fhwa.dot.gov/tools/data\\_tools/fhwasa09002/](http://safety.fhwa.dot.gov/tools/data_tools/fhwasa09002/)

**Description:** VDA, a digital simulation, analyses the effects of uneven terrain on the trajectory of a vehicle driving over it. For a particular median profile and barrier location, VDA can indicate whether a particular vehicle at a given speed and impact angle is likely to go over the barrier, to under-ride the barrier, or properly engage the barrier. This application of vehicle dynamics analysis is strictly an interface analysis – it considers only whether the

vehicle and the barrier are well aligned at the instant of impact. For angles greater than 25 degrees the vehicle is more likely to hit the ground hard; this is not modeled in VDA.

**Capabilities:**

- Digital simulation

**Potential Expansions / Modifications:** Expand to other barriers such as shrub or vegetation barriers; and consider other considerations such as vehicle loading, weather, suspensions etc.

**Key Initiative - SHRP 2 (on-going)**

**Source:** SHRP2 2008 Annual Report and Strategic Highway Research Program (SHRP) 2 Revised Safety Research Plan: Making a Significant Improvement in Highway Safety, April 2010 (provided by Kenneth Campbell)

**Description:**

The 2nd Strategic Highway Research Program, known as SHRP2, was identified in the TRB Special Report 260, published in 2001. SHRP2 focuses on applied research in four areas: safety, renewal, reliability, and capacity.

The central goal of the SHRP 2 Safety Research Plan is to address the role of driver performance and behavior in traffic safety. This includes developing an understanding of how the driver interacts with and adapts to the vehicle, traffic environment, roadway characteristics, traffic control devices and the environment. It also includes assessing the changes in collision risk associated with each of these factors and interactions. This information will support the development of new and improved countermeasures with greater effectiveness, with particular focus to lane departure and intersection collisions. Two central issues for the planned analysis are the statistical relationship of surrogate measures of collisions (conflicts, critical incidents near-collisions, or roadside encroachment) with actual collisions, and the formulation of exposure-based risk measures using these surrogate measures.

The development of the analytical methods for the data to be collected has started in 2007 for completion in 2010. Data collection will follow for a number of years before the analysis takes place.

**Capabilities:**

Extraordinary effort supported by significant funds to develop a knowledge base with data to be collected by means of modern technology. The table shown here provides the timelines for SHRP 2 projects and allocated respective funds.

<b>SHRP 2 Safety Projects</b> (Source: SHRP2 2008 Annual Report)			
<b>Project Number</b>	<b>Project Title</b>	<b>Budget</b>	<b>Start</b>
S01	Development of Analysis Methods using Recent Data; 4 contracts: A) University of Minnesota Center for Transportation Studies B) Pennsylvania Transportation Institute C) University of Michigan Transportation Research Institute (UMTRI) with Virginia Tech Transportation Institute (VTTI) E) Iowa State University CTRE with the University of Iowa	\$1,500,000	March 2007
S02	Integration of Analysis Methods and Development of Analysis Plan; University of Iowa with Iowa State University CTRE, University of Minnesota, and Montana State University	\$500,000	April 2008
S03	Roadway Measurement System Evaluation; Applied Research Associates (ARA) with Cambridge Systematics and KCI	\$500,000	January 2008
S04	A) Roadway Information Database Developer and Mobile Data Collection (Project S04B) Technical Coordination and Quality Assurance B) Mobile Data Collection	\$1,000,000 - \$3,500,000	April 2010 S04B RFP Aug. 2010
S05	Design of the In-Vehicle Driving Behavior and Crash Risk Study; Virginia Tech Transportation Institute (VTTI) with The University of Michigan Transportation Research Institute (UMTRI) and Battelle	\$3,000,000	June 2007
S06	Technical Coordination and Independent Quality Assurance for Field Study; Virginia Tech Transportation Institute, VTTI	\$6,200,000	June 2009
S07	In-Vehicle Driving Behavior Field Study (six site selected)	\$16,500,000	May 2010
S08	Analysis of Driving Behavior Field Study Data and Countermeasure Implications (multiple awards)	\$5,000,000	RFP late 2010
S09	Site-Based Video System Design and Development; University of Michigan Transportation Research Institute (UMTRI) with Virginia Tech Transportation Institute (VTTI), Soar Technology and University of California, Berkeley (PATH)	\$1,000,000	March 2007
S10	Design and Conduct the Site-Based Field Study	--	--
S11	Analysis of Site-Based Field Study Data and Countermeasure Implications	--	--
S12A	Data Acquisition System (DAS): Equipment and Vendor Services	\$10,000,000	Oct. 2009
<b>TOTAL</b>		<b>\$48,700,000</b>	

