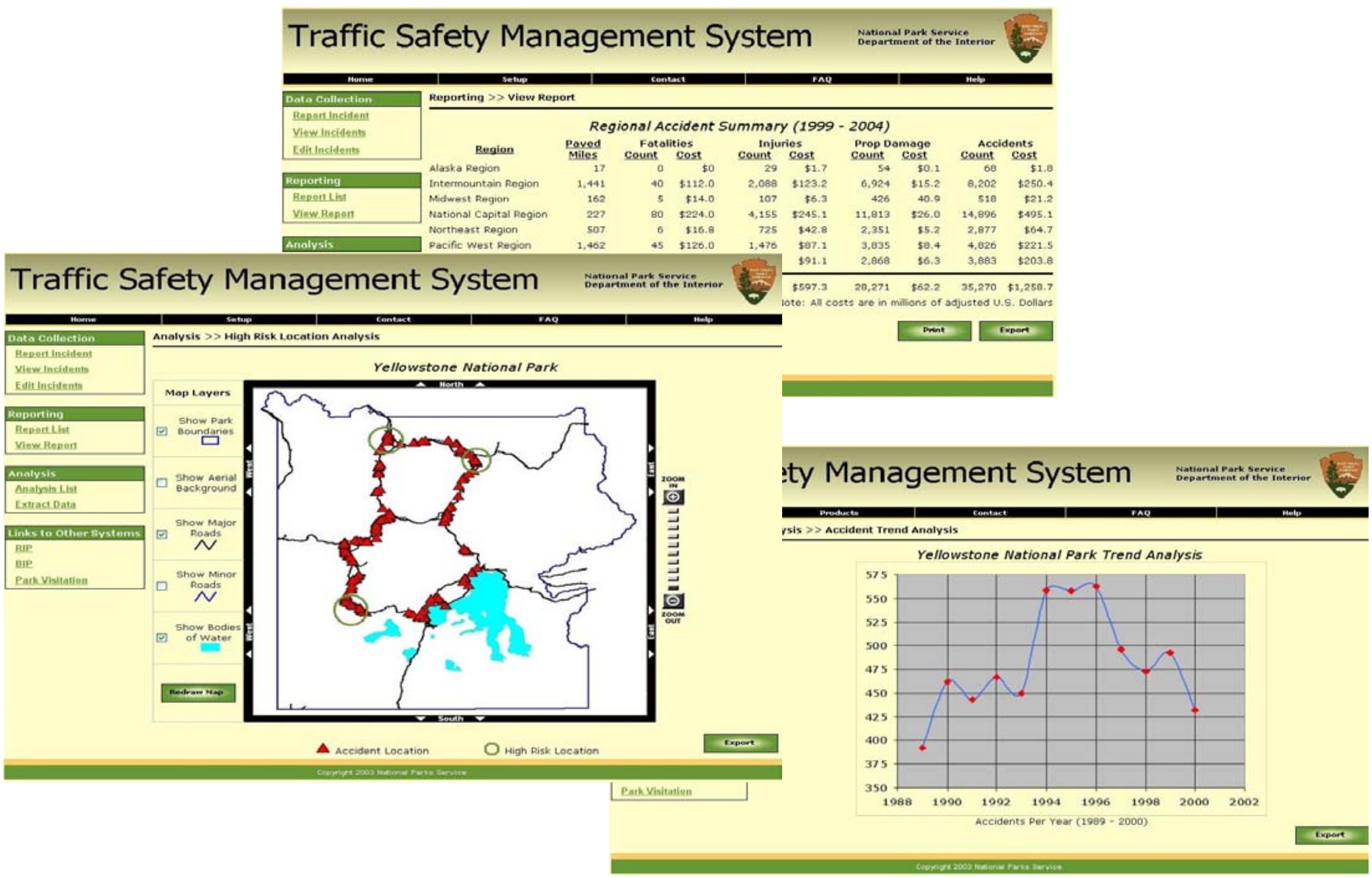
National Park Service
U.S. Department of the Interior

Park Roads and Parkways

National Park Service
Traffic Safety Management System Concept



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Abstract: It is the responsibility of the National Park Service (NPS) to ensure the safety of visitors traveling on its roads. To accomplish this task, the NPS needs to know the status of traffic safety within the parks to understand where improvements are needed. Once safety improvements are made, it is vital that the effectiveness of these safety improvements is tracked and used in future planning. It is for these reasons that the NPS needs to develop a system for managing traffic safety within its over 300 parks. This document describes the concept for a safety management system for the National Park Service that provides NPS with the information, analysis tools, and processes to manage effectively traffic safety on its roads.

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List of Acronyms and Abbreviations

AADT	Annual Average Daily Traffic
ATP	Alternative Transportation Program
ATS	Alternative Transportation System
BIP	Bridge Inventory Program
CBA	Choosing by Advantage
CIRS	Case Incident Reporting System
COTS	Commercial Off-the-shelf
DOI	Department of the Interior
FARS	Fatal Accident Reporting System
FHWA	Federal Highway Administration
FLH	Federal Lands Highway
FLHP	Federal Lands Highway Program
FMCSA	Federal Motor Carrier Safety Administration
FMSS	Facility Management Software System
FOTSC	Field Office Technical Support Center
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographical Information System
GPS	Geographical Positioning System
ICC	Interstate Commerce Commission
IHSDM	Interactive Highway Safety Design Model
IMARS	Incident Management and Reporting System
INDOT	Indiana Department of Transportation
Lat/long	Latitude and longitude
MMUCC	Model Minimum Uniform Crash Criteria
NHTSA	National Highway Traffic Safety Administration
NPRM	Notice of Proposed Rulemaking
NP	National Park
NPS	National Park Service
PC	Personal Computer
PDA	Personal Data Assistant
PRP	Park Roads and Highways
PRPP	Park Roads and Highways Program
PRPTIP	Park Roads and Highways Transportation Improvement Program
PS&E Package	Plans, Specifications and Estimates Package
RAD	Rapid Application Design
RFP	Request for Proposals
RIP	Road Inventory Program
RSAR	Road Safety Audit Review
SADT	Seasonal Average Daily Traffic
SAS	Statistical Analysis System, Inc.
SPSS	Statistical Package for the Social Sciences
STARS	Servicewide Traffic Crash Reporting System

SUV	Sport Utility Vehicle
TSMIS	Traffic Safety Management Information System
TSMS	Traffic Safety Management System
US	United States
USDOT	United State Department of Transportation
Volpe Center	John A. Volpe National Transportation Systems Center

Executive Summary

In 1999 the Federal Highway Administration (FHWA) required Federal Lands Management Agencies, including the National Park Service (NPS), to have a comprehensive Traffic Safety Management System (TSMS). The NPS recognizes that improved safety data and analysis capabilities could improve crash record keeping and consideration of safety in NPS transportation investment decisions. With a TSMS NPS could become proactive, rather than reactive, in addressing traffic safety by identifying crash risks at their earliest manifestation. It is conservatively estimated that a TSMS could result in a net benefit of approximately $560,000 annually. If TSMS-identified safety improvements prevented only one fatality, currently valued at $3 million by the United States Department of Transportation (USDOT), it would be well worth the cost.

TSMS Mission

In February 2002 the NPS drafted a mission statement to guide TSMS development:

While maintaining a balance of public safety and resource protection, assure a safe park transportation experience for all park users through the:

- *Efficient monitoring and reporting of incidents;*
- *Identification and correction of safety problems:*
  - *through effective enforcement,*
  - *by providing safety education, and*
  - *by the application of cost-effective safety technology;*
- *Effective utilization of safety data for allocation of resources;*
- *Timely maintenance of safety-related appurtenances; and effective communication with state and local safety official*

TSMS Concept

The USDOT Volpe National Transportation Systems Center, in collaboration with the Federal Lands Highway Program of FHWA, has developed a TSMS concept to fulfill the mission. Importantly, the TSMS concept reflects a comprehensive approach to safety, of which a Traffic Safety Management Information System (TSMIS) is a central element. The TSMS will address a number of critical issues affecting the NPS ability to track and manage transportation safety in national parks:

- The TSMS will reverse the downward trend in crash data availability through a combination of increased NPS headquarters emphasis on crash reporting, and an easy-to-use and reliable data collection system that in return gives parks direct and immediate access to crash data.
- Complete and up-to-date crash data will provide NPS with a clear view of safety in the national parks and accurate information on which to base safety decisions.
- Safety analysts and other users will have direct access to the crash database to facilitate ad hoc and exploratory safety analyses, rather than having to rely on a third party to fill data requests.

- With accurate crash location information in the form of lat/long coordinates, state-of-the-art analysis tools, especially GIS, will enable users to identify high-risk locations and road segments that are performing outside the norm.
- The TSMS will elevate safety to its proper role in all areas of park planning to fulfill an NPS goal that "visitors safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of park facilities, services, and appropriate recreational opportunities."

TSMS Strategic Safety Planning Process

The TSMS strategic safety planning process provides a framework for all the activities associated with managing NPS traffic safety:

- Determining the mission, goals, strategies and performance measures for the TSMS
- Determining the projects to improve traffic safety
- Implementing the safety projects
- Evaluating safety performance
- Evaluating the strategic plan

Key participants in the TSMS are:

- NPS Park Roads and Parkways (PRP) with overall responsibility for the TSMS, annual safety reports, and annual planning meetings
- Regional levels of NPS and FLHP with analytical responsibilities
- Park rangers and park police with responsibility for data collection
- TSMIS system administrator at the Field Office Technical Service Center (FOTSC) with responsibility for managing day-to-day TSMIS operations

Traffic Safety Management Information System

At the heart of the TSMS is the Traffic Safety Management Information System, a software system that serves three purposes: data collection, reporting, and safety analysis. A defining feature of TSMIS is its Web-based architecture that eliminates the existing NPS pitfalls associated with installation and maintenance of desktop computer applications at multiple sites. Online training modules and help instructions will minimize training requirements, reduce help desk calls, and make it easy for new users to learn the system in the face of staff departures.

The TSMIS supports all TSMS safety-related activities, including assessment of progress toward strategic safety goals and evaluation of strategies, identification of overall trends, patterns and developing safety problem areas, development of materials to justify budget requests to Congress, comparisons of transportation risk and safety performance measures among regions, parks, and types of roads, allocation of NPS resources among regions and parks, establishing priorities for safety projects, identification of high-risk locations, conducting safety studies for specific road projects and safety problem areas, and road safety audit reviews.

Data Collection The TSMIS concept offers two alternatives for interim crash data collection until the Department of the Interior's (DOI) department-wide Incident Management and Reporting System (IMARS) assumes that function. The first alternative is a Web-based data collection module, similar to the expected IMARS capability, and the second simply adapts the present data collection system. The Web-based approach addresses many of the problems with the current system and should facilitate crash data reporting by parks. It also expands the reported crash data by employing the Model Minimum Uniform Crash Criteria (MMUCC), developed by state and federal transportation agencies to standardize core crash data elements for uniform comparisons among states and other jurisdictions. The second alternative collects in their current format with the addition of latitude and longitude (lat/long). Because the reporting and analysis modules of the TSMIS will be based on the MMUCC model, under the second alternative, the crash data will have to be mapped into the TSMIS/MMUCC format to use in the other modules. The TSMIS will integrate with other NPS management systems, as well as provide access to other applications and programs throughout NPS.

Reporting The reporting module will allow users to generate detailed and summary reports. The TSMIS will contain pre-formatted reports, but will also allow users to design and save specifications for custom reports. Easy-to-use filter screens will guide users in selecting the particular set of data they wish to include in the reports. Users will be able to set up a schedule for TSMIS to send them periodic reports automatically.

Analysis Tools The analysis module will provide ad-hoc, investigative tools for planners and designers to utilize in their efforts to identify and correct safety issues. Using these tools, safety analysis can follow a line of investigation from the summary report level all the way down to root cause analysis. Users who require more options than the TSMIS can offer may export sets of data to use in software packages installed on their desktop computers.

The TSMIS will include the following analytical methods:

- Data queries, statistics, and analytic reporting for exploring crash data
- GIS analysis and identification of crash hot spots
- Calculation of performance measures, including crash risk (likelihood of a crash and its severity) and comparisons of road segment performance before/after road improvements
- Graphs and trend lines
- Selection of road segments for road safety audit reviews and storing audit results
- Safety indexes that combine performance measures for park safety into one statistic that is easily tracked over time and comparable among similar parks

- Performance monitoring to identify units, such road segments, whose performance in a particular area is significantly different from other similar units
- Performance models comparing actual and expected road segment performance
- Resource prioritization models that prioritize safety projects based on expected safety improvements

TSMIS Development and Implementation The first step is the design, development and implementation of a TSMIS prototype to be tested with several representative parks, NPS FLHP coordinators and FHWA Federal Lands Highway (FLH) safety analysts. After testing, the TSMIS will be rolled out to all parks, NPS and FLHP regions, at which point other elements of the TSMS will be initiated. Historical crash data for the top 30 parks in terms of crash totals will be converted to the new format to give users full analysis capabilities from the start. As required, expansion of the TSMIS functionality and integration with other available NPS data systems will occur through periodic TSMIS releases. The data collection function will transition to IMARS when the new system becomes operational. Subsequent improvements will occur as circumstances warrant and resources become available.

Cost to Develop and Implement TSMIS

	Alternative 1	**Alternative 2**
Reporting & Analysis	Web-based	Web-based
Data Collection	Web-based	Current system + lat/long
Users	10 safety analysts, 150 parks	10 safety analysts, 50 parks[1]
Development Cost	$749k	$646k
Annual Recurring Cost	$128k, Year 1 $90k, Out-years	$147k, Year 1 $109k, Out-years
Development Cost/User	$4.7k	$10.8k

Preparatory Next Steps

The uncertain timeline for IMARS implementation and recognized shortcomings of current NPS servicewide safety data collection and reporting provide strong motivation for NPS to initiate action on TSMIS development. In anticipation of a decision to adopt the TSMS as conceived in this report, NPS should take the following preparatory and requisite steps for TSMIS development:

- Further research into safety indexes and performance monitoring models to identify those most appropriate for inclusion in the TSMIS
- Standardizing the definitions for reportable crashes and reporting procedures among all parks

[1] Analysis assumes that with Alternative 2 there would be no new incentive for parks to submit crash data to the FOTSC, so the number of park users would remain at the current level of around 50.

- On an individual park basis, determination of whether crashes on non-park-owned access, circumferential, or cut-through roads will be included in the park crash database
- Conversion of crash location to lat/long for historical crash data for the top 30 parks
- Formation of a group of parks, NPS and FLHP safety analysts for participation in the TSMIS beta-test

Within an 18-month development and rollout period NPS could begin to experience the benefits of the TSMIS in full operation in support of safety management activities.