**Potential Expansions / Modifications:** No comment

## **STRATEGIES AND INITIATIVES**

Safety improvement is a multi-disciplinary pursuit involving at least the 4Es and expanding to numerous sources of data. Each data source has its unique quality threats and each state manages data in unique ways. States now manage their critical data sources under at least one, but often several related Strategic Plans. These documents (most notably the Traffic Record Strategic Plan) include reviews of the current status of crash, roadway, driver, vehicle, citation/adjudication, and injury surveillance (medical) data in the state. The plans include strategies for improving the timeliness, accuracy, completeness, consistency, integration, and accessibility of each of these data sources. In addition, state highway safety plans often include sections on data and analysis that map out additional strategies specific to the needs of engineers, planners, and others with direct involvement in highway safety initiatives.

As strategies are developed, there is a need to identify data elements to be collected so that the state can measure progress both at the individual project level and at a more macro level to ensure that programs are meeting their safety goals. States need timely data as implementation takes place and throughout a project's lifecycle in order to identify variances from plan, shortfalls in projected safety improvements, and to enable the state to modify programs promptly to achieve the desired results from the various strategies implemented.

With improvements in coordination among engineers and their counterparts in enforcement, courts, driver licensing, vehicle registration, and health care, there has been an expansion of the data sources available. This expansion will continue in the future. As a result, there will be a corresponding increase in the types of analyses that can be supported by the available data. New data systems and analysis tools will be required to support the strategies and initiatives discussed in the highway safety white papers as well as for assessing progress in the implementation of the national strategy for highway safety Toward Zero Deaths. These analyses and the frequent dissemination of their results to decision-makers are fundamental to obtaining continuous support for the necessary advancements and innovations in safety data collection and analysis. They also serve to develop confidence in strategies for new implementations – as decision-makers see that the strategies are working, as demonstrated by solid data and valid analyses, they will become more reliant on those new resources and tools.

### ***Data Systems Strategies and Initiatives***

Three strategies specific to data systems development and management were identified. The remaining strategies and initiatives that combine both data systems and analysis are included under the Data Analysis Strategies and Initiatives section.

### **Location Strategies**

The role of geography and location coding will continue to play a significant role in identifying where incidents are occurring. Geographic Information Systems (GIS) provide the infrastructure methodology to link various types of data for spatial analysis to support accurate and effective decision-making. Working together, all jurisdictions will benefit by establishing an enterprise approach to GIS, at a minimum throughout a state. Individual agencies with existing GIS programs can participate in this enterprise approach by data sharing through Web-based services. If all network data are identified, located, and updated throughout the state using one base GIS service, there will no longer be confusion about where traffic incidents are occurring and what elements of the environment may have contributed to a crash. This strategy will enhance agencies' communication, reduce redundant data maintenance and management, and provide the potential for linking in other types of data for safety analysis that have not been yet identified in today's safety data systems and analysis tools. A pilot test of this enterprise-wide strategy for location data sharing is described in Tennessee's Information Systems Plan for 2008.<sup>7</sup>

### **Linkage Strategies**

Through the E-9-1-1 enhanced computer-aided dispatch (CAD) system, a record is formed of exact location of an incident, what resources were deployed to that location (enforcement, emergency medical services, tow operators removing vehicles, routing of injured or killed participants, et al.). Furthermore, basic crash, citation, arrest, and other traffic data are initiated for the incident and all of these data are linked by the CAD and its records management system (RMS). E-911 has taken the dispatch centers from the 1970s mode of communicating by voice, to permitting the electronic transmission of data to and from the dispatch center.

Next Generation 9-1-1 (NG9-1-1)<sup>8</sup> is an initiative proposed by the Intelligent Transportation Systems (ITS) Joint Program Office to leverage the progress made by the Wireless E9-1-1 Initiative of the National Emergency Number Association and the US DOT Office of the Secretary.<sup>9</sup> The NG9-1-1 initiative will leverage the progress from the Secretary of Transportation's Wireless E9-1-1 Initiative, which has enhanced location capability for 9-1-1 calls placed from wireless phones. NG9-1-1 will go that additional step to use any communications device. The NHTSA study of Electronic Crash Data Collection Tools also recommends a strategy of obtaining initial data from the dispatch center RMS to initiate crash data collection.<sup>10</sup>

### **Customer Service Improvements**

In order to maintain access to data for safety analysis that is of sufficient quality and timeliness, rarely is it recognized that a well-trained, effective information systems



workforce is required. For example, as many crash data systems were moved to microcomputer-based systems, the desire to access driver and vehicle records during data entry to cross-reference these data was forgotten. Too often governmental offices of Information Technology (IT) are used as training grounds for new personnel, who then move on to other offices or private industry. It is critical that those IT persons with subject matter knowledge be retained, or changes and updates to systems will not include all of the business rules required for effective safety analysis. Strategies for retaining critical IT personnel to manage safety-related systems include supporting on-going and relevant technical training, providing access to web-based training courses, including on-line technical courses.

### ***Data Analysis Strategies and Initiatives***

Examples of information sources and analytic tools lead to a number of general conclusions:

- Include all injury crashes in national databases
- use of technology to automate and minimize redundancy and errors
- development of a data warehouse and provide online access
- development of state, regional and local SPFs for network screening and develop linkages between different local databases; expand the tools for all jurisdictions (not only states) and place them on a SPF clearinghouse
- Increase accessibility by posting all online
- Create an on-going mechanism to keep the knowledge base updated with new research and evaluation of treatments and online access
- Expand analytical tools to other road types and facilities; and road users

These conclusions are in line with the implementation strategies proposed at the completion of the international scan.<sup>11</sup> This report summarizes the international scan of Australia, Germany, and the Netherlands. Five strategies and several sub-strategies were developed. It concluded that:

*“If decision-makers are provided safety analysis tools that output better safety decisions or make the decision-making process easier, these tools will be used. If these tools require improved safety data, then these same decision-makers will find ways to generate these improved data.”*

With that in mind, Strategy 4 – Improve Safety Data by Increasing the Use of Critical Safety Analysis Tools (which themselves require good data) was developed. It has two key sub-strategies:

- (a) Market existing safety analysis tools and those under current development
- (b) Develop the next generation of safety analysis tools

These sub-strategies are critical in support of the Toward Zero Deaths goal. Similar to the effort of marketing and implementing the HSM, it is paramount that professionals and practitioners become familiar with and trained to use the tools, and that their agencies' systems are able to adapt to the tools' requirements. The second sub-strategy supports the concept of a data warehouse and integrated knowledge base in the nation; i.e., integrating the knowledge of NHTSA, FHWA, FMCSA, State and local safety analysts and safety researchers to develop the next generation of critical safety-data analysis tools.

#### Strategy 1: Implement state-of-the-art tools (Timeframe 1-5 years)

Significant resources have been devoted to the development of tools such as HSM, SafetyAnalyst, IHSDM, PLAN4SAFE, etc. Their implementation in the agencies has been slow. Toward Zero Deaths goal requires day-to-day actions and they need to be universally used at all highway agencies. Institutionalization of explicit safety quantification is a must. The sub-strategies to support this strategy as:

##### Strategy 1.1 Establish Resources, Training, and Outreach

Among the grants available, SAFETEA-LU State Highway Safety Grant Programs: Section 408 State Traffic Safety Information System Improvement Grants. This program encourages states to adopt and implement effective programs to improve the timeliness, accuracy, completeness, uniformity, integration, and accessibility of state data needed to identify priorities for national, state, and local highway and traffic safety programs; to evaluate the effectiveness of efforts to make such improvements; to link the state's data systems, including traffic records, with other data systems within the state; and to improve the compatibility of the state's data system with national data systems and data systems of other states to enhance the ability to observe and analyze national trends in crash occurrences, rates, outcomes, and circumstances<sup>12</sup>.