1 Introduction

1.1 Project History

In 1999, the Federal Highway Administration (FHWA) issued a Notice of Proposed Rulemaking (NPRM[2]) that required the National Park Service (NPS) to have a Traffic Safety Management System (TSMS) for its Park Roads and Parkways Program (PRPP).[3] The NPS requested assistance from the John A. Volpe National Transportation Systems Center (Volpe Center) to develop a concept for the TSMS, because of the Center's past experience with the NPS transportation programs, including the alternative transportation program (ATP).

In February 2002 NPS and the Volpe Center participated in a workshop in Washington, DC for government personnel focused on the safety needs of the national parks. The workshop resulted in the drafting of key recommendations that form the backdrop for the TSMS concept described in this document, including the TSMS mission statement:

> *While maintaining a balance of public safety and resource protection, assure a safe park transportation experience for all park users through the:*
>
> - *Efficient monitoring and reporting of incidents;*
> - *Identification and correction of safety problems:*
>   - *through effective enforcement,*
>   - *by providing safety education, and*
>   - *by the application of cost-effective safety technology;*
> - *Effective utilization of safety data for allocation of resources;*
> - *Timely maintenance of safety-related appurtenances; and*
> - *Effective communication with state and local safety officials.*

In August 2003, the Volpe Center commenced the development of the concept for the TSMS. Task 1 Review Existing Systems surveyed existing safety management systems that other government agencies and states had developed to address traffic safety in their areas, and examined the existing NPS road safety program. The results of Task 2 Requirements and the initial part of Task 3 Concept Development were documented in a preliminary TSMS concept report and a Web-based Traffic Safety Management Information System (TSMIS) mock-up that provided a visual demonstration of many of the concept's features. From February through July 2004 the Volpe Center obtained feedback on the preliminary concept from NPS and FHWA safety analysts who read the report and from eight groups of NPS, FHWA and Department of the Interior (DOI) representatives who viewed mock-up demonstrations. In August 2004 the Volpe Center completed Task 4 Costs to Implement and Operate for three TSMIS alternatives. This

[2] Department of Transportation, Federal Highway Administration, 23 CFR Part 970, FHWA Docket No. FHWA-99-4967, FHWA RIN 2125-AE52, "Federal Lands Highway Program; Management Systems Pertaining to the National Park Service and the Park Roads and Parkways Program."
[3] The Final Rule was promulgated on February 27, 2004 with no significant changes from the NPRM.

report presents the results of all previously completed tasks, the final TSMS concept incorporating the feedback from the preliminary concept reviewers, and the results of Task 5 Benefit Analysis and Task 6 Implementation Analysis.

1.2 Collaboration with Federal Lands Highway

The Volpe Center performed this project with guidance and assistance from the FHWA Federal Lands Highway (FLH) Central Division Office. FLH provides the NPS Park Roads and Parkways Program with management and technical expertise for road projects. Their experience with performing safety studies for proposed road projects is especially relevant to the TSMS concept development, as they have an intimate knowledge of NPS safety data needs and analyses.

1.3 Terminology, Scope and Assumptions

This report makes a distinction between the Traffic Safety Management System (TSMS) and the Traffic Safety Management Information System (TSMIS). TSMS refers to the broadly defined system described in the mission statement, while TSMIS refers to the software system for transportation data collection, processing, reporting and analysis. The TSMS includes the entire range of activities associated with ensuring transportation safety in the National Park Service. A key component of the TSMS is the TSMIS, which provides the information and analysis tools necessary to support TSMS activities, such as identifying safety issues, allocating resources to address safety problems, and determining the efficacy of remedial actions. This report describes both the TSMS and the TSMIS.

The concept focuses on road safety in the national parks. Expanding it to include other modes of transportation such as water, air and rail is outside of the scope of the concept. However, the inclusion of other modes would be relatively straightforward once the final concept for roads was completed, as the TSMS would serve as a model for the other modes.

The concept addresses crash data collection, even though the data collection function will eventually be assumed by DOI's department-wide Incident Management and Reporting System (IMARS), currently in the requirements definition and procurement phases. It assumes that, given the uncertainty of the timeline for IMARS deployment, an interim data collection module would have to be developed for the TSMIS to serve that function until IMARS took over. It provides options for the interim data collection module that range from modifications to the existing data collection process to one that would be transparent to the TSMIS user when the transfer of the data collection function to IMARS occurs.

1.4 Organization of This Report

Section 1 introduces the concept, terminology and assumptions. Section 2 discusses NPS' need for a TSMS and its requirements. Section 3 gives an overview of the TSMS concept and illustrates how a user would use the TSMIS for data collection, reporting and analysis. Section 4 provides a technical description of the TSMIS, its functions and operation, and the advantages and disadvantages of various technology alternatives. Section 5 describes a comprehensive TSMS for NPS to use to manage traffic safety in national parks based on outputs from the TSMIS. Section 6 provides an assessment of the benefits NPS will enjoy from its TSMS. Section 7 estimates the cost to develop, implement and operate the TSMS. Section 8 outlines a plan for implementing the TSMS in parks nationwide. Section 9 indicates areas where NPS needs to conduct further research before implementing the concept. Appendices include a list of the data collection systems currently being used by parks; a detailed comparison of NPS Form 10-413 and the Minimum Model Uniform Crash Criteria; a description of performance monitoring systems used by other modal agencies; a TSMS benefits worksheet; a description of several state highway safety management systems; and a CD containing the TSMIS Web-based mock-up.

2 The Need for a TSMS

2.1 The Two Basic Requirements

The need for a TSMS stems from two basic requirements for the National Park Service: achieving NPS' mission and goals, and satisfying requirements for management systems as stated in the February 2004 management systems rule.

2.1.1 NPS Mission and Goals

In support of its goal to provide for the public enjoyment and visitor experience of parks, the NPS is responsible for making the decisions that ensure the safety of park visitors. This goal derives from the NPS mission as stated in the NPS 1916 Organic Act which charges the NPS "to provide for the enjoyment of the [resources] in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." In the NPS 2001-2005 Strategic Plan, Mission Goal IIa envisions that "visitors safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of park facilities, services, and appropriate recreational opportunities;" and Long-term Goal II a2 calls for the improvement of visitor safety. These missions and goals provide the setting for the NPS Safety Programs in general and for roads in particular.

2.1.2 Management Systems Rule

The February 2004 management systems rule mandates that the NPS develop a safety management program for roads:

> *a systematic process used by the NPS…with the goal of reducing the number and severity of traffic crashes by ensuring that all opportunities to improve roadway safety are identified, considered, implemented, and evaluated, as appropriate, during all phases of highway planning, design, construction, operation and maintenance, by providing information for selecting and implementing effective highway safety strategies and projects.*

TSMS procedures and features include:

- ensuring the outputs of the TSMIS are considered in the development of NPS transportation plans and park road program transportation improvement programs (PRPTIP);
- analyzing and coordinating all TSMIS outputs to operate, maintain, and upgrade existing transportation assets systematically and cost-effectively;
- operating and maintaining the TSMIS and its associated databases;
- data collection, processing, analysis and updating the TSMIS;
- applying a geographical reference system that can be used to geolocate all database information;

- evaluating as part of the transportation planning process the effectiveness of the TSMS in enhancing transportation investment decision-making and improving the overall efficiency of the affected transportation systems and facilities; and
- operating the TSMS so investment decisions based on management system outputs can be considered at the national, regional, and park levels.

2.2 The Need for Better Transportation Data and Analysis Tools

Over the last decade, the ability of NPS to obtain a clear overview of transportation safety within the park system has eroded as the number of parks reporting their crash data to the Denver Field Office Technical Support Center (FOTSC) has decreased approximately 77 percent from 151 parks in 1990 to 34 parks in 2003.

The downward trend is partly due to the lack of standardized computer systems among the parks, such that the electronic crash records of many parks are incompatible with the NPS standard Case Incident Reporting System (CIRS) and the FOTSC Servicewide Transportation Analysis and Reporting System (STARS) database. Many of these other systems were developed because parks had difficulty using and supporting CIRS, a desktop computer application, and NPS did not provide help desk support. Appendix A shows the various crash data reporting systems parks are currently using.

Also contributing to the decline in crash data reporting are staffing and funding changes within a park, that can disrupt its ability to compile crash reports, as evidenced by the discontinuation of reporting by the Blue Ridge Parkway after a staff departure.

Finally, park personnel do not perceive a clear mandate from NPS headquarters or regions to submit their data to the FOTSC. Some parks that collect crash data have discontinued sending it to the FOTSC because they are not reminded to do so, or are not aware of the requirement.

The crash data limitations affect NPS' ability to make critical data-driven decisions to ensure visitor safety. Without supporting quantitative safety data, the NPS must rely mainly on qualitative assessments of safety conditions, problems and needs within parks to allocate resources to park regions and individual parks. At annual regional meetings, NPS FLHP coordinators and park superintendents must prioritize safety projects without the benefit of comparative safety reports to share with each other.

Not only is the lack of reporting a problem for safety analysis at the NPS, but also the data that are reported are not in an appropriate form for certain state-of-the-art analysis methods. The current NPS link/node method of recording crash location cannot support one of the most useful tools for safety analysis and a requirement of the management systems rule, a geographical information system (GIS). A GIS relies on point location information, usually in the form of latitude and longitude (lat/long) coordinates. It organizes information in layers tied to the location of the events or physical features that it describes, providing a visual element to quantitative analyses. NPS safety analysts are denied the benefits of a GIS system.

Further, safety analysts do not have direct access to the crash database to explore the crash data freely, but must request reports from the FOTSC. This limits their ability to conduct ad hoc inquiries of safety issues and to follow a train of investigation from start to finish without interruption while waiting for data requests to be filled.

Perhaps more importantly, the lack of reliable safety information reduces the role transportation safety considerations play in the overall park planning process. Transportation safety issues should figure prominently in planning all aspects of park activities, including operations, policing, construction and maintenance, recreation, preservation and conservation. With little information to go on, park planners cannot give safety issues proper due.

2.3 User Requirements for a New TSMS

Potential TSMS participants defined their requirements for the TSMS at a workshop in February 2002 and through telephone interviews conducted by the Volpe Center team during late 2003. The requirements revealed during the workshop and interviews are best organized as answers to the following series of questions.

2.3.1 What Transportation Safety Goals Should the TSMS Promote?

The overarching goal of transportation planning is to reduce the risk of crashes, that is, both the likelihood of crashes and their severity. This goal leads to other more specific goals that derive from the analysis of the particular types of safety problems that are prevalent in parks.

From a national perspective, NPS headquarters may determine that, for example, many rear-end crashes are occurring in wildlife viewing areas, and make it a goal to cut the number of this type of crash in half within two years. This goal would lead to strategies in individual parks to accomplish this with associated performance measures to track progress toward the goal.

In the current situation of limited NPS traffic safety data, goals referring to specific problems may be difficult to determine. NPS could set the development of better crash data and increased park participation as goals, leading ultimately to the ability to focus on specific safety problems.

The transportation safety goals are ever evolving, as old goals are achieved, and the environment changes. The TSMIS needs to provide NPS with data to develop performance measures so that progress toward goals can be assessed, and to provide the means to analyze crash data to identify emerging problem areas.

2.3.2 What Transportation Safety Problems Currently Exist on Park Roads?

Current transportation safety problems are identified anecdotally or through the experience of park rangers and superintendents, as opposed to data-driven analysis. Although the problems vary from park to park, the interviews with various NPS and FLHP personnel revealed the following sampling:

- Use of park roads for purposes other than visiting the park, such as a commuter cut through
- Automobile-animal collisions
- Collisions with fixed off-road objects, such as culverts
- Hairpin turns (Mesa Verde)
- Weather conditions, snow
- Alcohol-related crashes
- Lack of complete and reliable crash data for safety analysis

2.3.3 What Management and Decision Processes Should the TSMS Support?

The TSMS should support the annual transportation planning process that allocates funding to regions and in turn to individual roads projects. Safety studies to determine the need for a road safety project would rely heavily on TSMIS data. In addition, TSMIS data should support annual budget requests to Congress.

2.3.4 What Kinds of Quantitative and Qualitative Information Are Needed?

The primary data need is complete and thorough crash records with all fields relevant to crash analysis in a geographical information system.

If NPS' goal is to reduce the risk of crashes in its parks, then it must be able to determine both the probability of a crash and its consequences. Both numerators and denominators are necessary to calculate probability, e.g., crash counts and exposure measures. Crash counts need to be broken down into relevant analysis categories, including road classification, vehicle type, crash cause, crash type, time (hour, day, week, season), environmental conditions, crash location, and more. Appropriate exposure measures include average daily traffic volume, visitation, miles of roads, and more, and should be broken down into the same categories as the crash counts.

Auxiliary data for safety analyses include road characteristics such as the condition of roads and bridges, location of safety appurtenances, number of lanes, etc.

The crash database would contain most of these data items, but it would have to link to other databases to obtain the remainder, including the Road Inventory Program (RIP) and Bridge Inventory Program (BIP), visitation, and congestion management databases.

2.3.5 Who Are the TSMIS Customers?

The internal data users are headquarters, the NPS regional FLHP coordinators, and the FHWA's FLH divisions. National parks would likely embrace the crash data for their own use once they were able to obtain it easily and in a timely fashion.

External customers would include other agencies and organizations interested in traffic safety in national parks. Local areas and states may find the information useful for state transportation planning. NHTSA would be able to obtain data on automobile safety in national parks, a piece of the overall transportation safety picture in the United States heretofore missing. The Federal Motor Carrier Safety Administration (FMCSA) would be interested in traffic crashes involving trucks and interstate buses and the Federal Transit Administration (FTA) would be interested in crashes involving public transit systems.

2.3.6 What Crash Data Elements Need to Be Collected?

The Model Minimum Uniform Crash Criteria (MMUCC) were developed by a consortium of transportation safety experts and data users as a standard crash-reporting format. Many states have adopted the MMUCC as the basis for their safety management systems, and it would satisfy NPS needs.

The MMUCC would augment current NPS crash data by including such information as presence and deployment of air bags, latitude and longitude coordinates of the crash, digital crash diagrams, and results of alcohol and drug testing. It would also standardize field entries by providing coded choices for data entries to the extent possible.

2.3.7 What Other Attributes Should the TSMIS Exhibit?

Data analysts should have direct access to the TSMIS, rather than having to request reports through a third party. The TSMIS needs to be relatively simple to learn to use, especially for park personnel who will be entering the crash data. Perhaps a stand-alone training module would provide the needed instruction. Ideally, the Internet could host the training module, and also provide parks, regions and headquarters with procedures, analytical tools and output reports. Technical expertise in the form of a help desk should be available for consultation on technical TSMIS matters as well as to help interpret and evaluate outputs.

2.3.8 Who Needs Access to the TSMIS Databases?

Data users would have read-only access to the entire crash database for purposes of reporting and analysis. Parks would have access to their own crash data for editing and modification.