Additional resource and technical support efforts are required to get to the data analysis levels envisioned. A momentum created by a Lead State initiative would be very supportive, and demonstrate the feasibility and benefits of such implementations. Suggestions provided are:

- Establish a group of highway safety professionals trained in the analytical methods

- Adapt analytical tools for each agency (e.g., calibration of SPFs, data management)
- Provide venues for multi-disciplinary, and multi-departmental peer exchange
- Establish lead agencies` programs
- Establish a media national outreach channel (reaching the general public) to report on the results of the tools and other strategies

Strategy 1.2 Present tools and their requirements; establish agencies` needs to implement the tools; provide resources to implement the tools

While Strategy 1.2 is a critical one to create the momentum, it is absolutely critical to implement the state-of-the-art analytical tools at every agency in the nation, Agencies are police departments in each jurisdiction, State DOTs, MPO, and local agencies. The procedure at each one of these would be to meet with representatives, and present the tools in a hands-on workshop style. It is therefore important to gather their feedback in terms of how the tools compare with current practices, what benefits could be attained in implementing the new tools. The feedback need to be attained from those who will use the tools. For example, based on the challenges of current implementation of *SafetyAnalyst*, the key needs are data interface, data completeness and linkages, and a good understanding / acceptability of the new analytical methods found in the *SafetyAnalyst*.

Strategy 2 – Expand on methods and application tools (Timeframe 1-10 years)

Three sub-strategies will support the Toward Zero Deaths goal. They are:

Strategy 2.1 Development and inclusion of expected crash analysis within existing and future capacity and other operational analytical tools

The state-of-the-art methods found in the HSM provide the foundation to develop models to integrate safety explicitly in other non-safety tools, such as operational and capacity tools. In addition, the interrelationship of driver performance and behavior with roadway design and traffic conditions, that are some of the anticipated results of SHRP 2, will provide information to develop and expand the models suitable for these non-safety tools.

Strategy 2.2 Development and inclusion of crash costs (government and other real costs) within existing transportation and other cost analysis tools

Strategies toward the Toward Zero Deaths goal will be assessed in many ways, including their benefits in terms of prevented costs of crashes. As of today, there is not a comprehensive warehouse of government and public crash costs in the U.S. The linkages between databases do not exist but they are feasible. The development of a more oriented safety culture in our institutions should open the ways for such linkages. Analytical methods will be required to evaluate the data.

The databases should include emergency services crash-related costs (police, emergency medical services, fire services, and incident management services); medical costs (emergency room costs, inpatient costs, outpatient costs in hospital, outpatient costs out of hospital, the Child Health Improvement Program, state employee health insurance, or other state insurance programs); coroner costs; direct government crash costs (disability payments to injured government employees, travel delay (government workers productivity loss in crash-related traffic and sickness from the idling environment), government administration costs (processing personnel changes, processing productivity loss compensation claims, workers' compensation), cost of vocational rehabilitation for government employees, unemployment payments, the costs of workplace disruption that is due to the loss or absence of an employee, the cost of retraining new employees, overtime required to accomplish work of the injured employee, loss of unique skills, costs of investigating and keeping records on workplace injuries including any for cause drug and alcohol testing, and costs of disciplinary actions); property damage costs (damage to public property (such as replacing poles, guiderails, fences, traffic signals, illumination, treating trees and other damaged vegetation and structures and appurtenances, damage to government-owned vehicles, damage to vehicles in work zone crashes to government contractors), cost of personnel working at the claim department, and administration costs); Judicial system costs (operating courts, costs of judges, costs of transporting to/from courts, costs of maintaining jails, cost of government witnesses such as police officers, costs of lawyers responding to litigation cases, and cost of settling or paying victims of crashes); public revenue (decrease in tax revenues due to lost wages from those killed in crashes, and from those injured in crashes resulting in inability to work partially or for the rest of their lives; public assistance (welfare payments, food stamps, housing assistance, low-income energy assistance, and health insurance coverage through Medicaid.)

The execution of this strategy will assist in getting legislators and decision makers to realize the importance of TDZ goal, especially in times of resource limitations.

### Strategy 2.3 Development of climate change models and road safety analytical tools for proactive treatments and driver information systems

Climate change has not been studied to determine how these changes influence the frequency and severity of crashes. In a climate change impact analysis, it is important to separate natural climate variability and climate change signal. Thus, it will be important to collect sufficient data of climatological records and crashes to establish a good understanding of the problem.