2.3.9 What Reports and Analyses Are Desired?

The standard report formats currently generated by CIRS would be adequate for the new system to provide summary information on a regular basis. These could be tailored to individual parks or regions, in addition to servicewide formats. A custom report feature would be very helpful for ad hoc reporting, as well as basic statistical analysis capabilities. The TSMIS should produce periodic reports on critical safety statistics needed to track progress toward safety goals (i.e., performance measures) and evaluate the overall effectiveness of safety initiatives.

For engineering studies and site-by-site assessments, the TSMIS should provide various analysis capabilities, such as comparative analysis capabilities (for example, comparing the five highest crash park sites, or "hot spots," in Colorado and Wyoming); severity analysis capabilities; and crash rates by functional class of road, route number, specific road, etc. It should also have the capability to export data sets to external statistical analysis packages as desired by safety analysts.

The means to prioritize NPS roads for road safety audit reviews (RSAR) would be desirable, as well as the ability to store the audit results, and track safety on roads where the improvements recommended by the audits were carried out.

3 Overview of Traffic Safety Management System Concept

3.1 Strategic Planning Process

The Traffic Safety Management System is a forward-looking system that implements a proactive safety program in the national parks exposing safety problem areas as they emerge and addressing traffic risk at its earliest possible detection. With the TSMIS as its foundation, the TSMS encompasses all the activities associated with managing transportation safety in the NPS. These interconnected activities culminate in the implementation of safety improvement measures designed to address specific traffic safety issues.

The strategic planning process sets the framework for translating the information crash data contains into a plan of action to improve traffic safety throughout the NPS system. The strategic plan sets the goals and objectives for the TSMS, and organizes all the activities associated with transportation safety. The strategic planning process includes the basic stages of:

1. Determining the mission, goals, strategies and performance measures for the TSMS
2. Determining the projects to improve traffic safety
3. Implementing the projects
4. Evaluating their performance
5. Evaluating the strategic plan.

Participants in the TSMS derive from all levels of NPS staff and FLH divisions. The NPS Park Roads and Parkways Program has overall responsibility for the TSMS, convening strategic planning meetings, administering and monitoring the TSMIS, producing annual safety reports and reports to Congress. NPS Regional FLHP Coordinators are responsible for safety analyses and regional safety project prioritization. FLH Division Planners and Project Development Teams implement roads projects. At the park level, park police and rangers respond to crashes, compile crash reports and enter the data into the TSMIS. A more detailed description of the TSMS, roles and responsibilities and the annual strategic planning cycle appear in Section 5.

3.2 TSMIS Components

The foundation of the TSMS is crash data; without accurate and timely crash data the TSMS collapses. The TSMIS is the system for collecting, reporting and analyzing crash data. This section provides an overview of the TSMIS concept by illustrating examples of its use. The interim TSMIS data collection version described here is most like the one IMARS is expected to provide once it is deployed. A more technical description of the TSMIS appears in Section 4 along with a discussion of its functions and operation, and the advantages and disadvantages of various technology alternatives. The main components of the TSMIS are illustrated in Figure 1.

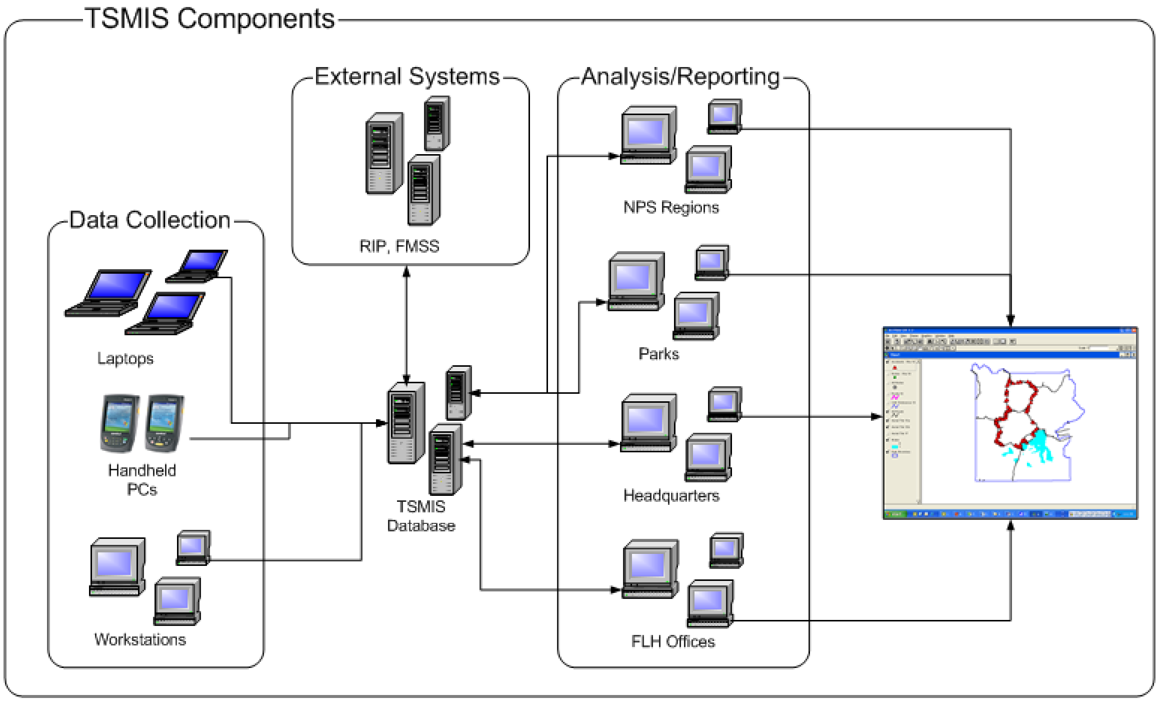


Figure 1. TSMIS Components

3.2.1 Data Collection

Data collection[4] will be as easy as possible and flexible enough to accommodate the varying levels of sophistication in technology among the parks. When available, rangers, park police and other responders will be able to record crash data on scene via an Internet platform accessed through the use of handheld, laptop or wearable personal computers. In areas where Internet access is unavailable, responders may download the crash data from their portable computers at office workstations. In parks without portable computer technology, the system will print out blank crash reporting forms on paper for responders to complete in the field, and administrators will be able to enter the crash data from the paper records to the Internet platform from their office workstations. The capability to scan in paper copies of crash reports will also be available.

Figure 2 shows the first of several data entry screens for a traffic crash report. Data entry will be designed to use drop down menus and will undergo extensive validation checks before being saved in the database. Free form data will be eliminated where possible; however, there will be provisions for scanning or entering crash narratives. The NPS'

[4] The TSMIS Overview assumes the TSMIS will contain an interim data collection module until the deployment of IMARS.

reliance on the link/node method of locating a crash will be replaced by a point location method, such as latitude and longitude, obtained from GPS receivers or from a map interface where users point to the crash location on the map screen and the lat/long coordinates are automatically entered into the record. Crash diagramming software will be available; however, users will be able to scan in hand drawn crash diagrams as well. The TSMIS will also store digital photos of the crash scene as well as scanned photos.

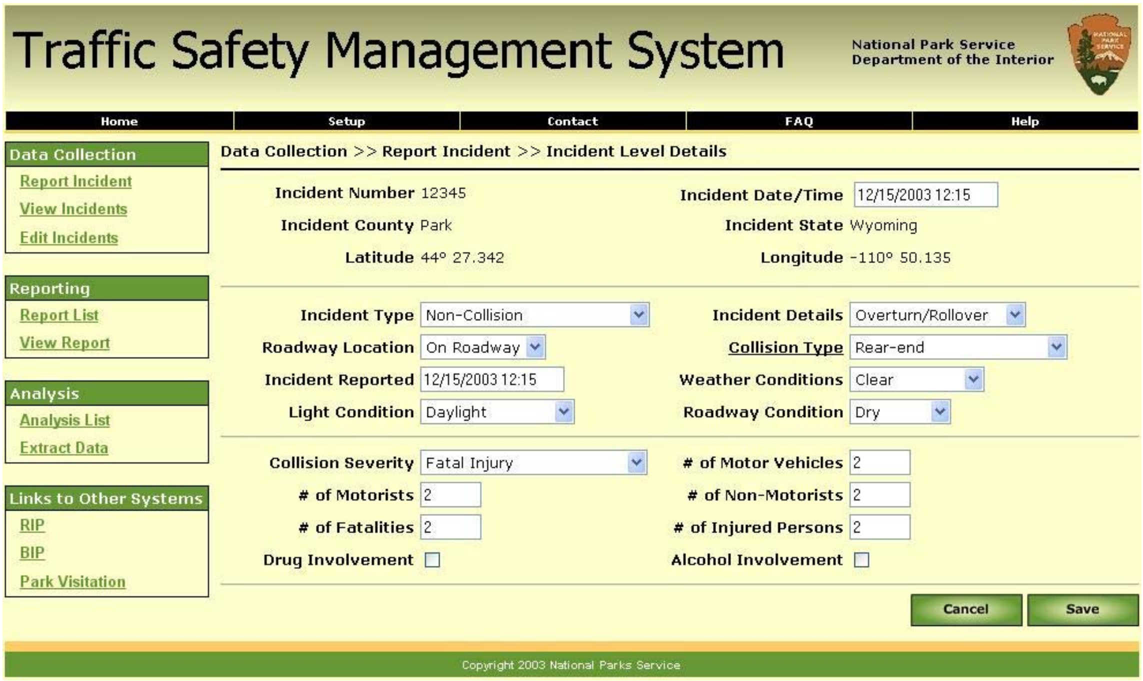


Figure 2. TSMIS Data Entry Screen

Data collected will automatically transfer from the park to the central NPS server. However, crash records will remain in an interim database location until they undergo reviews at the park level for completeness and accuracy and are approved, before being stored in the servicewide crash database.

Technical support will be available to handle problems, oversee installations, and manage enhancements and upgrades. As users increase their familiarity with TSMIS features and become more sophisticated in their analyses, the TSMIS will be flexible enough to accommodate demands for new requirements without major redesign and rewriting.

3.2.2 Reporting

In return for entering their crash data, parks will have instant and direct access through the Internet to their crash data and analysis tools as appropriate. User permissions will determine the set of accessible data elements and records. Individual parks will be able to access the records of crashes occurring in their own parks for editing and updating, and will have read-only access to all records; FLHP coordinators, FLH divisions and NPS headquarters will have read-only access to servicewide crash records.

Standardized and customized reports may be run on a regular schedule or on an ad hoc basis. They will reflect the current status of crashes in the park system, since once crash reports are entered, validated and approved, they become available to system users. These reports may be distributed to users via email, through the Internet or in paper form, as desired by the user.

Individual Crash Report

An authorized user will be able to access a report for a specific crash on the Internet-based TSMIS. He/she will be able to view it on the screen, as shown in Figure 3, or print it out in the crash report format.

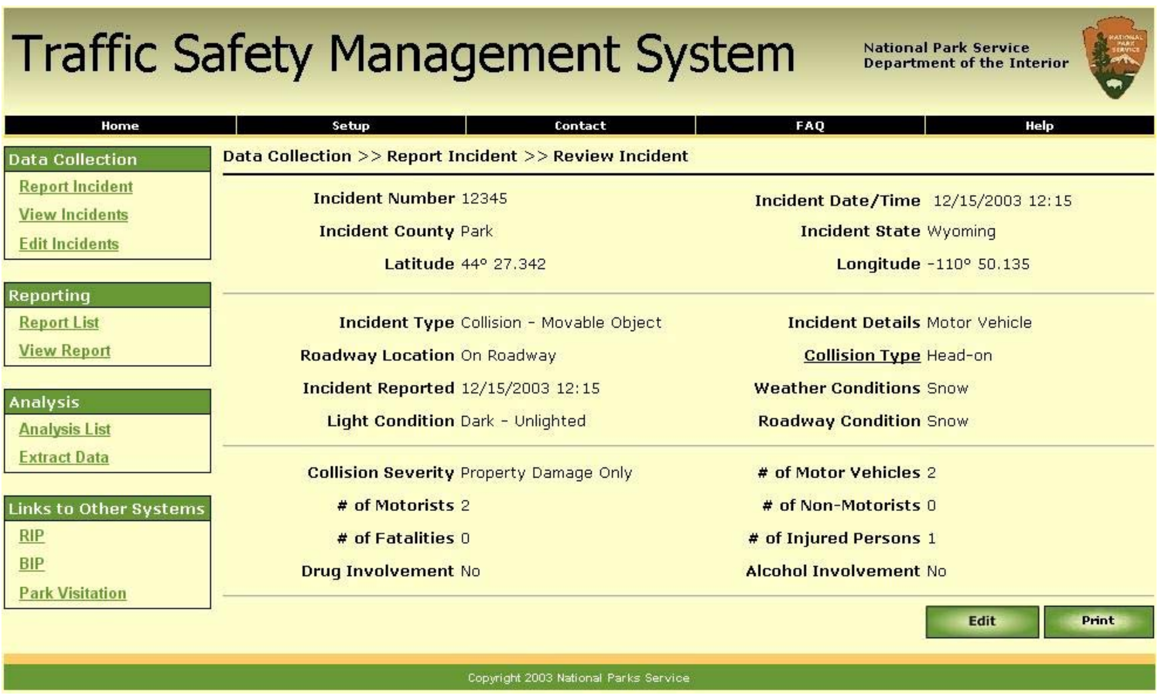
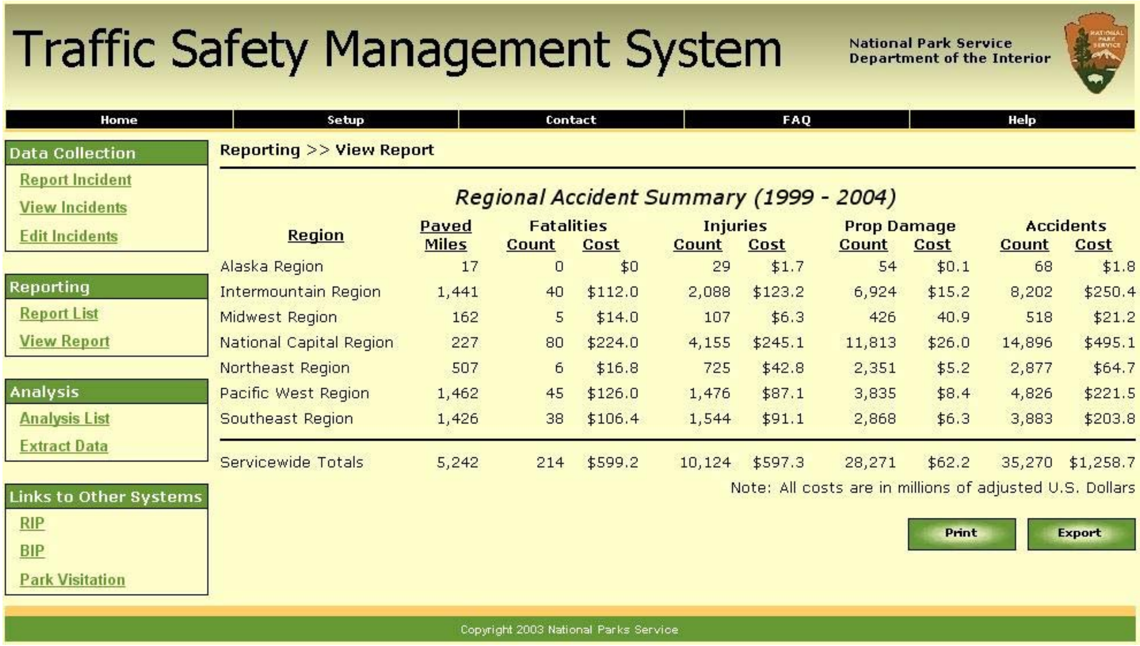


Figure 3. TSMIS Crash Report

Crash Summary Report

A user will be able to view crash summary reports on the screen and/or print them out. The user will be able to choose from among predefined reports or specify his/her own format within the parameters of the report generator. Reports may be for an individual park, all parks in a region, or all parks in the US, and may include breakdowns of crashes by type of accident, vehicle, road surface, or other variable, and may show yearly or other comparisons. Figure 4 shows a sample accident summary report.



Region	Paved Miles	Fatalities Count	Fatalities Cost	Injuries Count	Injuries Cost	Prop Damage Count	Prop Damage Cost	Accidents Count	Accidents Cost
Alaska Region	17	0	$0	29	$1.7	54	$0.1	68	$1.8
Intermountain Region	1,441	40	$112.0	2,088	$123.2	6,924	$15.2	8,202	$250.4
Midwest Region	162	5	$14.0	107	$6.3	426	40.9	518	$21.2
National Capital Region	227	80	$224.0	4,155	$245.1	11,813	$26.0	14,896	$495.1
Northeast Region	507	6	$16.8	725	$42.8	2,351	$5.2	2,877	$64.7
Pacific West Region	1,462	45	$126.0	1,476	$87.1	3,835	$8.4	4,826	$221.5
Southeast Region	1,426	38	$106.4	1,544	$91.1	2,868	$6.3	3,883	$203.8
Servicewide Totals	5,242	214	$599.2	10,124	$597.3	28,271	$62.2	35,270	$1,258.7

Figure 4. TSMIS Regional Crash Summary Report (1999 - 2004)

3.2.3 Analysis

The TSMIS will provide analysis tools and reports to support all the decisions made in the NPS transportation planning process. Analytical reports from the TSMIS will allow one to examine crash causes, damages, injuries and fatalities, and other related statistics. One of its most important products will be performance measures that include crash-related data, such as crashes per vehicle mile traveled, or participation-related data, such as percent of parks reporting crash data on schedule. Geographical information system (GIS) maps will display the locations of crashes, roadway features, traffic levels, and other information for analytical purposes.

The TSMIS will have the capability to link to other NPS databases of particular importance to transportation safety analysis including those pertaining to roadway and bridge facilities (the RIP and BIP databases providing safety appurtenances, traffic levels, vehicle mileage, hazards, roadway conditions); park visitation; and crashes and incidents of other modes, enforcement, and violations once IMARS is operational. It will also have the capability to link to external databases, such as those of other federal safety agencies[5] and state DOTs.

At the headquarters and regional levels, TSMIS data will support:

- assessment of progress toward strategic goals and evaluation of chosen strategies
- comparisons of transportation risk and safety performance measures among regions and individual parks

[5] National Highway Traffic Safety Administration (NHTSA), FHWA, FTA, FMCSA, etc.

- allocation of NPS resources among the regions and parks
- establishing priorities for projects
- headquarters level research providing a national perspective on overall trends, patterns and developing safety problem areas
- development of materials to justify budget requests to Congress, including performance measure trends that would demonstrate how previous funding has produced safety improvements

At the regional and individual park level, TSMIS data will support:

- inter-park and intra-park comparisons of transportation risk and safety performance measures
- identification of trouble spots within a park
- allocation of resources and prioritization of projects
- safety studies for specific road projects
- assessing progress toward goals and evaluating strategies

The following are examples of the analyses that the TSMIS will be able to provide.

Crash Rate Analyses

The TSMIS will draw on data from other NPS databases to obtain denominator data for calculating crash rates, such as crashes per vehicle or crashes per vehicle mile traveled, at specific locations within a park, or by type of road surface, or other variable. TSMIS data will enable analysts to compare crash rates among parks factoring in the variation in inherent risk from hazards and weather from park to park.

Geographic Safety Analysis

The GIS will allow TSMIS users to identify geographic locations (e.g., intersections, curves, etc.) which meet user defined input criteria. For example, they may identify all intersections in Yellowstone National Park (NP) having more than five crashes during the last year. The output of this analysis will be a GIS map of Yellowstone NP with these intersections highlighted.

From this point the user can zoom in to see a particular intersection and pull up the details of a specific crash. Figure 5 shows the location of crashes that occurred near the Visitor Center in Yellowstone NP. As features are added to the TSMIS, a user may eventually be able to obtain a video view of a designated road segment and its physical characteristics by linking to RIP.

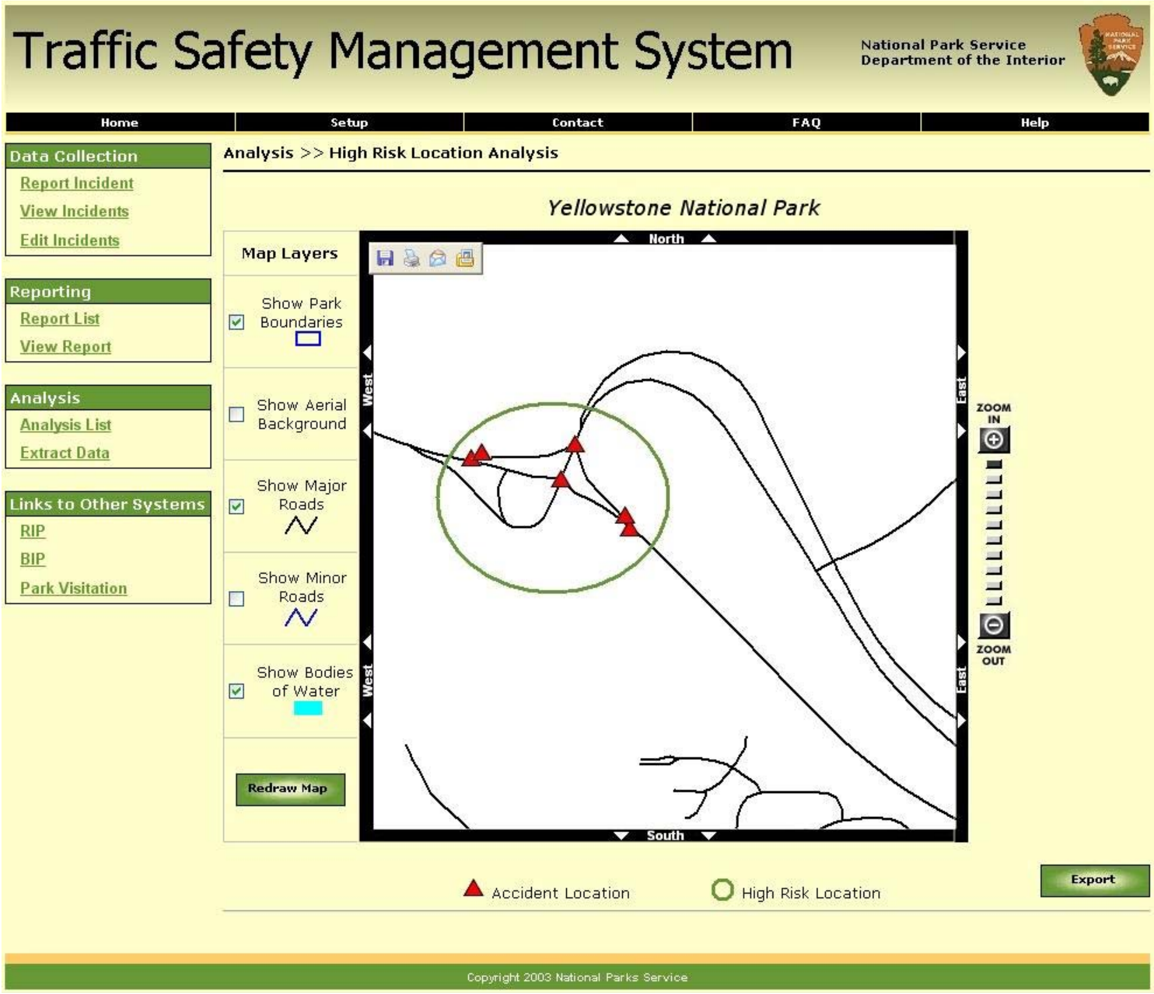


Figure 5. Crash Location Analysis

On a broader scale, a user may view the location of all the crashes that occurred in a park, in a specified area of the park or on a particular route. In Figure 6 the crashes that occurred on Route 10 in Yellowstone NP are displayed on a map. The GIS will allow the user to zoom in on the map to isolate route segments or crash clusters of interest.

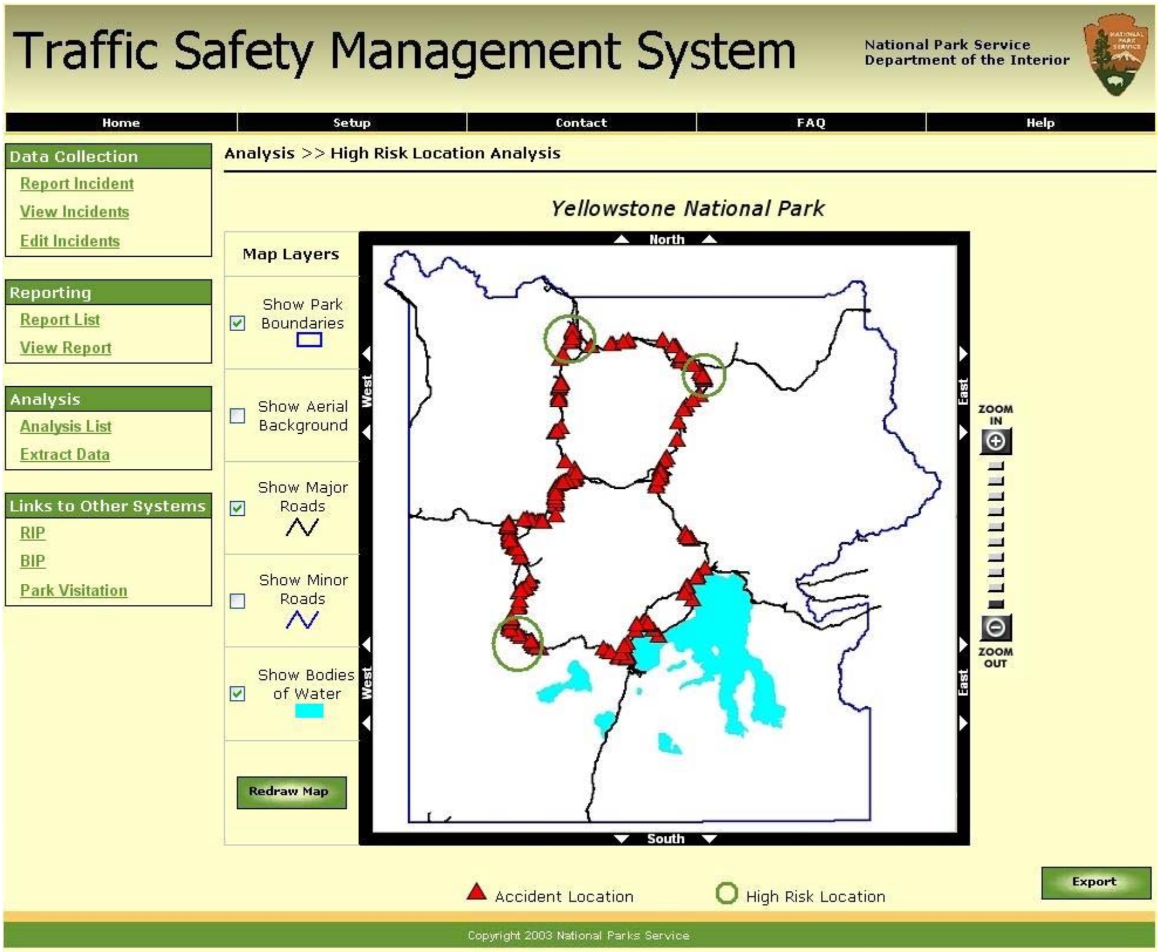


Figure 6. Location of Crashes on Route 10 in Yellowstone NP

<u>Geographic Crash Trend Analysis</u>

Using the GIS a user can click on a location on a park map and view the crash statistics at that location. He/she may view the crashes, for example, for the time periods both before and after a road improvement was made at that location. To assess the impact of the improvement, the TSMIS will be able to calculate before and after statistics, and plot an crash trend line.

Similarly, a user may also view all of the crash statistics of a park over a specified time period to assess if overall safety within a park has changed over time or with the addition of safety devices. Figure 7 shows a crash trend graph for the total number of crashes occurring in Yellowstone NP over a period of years.