Research has been done on the relationship between safety and weather, but no prediction models have been developed for a set of weather type/ intensity and time of the day. The analysis should examine both rainfall and snowfall events, with particular attention being

given to events of different intensity, e.g. heavy rainfall. The analysis should consider crashes of different severities, from property damage only to serious injury/fatality; and explore special types of weather-related driving risks that occur less frequently, e.g., on ice roads, during fog or high winds, with a view to developing a methodology for understanding the implications of climate change for these types of driving circumstances.

Explore the extent to which particular collision attributes (e.g., number and type of vehicles involved, driver age or other characteristics, collision configuration prior to impact, speed limit, roadway geometrics) are over/under represented during weather events of different types. This can be accomplished by establishing risk ratios for particular subsets of collisions and/or through statistical modeling.

The analytical methods and prediction models will enable an intelligent management procedure by advising about travel conditions ahead so that drivers and highway agencies alike will be able to modify their travel plans accordingly.

### Strategy 3 – Develop and Implement new methods and tools (Timeframe 1-15 years)

Strategies 1 and 2 are set to implement and expand state-of-the-art methods and tools. Strategy 3 supports the critical need for new analytical methods and tools to further support the Toward Zero Deaths goal.

#### Strategy 3.1 Real-time (ITS) information tools

Analysis tools for real time assessment of traffic operations and intelligent prevention of crashes – with inclusion of road conditions, vehicular movements, weather conditions, and driver conditions (integrates the vehicular information, the traffic assessment, the individual driver’s condition) – these will use GPS, GIS and other technologies using pre-crash conditions to provide intelligent information to drivers (supportive of the safety culture’s involvement of the public) as well as to the road operations’ managers toward the Toward Zero Deaths goal.

SHRP2’s new analytic methods and large datasets will provide very relevant and needed knowledge to support this sub-strategy. The use of surrogates for collisions, such as near-collisions, critical incidents, or traffic conflicts, would greatly increase the power of real-time information since SHRP2’s data collection technologies support continuous measurement of crash margin measures such as the time-to-lane departure, or the time-to-collision<sup>13</sup>.

A to-be-published report<sup>14</sup> provided the insight about the GIS-based methodology to be developed for the analysis of crashes and crash surrogates related to highway variables, in support to one of the priority SHRP 2 safety questions; i.e., road departure crashes. It describes:

*“The underlying hypothesis is that links can be drawn between variations in continuous driving behavior seen in normal driving, and the discrete crash events that are recorded in crash databases. Both crash and naturalistic data are explored from the perspective of spatial dependency and in particular on the highway factors associated with that dependency. At the core of the analysis is the use of spatial referencing of the supporting data sets, and the statistical analysis employed to measure co-dependency of these output variables on a range of highway variables. The linkage depends on the existence of crash surrogates, which are expected to include variables available in future driving studies; surrogates should be systematically related to road departure crash risk and hence to crash occurrence. As an intermediate step in developing surrogates, focus is placed on quantifying aspects of “disturbed control” in normal driving – with the expectation that feasible surrogates are essentially measures of such disturbed control states relative to the driving demands of a particular situation – risk being compounded by factors such as speed, lane width and curvature.”*

It further describes that,

*“Road departure crash rates depend on multiple factors, principally associated with human behavior and highway/traffic conditions. Traditional analysis of crash databases cannot determine the influence of human behavior in any great detail, so the “missing information” is to be developed from naturalistic driving studies. All approaches explored in this study include some mapping or common reference for associating naturalistic driving with the occurrence of crashes, and define surrogates that typify physical mechanisms that lead to road departure crashes. Many possible events or conditions can be proposed as surrogates for crashes. They can be discrete events or continuous conditions that result in a crash in the extreme, or in a non crash event that is necessary for crash occurrence. In this study we focused on developing surrogates based on measures of lane-keeping control performance. These started with relatively simple ones based on lane position and time to the crossing of a lane boundary to more complex measures such as a driver’s adjustment of the yaw angle of the vehicle to match that of the road”.*

It concludes with:

*“Two analytical methods developed in this study focused on the statistical relationship between surrogate measures of crashes and actual crashes and on formulation of exposure-based risk measures using the surrogate measures. The first approach is an extension of the traditional univariate response model for crashes to a model that treats crashes and crash surrogates as a bivariate response variable, incorporates a correlation structure between them, and can be extended to a*

*Bayesian model. The second approach is based on extreme value theory and estimates the probability of events that are more extreme than any that have been observed.”*

This is an example of the methodological development required to establish the knowledge for the vision of real-time safety information system. Similarly to the ITS showcases carried out in past years, a showcase demonstrating the implementation of the new tools would be very helpful to get legislators and decision-makers on board.