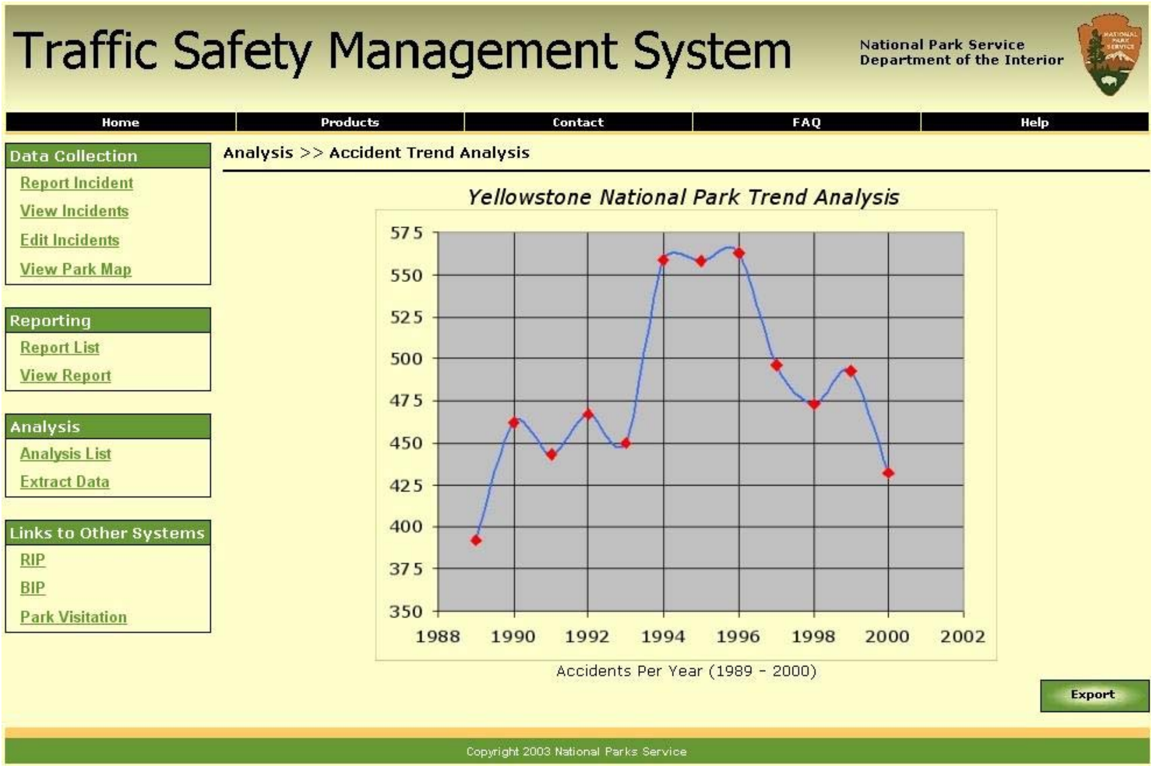


Figure 7. Crash Trend in Yellowstone NP (1989-2000)

High Risk Locations

NPS managers may develop database queries to assist them in allocating safety improvement funds across the US and within regions. They can use the TSMIS to identify, for example, the 25 highest risk road segments or intersections in a region, the ten parks in the US with the greatest number of crashes, the locations of all the fatal crashes in the US during a year, the locations of crashes involving animal hits, and more. Using the GIS feature of the TSMIS, locations may be displayed on maps, along with informative statistics.

4 Technical Discussion of Traffic Safety Management Information System Concept

This section provides a technical discussion of the main features of the TSMIS. The TSMIS encompasses all the activities and systems involved with the production of high quality, useful information, such as:

- Data collection: data collection procedures, design of crash and other reporting forms, reporting requirements, sampling procedures, field investigations, data elements, data quality considerations
- Data input: editing procedures, forms scanning, electronic data input technology
- Data storage: hardware requirements, computer system configuration, database design, maintenance programs
- Data access: data networks, access restrictions, linking to other NPS databases
- Reporting: development of statistical reports, updating NPS website
- Data analysis: statistical software, graphics packages, geographical information systems (GIS), development of performance measures

4.1 Interim Data Collection and Input

The TSMIS is a short-to-medium term goal of the NPS. Meanwhile, DOI has identified a need for a department-wide Incident Management and Reporting System to be developed as a medium-to-long term project for collecting data for all types of incidents, including transportation incidents, throughout DOI. Since the development timelines of the two systems do not coincide, the TSMIS will need to specify an interim process for collecting crash data until IMARS assumes responsibility for this function. Once IMARS comes online, the interim process of data collection can be phased out. This will leave IMARS with the incident collection responsibility while the TSMIS will focus on the analysis, reporting, and communication of the crash data. Options for this interim process include developing a new data collection component as part of the TSMIS development, or adapting the existing data collection system.

4.1.1 Develop Custom Data Collection Component

Description

This scenario proposes developing a custom data collection component as a part of the overall development of the TSMIS. This component, like the other TSMIS components, would be built on an Internet platform. This platform is commonly used to develop applications that need to interact with almost any type of device (e.g., wireless personal data assistants (PDAs), pocket personal computers (PCs), desktop PCs, and laptops) and integrate with many different back-end systems. Furthermore, this platform supports a Web-based user interface, which is vital for a distributed organization without high-end connectivity between the units, such as NPS. A Web-based user interface actually reduces the requirements on a user's computer, since the majority of the processing is completed at the server level rather than the user interface or client level.

In this scenario, responders with appropriate mobile computer equipment access the TSMIS at the crash scene via the Internet, and enter crash information directly into the system. Lat/long are obtained from their GPS receivers, or by marking the location on a GIS map display in the TSMIS. In cases where the mobile computer technology is not available or where reception is poor, respondents fill in paper copies of TSMIS crash reports and mark the location on a map for entry into TSMIS back in the office. The crash information is in the format needed by the TSMIS reporting and analysis modules without the extra mapping step necessary for the following scenario.

In order for this data collection approach to be feasible, the time required to develop and implement this component must be significantly less than the time required to implement IMARS. The only way for this to be accomplished is to use rapid application development (RAD) methodology. This methodology follows an abbreviated life cycle of planning, design, development, and cutover. After the planning phase, end users and developers work interactively to design and develop a working prototype. Upon acceptance of the prototype, it is rolled out to the end users (cutover). This approach allows applications to be developed very rapidly.

It should be noted the study team surveyed states and other safety organizations to determine if an appropriate commercial off-the-shelf (COTS) incident management and reporting system existed for application to NPS. While some COTS systems were identified,[6] none was Web-based, making the most efficient approach the development of a new system.

The Web-entry will offer a number of timesaving features. If data enterers are interrupted as they enter a crash report or have to obtain more information before being able to complete a report, they may save the incomplete crash record to return to at a later time without having to retype the previously entered information. For users without access to a GPS receiver in the field for determining the lat/long coordinates of the crash, this data entry option will offer a GIS interface that will allow a user to point to the crash location on a Web-displayed GIS base map of the park and automatically have its coordinates entered into the crash record. This GIS interface may be available on any computer, including portable, with Internet access.

Advantages and Disadvantages

The primary reason for developing a new data collection component is to reverse the decline in parks reporting crashes. Since this component would run in a Web-browser, it would eliminate almost all of the problems associated with installing custom software

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[6] (AASHTO Transportation Safety Information Management System (TSIMS), Iowa Traffic and Criminal Software (TraCS), Iowa GIS Crash Location and Analysis System (GIS-ALAS), California GIS Based Crash Records System (GIS-BARS), and CRIMES)

onto an employee's desktop computer. Furthermore, if an employee changes computers, there would be no need to re-install software. The only requirements for utilizing this component would be an Internet connection and a Web-browser. This component would also use typical Web-based constructs (i.e., radio buttons, drop down menus, point and click menus, etc.) so that anyone familiar with using the Internet could quickly learn how to use the system. Since the system would be far easier to use, it would address the issue of employee departures resulting in the discontinuance of crash reporting.

A secondary motive for the development of this component is to provide a testing ground for understanding what type of incident collection methods will be successful for NPS. The feedback on this data collection component from the system users would be invaluable to the IMARS project. It would increase the overall acceptance of IMARS and ease the transition to IMARS.

Third, rolling out a new application provides an opportunity to emphasize the importance of crash reporting. The TSMIS would provide system users with more functionality in the areas of reporting and analysis, which would provide additional motivation for crash reporting.

Finally, since this option does not rely on the use of CIRS, the problems associated with CIRS would not apply. This option would provide users with the largest amount of functionality and would easily satisfy the crash reporting needs of the NPS until the arrival of IMARS.

The drawbacks of this approach are fewer than expected since under the RAD approach, the expected cost and time to implement this option are comparable to the following option. The main disadvantage is that the users would have to learn a new, albeit more user-friendly, data entry system.

Crash Data Elements

In this alternative, the data model would be the Minimum Model Uniform Crash Criteria. The MMUCC is a set of guidelines developed by the Governors Highway Safety Association (GHSA – formerly National Association of Governor's Highway Safety Representatives and NHTSA) and the USDOT in 1998 and updated in 2003. The goal of the MMUCC is to use a set of core data elements that allows standardized data collection and uniform comparison among states and other entities. The MMUCC contains all the data elements that safety engineers and other professional safety analysts considered necessary for performing traffic safety analyses. Using this format will provide NPS with complete safety data, as well as make it possible to share crash data with states, localities, and national safety agencies and databases (NHTSA, FHWA, Fatal Accident Reporting System (FARS), FMCSA, FTA), and perform comparisons of park safety with other areas.

NPS safety analysts have indicated that they do not expect to do the same type of broad traffic safety research that an agency such as NHTSA might conduct. They would be more focused on NPS and park-specific issues, such as determining high-risk locations on park system roads, identifying hazards contributing to crashes that NPS could address through road safety improvements, traffic enforcement, safety appurtenances, education programs, etc., and prioritizing safety projects to gain the most benefit with limited resources.

The current NPS crash report form, Form 10-413, would need to be augmented by only a limited number of fields and codes to conform to the MMUCC. Data field additions include:

- Air bag deployment
- Results of alcohol testing for the vehicle driver
- Results of drug testing for the vehicle driver
- Lat/long coordinates for crash location
- New codes for driver distraction
- New codes for non-motorist location at time of crash
- New codes for non-motorist safety equipment
- New codes to distinguish non-motorist actions prior to and at the time of the crash

Appendix B contains a full analysis of the differences between the MMUCC and Form 10-413.

While all the data elements in the MMUCC are desirable to collect, NPS would not need them all for the types of analyses they are likely to conduct. The following 53 data elements are considered the "core" data elements for NPS purposes. These might, for example, be indicated as "mandatory" on crash reports or in the crash reporting screens of an online data collection system. A crash record would not be saved to the central database unless all the mandatory elements were completed. Other elements that would be desirable to collect might be considered "optional" and would not prevent a crash report from being accepted into the NPS crash database.

Table 1. Core Crash Data Elements

Data Classification	Level	Data Element
Crash Data (15 elements)	For each crash	Crash case identifier
		Crash date and time
		Crash city/place/street name
		Crash location
		First harmful event
		Location of first harmful event
		Manner of crash/collision impact
		Weather condition

		Lighting condition
		Roadway surface condition
		Contributing circumstances, environment
		Contributing circumstances, road
		Relation to junction
		Type of intersection
		Work-zone related
Vehicle Data (14 elements)	For each vehicle involved	Motor vehicle identification number
		Motor vehicle unit type and number
		Motor vehicle authorized speed limit
		Motor vehicle estimated traveling speed
		Direction of travel before crash
		Motor vehicle maneuver/action
		Extent of damage
		Most harmful event for this motor vehicle
		Sequence of events
		Contributing circumstances, motor vehicle
		Hit and run
		Trafficway description
		Roadway alignment and grade
		Traffic control devices type
Person Data (22 elements)	For each person involved	Age
		Sex
		Person type
		Injury status
	For each occupant	Occupant's motor vehicle unit number
		Occupant protection system use
	For each driver	Driver's action at the time of crash
		Driver condition at the time of crash
		Violation codes
		Distracted by
	For each driver and non-motorist	Law enforcement suspect alcohol use
		Alcohol test
		Law enforcement suspect drug use
		Drug test
	For each non-motorist	Non-motorist number
		Non-motorist action prior to crash
		Non-motorist action at time of crash
		Non-motorist condition at time of crash
		Non-motorist location at time of crash
		Non-motorist safety equipment
		Unit number of motor vehicle striking non-motorist
	For each injured person	Transported to medical facilities
Roadway Data[7] (2 elements)		Roadway functional classification (type of NPS road)
		Access control (parkway or unrestricted)

[7] If a park does not have a roadway inventory that can be linked to the accident database, or if the GIS base map does not contain enough information to ascertain roadway attributes when a crash location is displayed on the map, then at least these two roadway data elements should be collected at the scene.

Data for External Agencies

When crashes involving motor carriers or public transportation vehicles, fatal crashes and grade crossings occur, NPS is obligated to report to federal agencies involved with the regulation of carriers or highway safety, namely, NHTSA FARS, FRA, FMCSA, and FTA, as well as state DOTs. The TSMIS will facilitate this by providing for the collection of additional information required by these agencies. For example, when a crash involving a motor carrier occurs, the TSMIS will display a data entry screen for data important to FMCSA, such as Interstate Commerce Commission (ICC) number, carrier name and address, vehicle type, cargo, hazardous material carried, hazardous material release, etc. Upon approval, these reports can simply be emailed to the appropriate agency to fulfill reporting requirements.

4.1.2 Adapt the Current Data Collection System

Description

In this scenario, park employees would still use the STARS Revision of Form 10-413 to report crashes, but in addition would report crash locations either in lat/long coordinates read from a GPS receiver[8] or by marking a park map. Back in the office, a staff member would enter the data from the form into CIRS or other crash database[9] used by the park, or collect the year's forms to send to the FOTSC annually for them to enter. The data enterer would have to determine the location coordinates from the map in cases where a GPS receiver or other means was not available to determine the exact coordinates in the field. These records would have the STARS database format, with the additional fields of latitude and longitude.

A major component of this alternative is to define a mapping from the STARS data model to the TSMIS data model. This mapping would identify the steps required to transform each field in the STARS data set into something compatible with the TSMIS data model. Once this mapping was defined, the process for migrating the data could be automated. Periodically, a batch process would migrate the newly added crash data from STARS to the TSMIS. The crash data would then be in the format required for the TSMIS reporting and analysis modules.

This system could be used indefinitely as the data collection component. This would allow for up-to-date safety analysis and reporting throughout the IMARS implementation as well as in the event that IMARS is delayed or cancelled.

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[8] The accuracy of a location determined with a GPS receiver ranges from 3 to 10 meters, depending on the manufacturer of the receiver, as well as factors such as presence of high buildings or hills/mountains.
[9] Appendix A contains a breakdown of crash data reporting systems used by national parks as indicated in a 2004 survey of parks conducted by the FOTSC. Results showed that 109 of the responding parks are using CIRS. Of the 21 high accident parks, eight use CIRS, seven retain the paper forms, and the remaining use their own systems.

Advantages and Disadvantages

The advantage of this option is that it does not require the users to learn how to use another application for collecting crash data, other than to add location coordinates. The users would continue with the current process that is in place (using Form 10-413 to collect data).

The disadvantages of this option, however, are not insignificant. First, this option does little to address the decline in crash reporting throughout the NPS: the number of parks reporting crashes has declined precipitously in the past ten years. Second, it postpones the addition of data fields and new codes for existing fields that are currently missing from Form 10-413 but important for safety analyses, until IMARS is ready. Third, it does not address current coding anomalies that make data interpretation difficult for some fields. Reporters must still take the extra time to find the Form 10-413 code key sheet and manually look up the proper codes to be inserted into the crash report. These points were discussed in more detail in the previous section on the custom data collection alternative.

4.2 Data Storage and Access

4.2.1 Data Storage

Regardless of the data entry method chosen, the TSMIS will utilize a three-tier[10] architecture: the database tier will house the TSMIS crash database; the application tier will house the TSMIS logic behind the software; and the Web tier will allow the users to interface with the other tiers over the Web.[11] A crash record entered via the Web interface will eventually be stored on the database server once it passes successfully through the system's application layer, which is responsible for validation of the record. This architecture will ensure the TSMIS has the capacity to handle the expected amount of data and number of users, as well as provide an added measure of security to insure the integrity of the TSMIS crash database over the current limited security for CIRS where multiple client PC's connect to a central server.

Additionally, the database layer will also store queries, report specifications and formats, and historical reports generated by individual users, so that a park, for example, may recall a custom report format from the previous quarter to apply to the next quarter's crash data. When necessary, database archival procedures will move historical data to a separate database (commonly referred to as an archive) to keep the production database from becoming too large and impacting system performance.

[10] A tier can be thought of as a distribution level within a system, where each level is responsible for a certain set of actions.

[11] The exception to the three-tier system architecture would be if NPS chose to develop a desktop version of the data reporting and analysis portion of the TSMS in conjunction with the current system of data collection adapted for lat/long. This system structure is not discussed in Section 4, but is included in Section 8 on costs for comparative purposes, since despite its limitations, it would be the least costly option to develop and operate.

4.2.2 Crash Record Approval Sequence

The TSMIS will have a crash record approval, or verification, process built into it to insure the quality of the crash data stored in the database. Upon initial entry, the records will be stored in temporary tables within the database to ensure that they are not used in any analysis or downloaded by any system users. Only when the records are reviewed and verified by a data entry supervisor, will they be added to the TSMIS production crash tables and become available to analysts and other users.

The TSMIS will be able to produce reports to aid in tracking the record approval process, so that supervisors and/or the system administrator may monitor the amount of time it takes to move crash records from the temporary tables to the permanent database.

4.2.3 User Permissions and Data Confidentiality

Even though all the NPS crash records will be stored in the same TSMIS crash database location, different levels of user permissions will ensure that users will be able to access only those records and data elements that NPS policy deems appropriate. Information identifying persons involved in crashes will be considered confidential. Individual parks will be able to access their own records for editing and modification, and will have read-only access to the non-confidential elements of all crash records in the TSMIS database. Law enforcement personnel will have read-only access to the entire crash record including confidential information. All other users, including regional FLHP coordinators, FLH planners and project managers, analysts performing servicewide studies and inter-regional and inter-park comparisons, will have read-only access to all non-confidential information in the database.

In addition to limiting what data a user can view, permissions can also be used to limit what actions users can take once they are in the system. For instance, if NPS wants to allow other government agencies to view the data, such as NHTSA, it may set up permissions allowing them to log into the system, but their permissions would only allow them to view the data. For non-NPS first responders, the TSMIS could give them permission to enter data into a temporary table within the database, but not view other crash records. Once an NPS data entry supervisor verified the crash information with the outside responder, the record could then be added to the TSMIS production crash tables and become available to analysts and other users.

The range of typical permissions would include: create, read, delete, update, and download, just to name a few of the possibilities. The TSMIS system administrator would manage the permission levels and passwords.

4.2.4 Data Access - Integration with External Databases

In addition to crash data collected by users, the TSMIS components will require a significant amount of base data (e.g., highway inventory data, GIS park maps, bridge inventory data, etc.) to support the analysis and reporting components. Furthermore, the results of the reporting and analysis components will need to be accessed by other applications and programs throughout NPS. Thus, the TSMIS will need to be integrated with a number of other systems. The level of integration, which may vary from a user-driven manual data download process all the way to a custom-developed link between applications, will depend on the characteristics of the data being shared and the frequency of the transfer.

At the minimum, the following NPS data systems will need to be integrated with the TSMIS:

- RIP, BIP
  - Road and bridge geometry and characteristics
  - Safety appurtenances
  - Condition assessment
  - Road ownership
  - Traffic counts (annual average daily traffic (AADT), seasonal average daily traffic (SADT))
  - Video components
- NPS Visitation Database
  - Recreation and non-recreation visits
  - Modal split
- Congestion Management System
  - Congestion locations
  - Temporal data
- IMARS
  - All crash data after IMARS is implemented

Secondary data systems that safety analysts may require include:

- ATP
  - Routes
  - Vehicle data
  - Ridership data
- Facility Management Software System (FMSS)
  - Facility locations

The database tier may also need to store extracts from external databases that the TSMIS requires for analytic purposes, if it is not practical or possible to link to the databases in real time. For example, if a link to the RIP and BIP databases is too cumbersome in real time, the TSMIS may periodically download snapshots of NPS road characteristics and condition. The TSMIS will retain historical copies of the snapshots so that analysts will be able to conduct before/after studies for roadway improvements. At some point the historical snapshots of the external databases may also be offloaded to an archive where they can still be accessed if necessary.

Active links to systems external to NPS, such as federal agencies' safety databases (NHTSA, FRA, FARS, FMCSA, and FTA) and state crash databases may not be practical due to infrequent need. Data from these agencies' databases would not be required on a regular basis, but would likely be of interest to NPS safety analysts only for periodic comparison of NPS safety performance to national trends. When needed, NPS could request extracts from external databases to be written to CD and mailed, or put into an electronic file and emailed depending on the size, for loading into the TSMIS database tier for access by safety analysts. Reports of crashes of interest to these agencies could be transferred to them in a similar manner.

4.3 Reporting

4.3.1 Detailed and Summary Reports

Crash reports generated from the crash data generally take one of two forms:

- Detailed Reports - show detailed information for one or more data records.
- Summary Reports - aggregate detailed information to a summary level.

Detailed Reports

These reports generally deal with the details of one or more data objects (e.g., park, crash, user). Detailed reports can be used to generate a paper copy of a crash report or even a list of non-reporting parks. Detailed reports are typically used for identifying specific sets of data and drilling into the details of a specific piece of data. Here are a few examples of detailed reports:

- View Incident Details - a report that accesses the details of a single data object (a crash). This report would provide all the relevant details of a crash on one page, which the user could easily print, save to a file, view, or copy the data. An example of this type of report is provided in Figure 3 in Section 3.
- View Non-Reporting Parks - a report that identifies one or more single data object (in this case a park) based on the details (i.e., whether or not they have reported a crash) of that data object. Since it would not be feasible to view all the details of more than one park on a single page, the output of this report might be a tabular list of the parks that meet the criteria, along with selected detailed values displayed in the table. From this tabular list, the user could access the details of a specific data object from a link.
- View All Incidents in Park X on Route Y - a report that identifies multiple objects based on their details. The output would be similar to the previous example.
- View All Crashes Involving Culverts for All Parks in a Region – a report that would list the details of multiple objects (crashes in a region that involve a vehicle running into a culvert).

Summary Reports

Summary reports first select a group of records based on specified criteria and then aggregate, or summarize, certain detailed values across the selected records. At a minimum, the TSMIS would include the same reports that are now available from the

STARS database. Here are a few examples of summary reports including those currently available from STARS:

- Annual Crash Loss Totals - for all crashes in the specified year, the total number of fatalities, total number of injuries, and total property damage value by park, region and servicewide (this standard summary report is currently available from STARS).
- Annual Crash Totals – total number of crashes, fatal crashes, injury crashes and property-damage only crashes broken out by park, region and servicewide (this standard summary report is currently available from STARS). An example of this type of report is shown in Figure 4 in Section 3.
- Total Number of Parks Reporting by Year - the number of parks reporting any crashes totaled by year.

4.3.2 Report Generation

Since reports, particularly summary reports, may be fairly complex in their definition, the TSMIS will offer two options to provide this functionality to users. The simpler method for generating reports is for the system designers to identify standard reports that are regularly required for the management and analysis of park safety. Once the standard reports are identified, they can be constructed as a part of the overall development of the TSMIS. When the system comes online, the list of standard reports will already be defined in the database and available for system users. If it becomes apparent that another standard report is regularly required, then a database administrator will design and code the report.

The more complex method of generating reports is to allow custom reports to be created through the user interface by the system users. Once a user defines a report, it can be saved and even shared with other system users. However, the report-generating user interface required for designing custom reports is a challenge. The process of creating a custom summary report, for example, would involve the following steps:

1. Select the tables to be joined.
2. Select the fields to be used in the report.
3. Specify the fields to be grouped (i.e., by park, region, year).
4. Specify the fields to be aggregated (i.e., sum, average, min, max, etc.).

Since the process of defining custom reports can be challenging even for experienced users, it is recommended that this functionality be deferred for a later release of the TSMIS. The pre-defined reports would most likely meet most of the initial NPS needs. Until the custom report generator is implemented, an interim process can be developed for adding a pre-defined report to meet the needs of the park users.

4.3.3 Scheduling Reports

Many users will want to receive standard reports on a regular basis. The TSMIS will offer the option to have the system generate the reports and email them to the users on their specified schedules. The automatic report mailing will have two benefits: 1) it will save users time in obtaining periodic reports, and 2) it will make it less likely for the system to experience an overload of users at key times such as the beginning of a month, quarter or year.

Additionally, reports that involve a large amount of the data, such as annual summaries of servicewide crashes, may require so much of the system's capabilities that they can affect the response time significantly for other users on the system while they are being run. Users desiring these large reports will likely have to submit them for overnight runs when system usage is low.

4.4 Analysis

4.4.1 Overview of Analysis Component

The main function of the analysis component is to provide an ad-hoc, investigative tool for planners to utilize in their efforts to identify and correct safety issues. Using this tool, planners can follow a line of investigation from the summary report level all the way down to the root cause analysis. This component will utilize charts, graphs, statistical analyses and models, tabular data, and GIS data in the analysis of potential safety issues. This component will also be very flexible since the process of identifying and correcting safety issues requires planners to examine many different questions.

This component will be developed in a phased approach similar to that used for summary reports. To begin, the TSMIS will only have a few specific analysis capabilities; however, these capabilities will be expanded as TSMIS users identify needs. As much as possible will be defined up front; however, it is expected that more functionality will be needed as users become more skilled at using the TSMIS. Therefore, future versions of this system will include refined and expanded analysis options.

However, the TSMIS will not attempt to incorporate all the functions of analytical software packages like Microsoft Excel and Access, Statistical Analysis System (SAS), Statistical Package for the Social Sciences (SPSS), and others. Sophisticated safety analysts may find that the TSMIS analysis capabilities are not sufficient for all the analyses they might wish to perform. The TSMIS will permit them to export sets of data for use in software packages that are installed on their desktop computers. Data export screens will allow them to specify parameters for the set of data they need based on key fields in the database, and allow them to export it in various formats that will be compatible with external statistical analysis packages.

4.4.2 Analysis Capabilities

The TSMIS will offer the user a wealth of safety analysis options. Most will involve an initial data selection screen where the set of data to be analyzed is specified. Online instructions will then guide the user through each analysis option. Table 2 provides an overview of the TSMIS analysis options.

This section describes the analysis possibilities and provides examples of their uses. The options are arranged in the order of increasing complexity that mirrors the order an analyst might approach his/her work. Simpler, exploratory options that provide insights into more general areas to pursue would lead to options that enable the analyst to examine specific relationships and hypotheses, and involve more complicated analytical and statistical methods.

Typically, a user would follow one of two tracks in analyzing crash data. The first would be to identify *high-risk locations* utilizing the capabilities of the GIS map displays and supporting data. The second would be to identify broader *safety problem areas* not keyed to specific locations using the analytical reporting and statistical analysis tools. However, the full range of TSMIS tools is available for an analyst to apply in pursuit of any line of analysis.

Table 2. Overview of Analysis Options Available in the TSMIS

Analytical Method	Brief Description	Example
Analytical queries, crosstabulations, statistics, and reports	Queries/reports involving data selection & grouping, data manipulation, and calculation of statistics	The distribution of crashes in Valley Forge National Park during 2004 by time, day and season, compared to similar data for PA
GIS	Crash and other data organized by location and accessible by clicking mouse on park base maps.	Highlight all road segments in a park with the same characteristics; identify road segments with high crash rates ("hot spots")
Performance measures	Statistics that describe road safety performance	Number of crashes; number of crashes involving culverts
Performance measures: crash risk	The likelihood of a crash and its severity	Number of crashes per AADT for each road segment in a park
Performance measures: before/after comparison	Comparison of performance measures before and after an event, like a road improvement	Number of crashes occurring on a road segment several years before and after reducing the speed limit
Graphs	Diagram representing relationships among variables	Trend line for the number of crashes over a ten-year period
Road safety audit reviews	Surveying road segments for potential problems and taking immediate short-term steps to remedy them	Installing yellow "Caution" signs to warn of sharp curve ahead and cutting down foliage blocking lower speed limit sign; tracking

		safety before/after these changes
Safety indexes	Weighted combination of several performance measures relating to same attribute	Crash severity index for a road consisting of crash risk, injury / fatality risk, & average property damage
Performance monitoring	Comparing performance statistics or indexes for groups of like elements to identify outliers	Identifying road segments with crash rates per AADT greater than 2 standard deviations from the mean of crash rates for all road segments on NPS parkways
Performance models	Comparing NPS safety performance with performance standards from statistical models	Compare crash rate on NPS rural two-lane road segment with expected rate from the Indiana model for rural two-lane roads
Resource allocation / prioritization models	Models that prioritize roads projects based on expected improvements in safety & cost	Adaptation of Indiana model to produce a ten-year plan for roads projects for Intermountain Region, maximizing safety while remaining within annual budget

Analytical Reports, Crosstabulations, Statistics, and Queries

Users will be able to query the database, calculate statistics, and use the custom report generator to produce crosstabulations and analytical reports to aid in their investigations. Analytical reports are related to the summary reports described in Section 4.3.1 above, but typically involve more data selection and grouping, data manipulation and calculation of statistics. Queries and reports may incorporate data from external databases, such as state or national crash databases. Analysts will have the use of pre-programmed statistical functions, including:

- Sum
- Mean, mode, median
- Standard error, standard deviation
- Correlation coefficient
- Percentage
- Ratio, proportion
- Simple regression

The TSMIS would limit the application of statistical functions to about 20 key variables, and crosstabulations to four variables at a time. A count of records excluded from analysis because of missing data or other problems would accompany results. For further statistical analyses or larger crosstabulations, the user would have to export the data to his/her own desktop computer for use in analysis software. The list of key variables would include the following at the minimum:

- Crash location
- First harmful event
- Manner of crash/collision impact
- Weather condition
- Lighting condition
- Roadway surface condition
- Contributing circumstances, environment
- Contributing circumstances, road
- Type of motor vehicle
- Estimated vehicle speed
- Motor vehicle damage
- Contributing circumstances, motor vehicle
- Number of occupants
- Driver age
- Driver sex
- Drug/alcohol involvement
- Seat belt usage
- Fatalities
- Injuries
- Functional class of roadway

Examples of analytical queries and reports include:

- A query to list all road segments and their physical characteristics in Yellowstone NP with more than 5 crashes during 2004.
- A query to list all accidents involving culverts in Midwest Region during 2004.
- A table showing the number of crashes, average damages per crash, total number of fatalities, average number of injuries per crash, and SADT by type of roadway segment and by roadway condition in Acadia National Park during the high season of 2004.
- The distribution (percentage) of crashes occurring in Valley Forge National Historical Park during 2004 by time of day, day of week, and season, compared to the same distribution for roads with similar physical characteristics in the State of Pennsylvania or in other parks in the same park peer group.
- A table showing the number of crashes per visitor for each park in the Pacific West Region, and how many standard deviations it is from the mean number of crashes per visitor for all parks in the region during 2004.
- A table showing the ratio of number of crashes in intersections to SADT by type of intersection control system in Intermountain Region parks.