### Strategy 3.2 Expansion of historical integrated (warehouse) data and analysis tools

Crash, traffic and road data analysis tools for assessment of road networks, critical linkages for the assessment of safety performance on our roads, the identification of sites with promise, and assessment of countermeasures, are included in Strategy 1, as they are fundamental for the implementation of the HSM, *SafetyAnalyst* and other tools. These linkages are now expanded to include other facilities, drivers’ and other road users’ data, and vehicle elements.

This data warehouse will allow new analysis toward better understanding of causes and contributing crash factors, and the effectiveness of treatments. It is envisioned that the warehouse will include all fatal and injury crashes (as a minimum) and will also include non-state roads. It is envisioned that the warehouse will be online and the analytical tools available for all local and non-local safety and transportation analysts toward supporting the actions toward the Toward Zero Deaths goal.

The product of this sub-strategy will support Strategy 3.3, and will function as the “go to” for answers to questions related to crash-based safety performance.

### Strategy 3.3 Evaluation Methods to assess pre-defined performance indicators

The need to establish an on-going performance measurement system has been documented.<sup>15</sup> As indicated in this report:

*“Monitoring of a safety plan or program consists of the systematic recording of the many actions and activities that make up the program. Monitoring is an essential first step in systematic evaluation. While the various activities may be carried out by many different agencies, it is essential that the monitoring be conducted, or at least coordinated, by a lead agency.*

*Evaluation consists of the systematic study of the effects of the various program elements on road safety. As will be explained below (see section on performance indicators), not all activities can be directly related to safety outputs, i.e. reductions in the number of crashes, casualties and fatalities. For such activities, a number of*

*surrogate indicators can be developed to measure the scope, quality and success of the activity.”*

It further states that:

*“It is important to ensure that the data available for program monitoring are at a level that enables evaluation of the separate program elements and their possible interactions. Ideally, crash forecasts and a detailed evaluation program should form part of the evaluation/monitoring process. Some countries, including Sweden, the Netherlands and the United Kingdom, have developed prediction curves and are starting to use them in their safety programs.*

With respect to performance indicators, the report summarizes that:

*“Given the number of countries now involved in monitoring and evaluation, it seems possible to prepare a framework for successful monitoring and evaluation of a safety plan. The data requirements and the level and type of disaggregation needed for evaluation are closely linked to the details of the safety programs. It is generally accepted that road safety is expressed in the number of collisions, casualties and fatalities that occur in the transport system – the “tip of the safety iceberg”. Accepting these measures is an admission of the inability to collect more complete information that can reveal the root causes of and precursors to collisions, casualties and fatalities. This more detailed information should cover near-miss events and incidents that do not result in collisions, casualties and fatalities. It should be realized that many safety actions and program elements cannot be directly related to these safety indicators. Programs that deal with safety awareness campaigns, advertising and traffic education, for example, cannot generally be assessed on their direct effect on the numbers of collisions and casualties. For such programs, other types of performance indicators are developed which can be monitored and evaluated. Behavioral measures have behavior indicators and other activities have process indicators that can be assessed. Usable performance indicators should be SMART: Specific, Measurable, Ambitious (but also Acceptable), Realistic, and Time-dependent.”*

In a similar manner, pre-defined performance indicator analysis tools are needed to assess the progress in the implementation of the programmatic, systemic and specific strategic actions adopted toward the Toward Zero Deaths goal. The results of such implemented actions will be weighed against the expected decreasing trend toward the Toward Zero Deaths goal.

GHSA, NHTSA, the states, et al. developed Traffic Safety Performance Measures for States and Federal Agencies (August 2008) and plans are in place for all states to begin using a minimum set of 14 performance measures in FY 2010 to achieve a level of consistency



(URL: [www.ghsa.org](http://www.ghsa.org)). This guidance recommends use of a range of measures to provide a more complete picture of safety performance. When incorporating safety into system performance measures, a number of issues should be considered. Performance measures must be sensitive enough to assess changes in safety performance after strategies are implemented. Agencies must be capable of collecting or accessing timely and accurate data relevant to the performance measures. Finally, the safety performance measures should be linked to the evaluation criteria for assessing the relative benefits of one project or strategy over others.