GIS

One of the most useful features of the TSMIS analysis component will be the geographical information system (GIS). The GIS organizes data by location, as expressed in latitude and longitude, so that it can be displayed on a map. The TSMIS crash data, the RIP and BIP roadway and bridge features and condition, safety appurtenances, road ownership, traffic levels, alternative transportation system (ATS) routes, IMARS incidents, and FMSS facilities data are all keyed to location and therefore have the potential to be accessed through the GIS base maps.

In the TSMIS the versatile GIS software can facilitate safety analyses by making crash location patterns on the map visually pop out at the user. Examples of the types of ad hoc analyses the user will be able to conduct include:

- A user may display all the crashes occurring in a park on the GIS base map and observe the locations of crash clusters or "hot spots" (see Figure 6 in Section 3).
- By clicking with a mouse on a point on a park map a user can display crashes that occurred at that point, pull up the corresponding crash records, road features of the crash location, the AADT, SADT, nearby safety appurtenances, and more.
- Conversely, a user can define a set of crashes, such as all rollover crashes that occurred in a particular park at night in sport utility vehicles (SUVs), and the GIS will display their locations on the park map.
- A user can select a road segment on the park base map, find all other segments in the park database with features similar to the selected road segment, such as travel direction, speed, curvature and safety appurtenances, and then highlight all those segments on the park map.

Performance Measures

Performance measures in the context of safety analysis are statistics that describe the safety of road transportation in the NPS. They are keyed to the goals and objectives of the TSMS, and changes in performance measures from time period to time period can indicate progress made toward the goals and objectives. The TSMIS will be able to track the simple performance measures that are usually part of typical safety management systems:

- Number of crashes
- Number of injured persons
- Severity of injuries
- Crash damages

Risk

A powerful measure to gauge traffic safety is crash risk, that is, both the likelihood of crashes and their severity. Risk is more complicated to determine than simple performance measures because it requires not only information about crashes that have occurred (the numerator in a risk measure), but also exposure measures (the denominator in a risk measure), i.e., information about the environment in which the crashes occurred. By linking to the other NPS databases, the TSMIS will be able to access the exposure measures of AADT, SADT, visitation, and miles of road by type. Risk may be calculated only to the extent that both the numerator and denominator can be broken down into the same analysis categories, such as road classification, vehicle type, time (hour, day, week, season), crash location, etc. For example, if only AADT is available, then only annual risk may be calculated, even though breakdowns of crashes are available by week or by month.

Examples of risk performance measures include:

- Number of crashes per AADT for each road segment within a park
- Number of injuries per visitor for each park
- Number of crashes per mile for road segments in the Northeast Region with similar characteristics (width, speed, curvature, AADT, safety appurtenances)

<u>Before/After Comparisons</u>

An important application of performance measures is making comparisons of applicable performance measures before and after a safety improvement has been implemented: "before/after" studies. FLH project teams are particularly interested in this application as they are responsible for evaluating the success of the roads projects they have funded and carried out. Careful evaluations can identify the circumstances under which the projects achieve the greatest improvements in safety.

Before/after studies require that crash and other data used to calculate performance measures be available for appropriate time periods before and after a safety improvement is made. The TSMIS will keep historical periodic snapshots of the TSMIS crash database to facilitate before/after analyses. If the external databases that provide other data required for calculating performance measures do not also maintain historical snapshots, then the TSMIS will have to download snapshots of these external databases at times that correspond to the TSMIS snapshots, and store them on the TSMIS data server.

Examples of before/after comparisons include:

- Number of crashes occurring on a road segment several years before and several years after reducing the speed limit
- Number of crashes occurring at an intersection several years before and several years after installing a stop sign
- Number of crashes occurring in a park several years before and several years after implementing a program of driver education on hazards (signage and handouts) and increased traffic enforcement efforts

Trend and Graphical Analysis

The TSMIS will offer simple graphical analysis capability. For more complex graphs, the user would have to export the TSMIS data to his/her desktop computer to take advantage of external graphics software.

- Trend lines - a trend line shows how a variable changes over time. An example of a trend line showing the number of crashes occurring annually in Yellowstone NP from 1989 to 2000 is found in Figure 7 in Section 3.
- Pie charts - a pie chart shows how a total is divided up into its parts. The size of each part is represented as a proportionate wedge of a circular. Examples would include: the total number of crashes by contributing factor; the total number of injuries by seatbelt usage; and the total mileage of roads in a park by road classification.
- Bar graphs - a bar graph shows the relative sizes of a series of measurements. Examples would be: the number of crashes occurring in the parks of the Intermountain Region, where the height of each bar would represent the number of crashes in an individual park; the number of crashes in a park by time of day, where the height of each bar would represent the number of crashes for an hour of the day; and the number of fatal crashes by roadway speed limit, where each bar would represent the number occurring at a specific speed limit.
- Scatter plots – a scatter plot shows the relationship between two variables. Examples would be: number of crashes (x-axis) versus speed limit (y-axis), where each point on the graph represents one road segment; AADT (x-axis) versus crash rates (y-axis), where each point represents one road segment.

Road Safety Audit Reviews

The TSMIS can facilitate the RSAR process, if NPS should decide to pursue it. The RSAR has been proven a powerful tool for localities to improve safety on their roads. It involves road safety personnel surveying road segments for potential problems, deficiencies, and hazards, and taking immediate steps to remedy those that can be addressed with short-term and low-cost solutions, such as the installation of a stop sign, or the cutting down of view-impeding brush. Those problems requiring longer-term solutions (and typically more costly solutions), such as road re-grading or widening, are identified and added to the list of major road improvements for prioritization (3R and 4R projects in the case of NPS). The RSAR is considered a pro-active safety improvement method, because localities perform RSARs on all their roads regardless of a road's crash history. The presumption is that the removal of potential hazards, even if it does not appear that they have caused crashes in the past, will decrease the likelihood of crashes in the future.

However, it is possible that NPS' limited funds will require them to be more selective, or re-active, in applying the RSAR method by restricting it to their most dangerous road segments, at least initially. The TSMIS can be used to select road segment candidates for RSARs. Those segments that have exhibited high crash risk historically combined with segments having a large number of crashes would be likely candidates for the first RSARs. Limiting RSARs to only those roads with high crash risk (the most comprehensive measure of road safety) could overlook roads with low crash risk but nevertheless large numbers of crashes due to high usage. NPS needs to address both to maximize the effects of the RSAR and their overall efforts to improve road safety in the national parks. If resources eventually allow, NPS can also become more pro-active and conduct RSARs on all park roadways, regardless of their crash histories.

The TSMIS will provide a repository of audit information as well as providing a system for tracking the accomplishment of audit recommendations. Results of RSARs would be entered into the TSMIS via special input screens. They would be keyed to the specific road segments they pertained to, so that users could access them via the GIS, and tie them to all the other TSMIS information available about the road segment, including road and bridge geometry, safety appurtenances, traffic and condition from RIP and BIP. The results would be stored in subtables that would include not only the assessments of road segment elements, but also recommended improvements. The TSMIS would allow users to record the dates the road improvements were actually implemented and their cost. This will facilitate the analysis of the effectiveness of the improvements on crash risk.

Safety analysts should conduct before/after studies on the road segments undergoing RSARs to determine the effectiveness of the improvements that were implemented as a result.

Safety Indexes/Performance Monitoring Systems

The TSMIS will be able to take safety analysis a step further than simple performance measures by calculating safety indexes to serve in a safety performance monitoring system for parks or roadway segments. Both the Federal Aviation Administration and FMCSA, among others, have developed this type of system to help them identify carriers that are operating outside the norm of other carriers or differently from their historical patterns. (See Appendix C for summary descriptions of the FAA and FMCSA safety systems.) In the context of the NPS, this type of system could combine various safety performance measures for each park or roadway segment to form an index, to compare safety records and identify roadway segments or parks that exhibit unusual safety performance.

With this analysis feature, the TSMIS would calculate a safety index for each park and/or road segment, and conduct two types of comparisons. Peer group comparisons would compare each index with those of its peer group, that is, road function or park classification group with similar traffic characteristics. Historical comparisons would compare each index with its own value for previous time periods. Outlier indexes could easily be identified using plots, or highlighting them in reports or on GIS maps.

The safety index would consist of a weighted combination of performance measures, where the weights represented the relative importance of each index component. Candidates for inclusion in the index might be, for example:

- Crash risk (number of crashes per AADT if available)
- Total number of crashes, fatalities, injuries
- Total amount of property damage
- Proportion of cut-through traffic
- Exposure measures, such as AADT
- Average speed

For the first release of the TSMIS, the initial index would be restricted to readily available data. Safety experts would set the initial weights by relying on relationships of these factors obtained from safety studies in the literature or on their own knowledge of the relative influence of the candidate performance measures on crashes. These weights could be adjusted for later TSMIS releases as new data became available, as safety experts developed new insights into the behavior of the indexes over time, or as safety improvement strategies and approaches changed. With the retention of historical snapshots of the TSMIS database, it would be relatively simple to recalculate historical indexes when index definition changes were warranted.

The ability of indexes to identify unusual performance relies on appropriate assignments of parks and roadway segments to peer groups. For example, crash risk on a parkway may always be greater than crash risk on a two-lane wilderness road, because of the higher traffic density and speeds, no matter what safety improvements are taken to reduce crashes on parkways. Comparing parkways to parkways will highlight both problems and effective safety measures within the same type of environment.

Statistical Models

There are a number of statistical models that take the safety analysis tools beyond safety indexes, in that they incorporate safety standards and research results from sources external to the NPS environment. Many of these are still in research stages, and have not been tested beyond the particular set of data used to develop them. They may not be applicable directly to the NPS environment, but might be adaptable with further research. The TSMIS could incorporate the most useful of these models as analysis options; users would also have the option of exporting TSMIS data to their own desktop computers for developing their own models or applying other models not included in the TSMIS. Two types of models are described here.

Performance Models

Performance models permit comparison of current NPS safety performance with performance standards developed through statistical modeling. Typically, these models predict the expected number of crashes and their severity for a particular type of road segment given AADT and/or other parameters. The actual crashes are compared to the expected to see if they are greater or less than what random variation would likely account for. Safety experts can then investigate other explanations.

There are numerous examples in the literature of attempts to develop such performance models. Typically, the models are developed using the historical database of the road system being assessed. But if one is willing to assume that the same type of road segment will have the same number of crashes given the same AADT regardless of the geographical location, then these models might have applicability to NPS roads. For example, Lamptey et al[12] offers negative binomial models for six road segment types in Indiana: rural two-lane, rural multi-lane, urban two-lane, urban multi-lane, rural interstate, and urban interstate. Kononov and Allery[13] developed a combination of Poisson and negative binomial models for three road segment types in Colorado: four-lane rural freeway, two-lane rural arterial, and six-lane urban freeway. The Interactive Highway Safety Design Model (IHSDM) is an effort underway by FHWA to evaluate safety and operational effects of geometric design decisions, and currently offers crash prediction models for rural two-lane highways.[14] To the extent NPS road segments fall into these categories, these models could be applied to the NPS road system. These models apply only to road segments that do not contain intersections; alternative diagnostic tools are required for intersections. More research is needed to identify additional models for road segments and diagnostic tools for intersections, and to determine their quality and applicability to NPS roads.

On the other hand, the TSMIS must contain the data to support the models if the NPS desires to use them. Variables required by the Indiana models include:

- AADT, in vehicles per day
- Lane width
- Right shoulder width
- Median width
- Left shoulder width
- Access control
- Pavement friction
- Presence of turning lanes on segment
- Presence of curbs
- Shoulder type
- Average horizontal curve radius
- Average vertical curve grade

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[12] Lamptey, Godfrey, Samuel Labi and Kumares C. Sinha, *Investigating the Sensitivity of Optimal Network Safety Needs to Key Safety Management Inputs*, 2005 Transportation Research Board Annual Meeting.
[13] Kononov, Jake and Bryan Allery, *Highway Safety Manual A Conceptual Blueprint and the Analytical Framework*, 2000; http://diexsys.com/PDF/Levels of Service of Safety.pdf.
[14] IHSDM Web site.

At this time, RIP and BIP, the databases that would logically provide these data to the TSMIS, do not contain all of the road geometry data elements for each road segment and bridge. With the current efforts to upgrade and improve these databases, the timing may be right to begin collecting the missing elements required by many of these models. However, RIP and BIP managers may be reluctant to spend the resources to collect this additional information unless there are other demonstrated uses for it.

Resource Allocation/Prioritization Models

The State of Indiana has supported the development of perhaps the ultimate in highway safety management models: a model that determines a ten-year plan for safety improvement projects on its road network by location and type of improvement that cost effectively maximizes safety while remaining within annual budgetary constraints.[15] A number of assumptions and qualifications are required for the model to work:

- Only road segments that fall short of the recommended design values specified in the Indiana Department of Transportation's (INDOT) Road Design Manual are included as potential projects. Improvement projects considered by the model are thus restricted to road improvements as opposed to driver and vehicle programs.
- The benefits of each safety improvement are measured in terms of the expected crash and crash severity reduction.
- Crash patterns covered in this study include rear-end, head-on and opposite direction side-swipe, same direction side-swipe, off-road and night crashes. Factors such as weather, road surface conditions, sight distance, obstructions are not considered.

After estimating the expected crash frequency for each road segment over the ten-year analysis period, the model selects candidate locations for safety improvement by identifying the locations with crash frequencies greater than the critical values (see the Performance Models section above). Then alternative safety improvement projects are identified for the candidate locations to bring them up to INDOT's road design standards. The model computes the costs and benefits of the alternative projects (costs are based on Indiana, FHWA, and other road project cost data, and benefits are based on research in the literature on the degree various improvements reduce crashes and their severity). An integer-programming type algorithm then produces the ten-year plan, trading off the benefits of alternative projects with their costs, determining which alternative project should be pursued for each site and during what year, and maximizing the reduction in crashes and severity for the overall period. In addition, the model determines the optimal level of safety investment beyond which the cost-effectiveness of the safety funding decreases.

Another effort by FHWA and thirteen state highway agencies (Indiana included) is underway to develop a decision support application known as SafetyAnalyst.[16] It does

[15] Lamptey, Godfrey, Samuel Labi and Kumares C. Sinha, *Investigating the Sensitivity of Optimal Network Safety Needs to Key Safety Management Inputs*, 2005 Transportation Research Board Annual Meeting.
[16] http://www.safetyanalyst.org/

not go quite as far as the Indiana resource allocation model, but aims to identify high-risk locations throughout the highway network, determine appropriate countermeasures, evaluate them according to their safety effectiveness and cost, and give them a priority ranking to maximize safety improvement throughout the network.