Similarly, evaluation of the strategies adopted toward Toward Zero Deaths goal will be evaluated based on pre-defined performance indicators. As shown in Appendix D (NCHRP Report 501, Integrated Safety Management Process, 2003), some methodologies are available for such evaluations and others need to be developed. Integration of the several sources for before-after data collection for the purpose of a holistic analysis of the implementation progress and impact is fundamental to the Toward Zero Deaths goal, as seen in European Countries.

In summary, this sub-strategy will provide the methods to assess, among others, the following aspects:

- safety and other impacts of the initiatives and strategies
- global impact of safety programs
- implementation progress
- coordination among agencies and departments
- analytical methods sufficiency and application

## REFERENCES

---

- 1) Success Strategies: *Rahn Recommends “Practical Design” in Tight Budget Times*, AASHTO Journal, Weekly Transportation Report, January 15, 2010. (Based on presentation made by Rahn upon receiving the Lester P. Lamm Memorial Award). URL: <http://www.aashtojournal.org/Pages/011510roadgang.aspx>.
- 2) Draft Discussion Framework for State Strategic Highway Safety Plans (SHSP), Federal Highway Administration, 7/14/2010.
- 3) Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Title 23, United States Code, including amendments.
- 4) Traffic Records Curriculum, Traffic Records Overview Module, URL: [www.trafficrecords101.net](http://www.trafficrecords101.net).
- 5) Fatality Analysis Reporting System (FARS), National Center for Statistics and Analysis, Data Resource Website, National Highway Traffic Safety Administration, US Department of Transportation, URL: <http://www-fars.nhtsa.dot.gov/Main/index.aspx>.
- 6) The State of Tennessee 2008 Information Systems Statewide Plan, Office of Information Systems, Nashville, TN, December 2008, URL: <http://www.tn.gov/finance/oir/planning/stplan.pdf>.
- 7) Next Generation 9-1-1 Service, Intelligent Transportation Systems, US Department of Transportation, URL: <http://ntl.bts.gov/lib/jpodocs/brochure/Initiatives/14092.pdf>.
- 8) 9-1-1 National Deployment Status and US DOT Wireless E9-1-1 Secretarial Initiatives, National Emergency Number Association, URL: <http://www.nena.org/wireless-911-deployment>
- 9) DeLucia, B. H. and R. A. Scopatz, E-Crash: The Model Electronic Crash Data Collection System, National Highway Traffic Safety Administration, US Department of Transportation, Report DOT HS 811 326, June 2010. URL: [http://h2.rita.dot.gov/traffic\\_safety\\_data\\_projects/](http://h2.rita.dot.gov/traffic_safety_data_projects/)
- 10) Highway Safety Manual, URL: [http://www.cmfclearinghouse.org/collateral/HSM\\_knowledge\\_document.pdf](http://www.cmfclearinghouse.org/collateral/HSM_knowledge_document.pdf)
- 11) Traffic Safety Information Systems International Scan: Strategy Implementation White Paper, Publication No. FHWA-HRT-06-099, September 2006.

- 
- 12) Transportation Planner’s Safety Desk Reference, FHWA-HEP-10-001, February 2010.
  - 13) Strategic Highway Research Program (SHRP) 2 Revised Safety Research Plan: Making a Significant Improvement in Highway Safety, April 2010 – (provided by Kenneth Campbell)
  - 14) Development of Analysis Methods Using Recent Data: A Multivariate Analysis of Crash and Naturalistic Event Data in Relation to Highway Factors Using the GIS Framework - Final Report – July 2010 - University of Michigan Transportation Research Institute, National Academy of Sciences, University of Michigan Transportation Research Institute: Michelle Barnes\*, Adam Blankespoor, Dan Blower, Tim Gordon, Paul E Green, Lidia Kostyniuk, Dave LeBlanc, Scott Bogard; and Virginia Tech Transportation Institute: Brad R. Cannon and Shane B. McLaughlin (provided by Kenneth Campbell).
  - 15) “Safety on the Road – what is the vision?” OECD Report, 2002.