These types of algorithm could be very beneficial to NPS as an automated input to the process for allocating its PRPP funding to locations throughout the NPS road network to maximize the safety benefits. However, it would not be wise for NPS to rely solely on such algorithms; indeed, it is unlikely that the Indiana algorithm, for example, could be adapted to model all NPS' needs:

- The algorithm assumes that eliminating a deficiency in road design will improve safety on that segment, but NPS is not always at liberty to make such improvements due to other priorities. For example, the algorithm may recommend straightening a curve in a road as the most cost-effective solution, but NPS may not want to remove the curve on an historic road. NPS may have to apply user education and enforcement to the problem, or implement a less effective solution, such as signs and guard rails.
- Some crash situations that occur frequently in NPS locations, such as animal strikes, have not been researched to the degree that their effectiveness in reducing crashes and crash severity can be quantified for inclusion in the model.
- Difficult terrain or other environmental factors for NPS locations may not be reflected in the cost database for Indiana roads projects.
- The model allocates funds to locations based on their crash histories. There may be other NPS locations that local safety planners know to be "dangerous" but through luck or other factors have not resulted in enough crashes to qualify as candidate locations for the model. Similarly, NPS may be influenced by other pressures to address some locations before others.

Nevertheless, such models could serve as an important element of a suite of information sources to guide NPS planners in allocating their PRPP dollars. The adaptation of the Indiana model to NPS could be a goal for a future release of the TSMIS. It could be adapted so it would not require NPS to augment the crash data collected through IMARS (the MMUCC data elements) or the road description data by RIP, BIP.

Short of a full-blown resource allocation or prioritization model or in anticipation of model implementation, the TSMIS could research, develop and provide access to online reference tables for safety analysts to look up parameters, such as effectiveness of safety measures, implementation costs of safety measures, and appropriate safety measures for given safety problems, based on industry standards, industry practices, and accepted research results. Safety analysts would use this type of information, which would be required input to an automated resource allocation or prioritization model, to accomplish the same allocation analysis manually. In fact, the allocation process, whether accomplished manually or automatically, as with the Indiana model, is an important part of the TSMS, described in Section 5 below.

4.4.3 Conversion of Historical Crash Data

Many of the analysis methods mentioned in previous sections refer to historical data. When the TSMIS is implemented, only data collected from that point on will be available to analysts unless historical STARS data are converted to the new crash record format and added to the TSMIS database. Since the data conversion process is quite costly (see Section 8 Costs to Implement and Operate the TSMIS), it is recommended that data for only the parks with the greatest number of crashes be converted. As 30 parks accounted for 85-90 percent of all crashes occurring between 1989 and 2000, these parks would be the likely candidates for historical crash data conversion.

A major step in converting the historical data is to define a mapping from the STARS data model to the TSMIS data model. This mapping will identify the steps required to transform each field in the STARS data set into something compatible with the TSMIS data model. Once this mapping is defined, the process for migrating the data can be automated. In fact, if NPS chooses to adapt the current data collection system in the interim prior to IMARS rather than develop a custom data collection component, this step will already have been accomplished.

In either case above, however, the second step of determining the latitude and longitude of the crash location is problematic, and responsible for the bulk of the conversion cost. Crash location in STARS is defined by a link and node system, which must be translated into latitude and longitude coordinates for the GIS. Unfortunately, this process requires manual intervention and cannot be fully automated.[17] One possibility to mitigate the cost is to migrate only the historical summary level data needed for some of the more important analyses and reports, and forego GIS analysis of historical crash data until the TSMIS database acquires its own historical data several years down the road.

[17] Refer to Volpe Center Technical Memorandum on GIS Conversion of STARS Incident Data from Gary T. Ritter of the Volpe Center to Mark Hartsoe, Park Roads and Parkways Program, NPS, April 2, 2004.

5 The NPS Traffic Safety Management System

Up until this point the concept has concentrated on crash data and their reporting and analysis, i.e., the TSMIS. This section describes the framework for translating the information the data contains into a Traffic Safety Management System (TSMS) that will improve traffic safety throughout the NPS system. With the TSMIS as its foundation, the TSMS encompasses all the activities associated with proactively managing transportation safety in the NPS. These interconnected activities culminate in the implementation of safety improvement measures designed to address specific traffic safety issues.

5.1 Strategic Planning Process

The strategic plan sets the goals and objectives for the TSMS, and is the framework for all the activities associated with transportation safety. The strategic planning process includes the basic stages of:

1. Determining the mission, goals, strategies and performance measures for the TSMS
2. Determining the projects to improve traffic safety
3. Implementing the projects
4. Evaluating their performance
5. Evaluating the strategic plan.

5.1.1 TSMS Mission, Goals, Strategies and Performance Measures

As stated in the beginning of this report, participants in the February 2002 NPS safety needs workshop recommended the following TSMS mission statement:

While maintaining a balance of public safety and resource protection, assure a safe park transportation experience for all park users through the:

- *Efficient monitoring and reporting of incidents;*
- *Identification and correction of safety problems:*
  - *through effective enforcement,*
  - *by providing safety education, and*
  - *by the application of cost-effective safety technology;*
- *Effective utilization of safety data for allocation of resources;*
- *Timely maintenance of safety-related appurtenances; and*
- *Effective communication with state and local safety officials.*

The mission statement embodies the vision or charge to NPS for safe transportation on its roads. With the mission set, the next step is for the NPS to determine goals and strategies for the TSMS. Goals represent achievements or ends toward which the TSMS should direct its efforts. Strategies are specific actions or projects NPS must take to reach a goal.

Goals and strategies are not static, but change as the TSMS evolves, progress is made, and new problems and areas of concern emerge and take precedence. Performance measures are statistics that permit the evaluation of progress made toward goals over time.

Initially, TSMS goals, strategies and performance measures may be oriented toward general safety issues that do not rely on extensive data analysis and user experience with the TSMS to identify. As the TSMS process matures, the TSMIS becomes more populated with crash data and analysis features, and participants become more knowledgeable about the nature of traffic crashes in parks, the goals, strategies and performance measures can be targeted toward more specific safety issues.

For example, initial goals, strategies and performance measures for the TSMS might consist of the following two goals. They could apply to the US as a whole, or to individual regions, states, and parks.

Goal 1: *Reduce crash risk on park roads, that is, the likelihood a crash and its severity.*

- ***Strategy 1***: *Address road design deficiencies at the highest crash risk locations in the NPS.*
- ***Strategy 2***: *Conduct Road Safety Audit Reviews on high volume roads.*
  - ***Performance Measure 1***: *Average number of crashes per AADT*
  - ***Performance Measure 2***: *Average number of injuries/fatalities per crash*
  - ***Performance Measure 3***: *Number of miles of roads subjected to RSARs*

Goal 2: *Increase park participation in the TSMIS*

- ***Strategy 1***: *Educate "Top 21" parks in use of TSMIS features (GIS, reporting, analysis)*
- ***Strategy 2***: *Contact not-reporting parks*
  - ***Performance Measure 1***: *Number of reporting parks*

In later years, the goals, strategies and objectives might reflect specific problems that emerged in safety analyses, such as the following. While this particular example might have wide applicability across regions and parks, individual regions and parks could have their own goals that applied to safety issues limited to their own area.

Goal 3: *Reduce the risk of crashes on curved roadways.*

Strategy 1: *Inform visitors about safe driving on curved roads where appropriate.*

Strategy 2: *Conduct RSARs for road segments with curve radii greater than 40 degrees.*

Strategy 3: *Improve guard rails, road surfaces and signage on curved road locations with highest risk for crashes.*

Performance Measure 1: *Average number of crashes per AADT for curved road segments*

Performance Measure 2: *Average number of injuries/fatalities per crash on curved road segments*

Performance Measure 3: *Number of miles of curved road subjected to RSARs*

Appendix D contains examples of missions, goals, strategies and performance measures from several state highway safety management plans.

5.1.2 Project Selection

The next stage is the selection of projects to pursue during the planning cycle that will make the most progress toward the goals while remaining within the given budgetary constraints. This process begins with highlighting the safety problem areas and high-risk locations through the analysis of crash and exposure data. Once the problems are identified, potential solutions are developed along with their costs, funding sources, and effectiveness at reducing crashes. With this information it is possible to trade off the benefits and costs, and finally, select the projects.

Identifying High-risk Locations and Safety Problems Areas

Identifying high-risk locations and broader safety problem areas relies on the information and analyses provided by the TSMIS. TSMIS reports and analysis results, based on its timely, reliable and accurate crash database, will provide a clear picture of safety in the NPS, regions, and parks that will reveal where the system is performing poorly, and the factors that contribute to the poor performance.

Information for identifying *high-risk locations* consists of:

- Crash rate by road segment
- Injury rate by road segment
- Road segments where fatal crashes occurred
- Average property damage by road segment
- Societal loss (total of property damage cost, injury cost, and value of life) by road segment

The data can be broken down by region, park, park peer group, road classification, segments with and without intersections, etc., or combinations of these. Reports can simply rank the road segments by safety rating, with the segments with the worst performance appearing first, or they can indicate which ones fall outside of a norm or standard. In early releases of the TSMIS, road segments with poor performance might be determined by their crash rates (or other statistics) being greater than two standard deviations of the mean crash rate. In later releases, safety indexes or performance models based on national standards, as described in Section 4.4.2, could be used to identify outlier road segments with poor performance.

Information for identifying *safety problem areas* consists of breakdowns of crashes by:

- Contributing factor
- Season, day of week and time
- Vehicle type
- Crash type
- Weather conditions
- Road surface conditions
- Lighting conditions
- Alcohol/drug involvement

Again, the data can be broken down by region, park, park peer group, road classification, segments with and without intersections, etc., or combinations of these. Comparing these breakdowns with those from previous years can indicate emerging problem areas that are not necessarily keyed to specific locations.

Identifying Candidate Solutions

Safety analysts must develop candidate solutions to address high-risk road segments and safety problem areas by conducting safety studies. The TSMIS provides them with a wealth of analytical tools. For a high-risk road segment, analysts can use the TSMIS, for example, to:

- Locate it in relation to other high-risk segments on a GIS base map
- View the records of crashes that occurred there for patterns in causes and circumstances
- View current roadway condition assessment, traffic volumes, roadway characteristics, safety appurtenances, and video footage, through integration with RIP and BIP
- Assess congestion, through integration with the Congestion Management System
- Identify nearby facilities, through integration with FMSS
- Identify other road segments with similar physical characteristics and traffic volumes to compare performance
- View its performance in previous years

In some instances, the TSMIS alone may provide them the information they need to develop candidate solutions for risk factors, and eliminate the need for a site visit. Where site visits are necessary, safety analysts' comprehensive knowledge about the site's performance beforehand will enable them to be more focused in their investigations.

Based on the TSMIS information and site visits, safety analysts can develop potential solutions to address the risk factors identified, and their costs and likely benefits in terms of crashes and injuries prevented. They may propose a hierarchy of solutions in terms of costs and benefits. For example, to address a road segment where the vast majority of crashes involved skidding off the curved road segment into trees, possible hierarchical solutions could be:

- Installation of warning signs
- Removal of trees
- Application of non-skid road surface
- Installation of guard rails

Similarly, safety analysts may use the TSMIS to obtain further information about safety problem areas suggested from the analytical reports. They may use TSMIS analysis features to:

- View the records of crashes related to the safety problem area and look for similarities in their circumstances
- Perform park to park comparisons of the safety problem area to see if it is consistent among parks or if it occurs only in certain parks, or on certain types of roads
- Identify road segments that had crashes related to the safety problem area and display them on a GIS map

Solutions to safety problem areas identified here might more appropriately be RSARs, enforcement actions, public awareness and education programs, rather than roads projects. For example, possible solutions to an increase in SUV rollover crashes might be:

- SUV-targeted public awareness campaign at entrances on obeying speed limits, especially on curves
- Increased enforcement of speed limits on curves
- Speed limit reductions on curves

Costs are estimated from previous experience with NPS projects. Expected reductions in crashes must be obtained from past experience with the effects of NPS projects or from the literature, such as *The Handbook of Road Safety Measures*,[18] a compendium of international research results on effects of eight categories of traffic safety measures on crash risk.

[18] Elvik, Rune and Truls Vaa, *The Handbook of Road Safety Measures*, Amsterdam, Elsevier Ltd., 2004.

It should be noted that high risk may be associated with certain types of roads or traffic volumes regardless of other factors, and, short of closing the road, NPS may not be able to reduce it. Over time safety analysts will gain an understanding of the limits of their efforts, and focus on road segments where there is a greater chance of improvement.

Choose the Projects

Analysts trade off project costs and benefits within the budgetary constraints to choose the projects to implement during the budget year,. In addition to projects identified by the TSMIS analytical process above, other projects may need to be included as choices, such as those responsive to perceived problems, local inputs, and other pressures. For example, it may be prudent to consider a safety improvement to alleviate traffic conflicts on a park's fringes that are of particular concern to the local town, even though the TSMIS indicates those locations are not prime candidates in terms of crash risk.

There is no simple formula for project selection. NPS follows a process for allocating funding for road construction projects under the PRPP (including appropriate safety appurtenances), but the process for addressing non-construction projects, such as public education or enforcement, is not well established and the funding for such projects comes from different sources or individual park budgets.

Currently NPS allocates funds for the PRPP to regions based on a formula that includes the number of miles of roads, visitation, crash history, climate, and other factors. Then each region selects projects in the 3R and 4R categories[19] (a 60/40 split between 3R and 4R project costs) using the Choosing by Advantage (CBA) methodology until the budget limit is reached. The CBA criteria include many factors of which safety is one.[20]

NPS could continue to use this basic method of funding allocation and project selection, but if they wish to give safety a more prominent position in the process, meet their goals, and experience incremental safety improvements each year, simple modifications could do so. They might consider a regional funding formula that is based predominantly on safety performance with the influence of other factors like miles of roads reduced or

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[19] 3R projects refer to projects involving resurfacing, restoration, and rehabilitation, while 4R projects refer to major realignment, reconstruction projects requiring "moving dirt" (i.e., substantial work), and may require environmental assessment.

[20] CBA is a structured method for decision-making based on determining the advantages of different alternatives for a variety of factors or goals. It is anchored in relevant facts (not arbitrary) that enable comparison of diverse projects involving diverse park resources, determine the advantages each alternative provides, and provide the basis for a decision. The factors are:

- Provide safe visits and working conditions
- Protect cultural and natural resources
- Improve visitor enjoyment through better services and educational and recreational opportunities
- Improve operational efficiency, reliability, and sustainability
- Provide cost-effective, environmentally responsible, and otherwise beneficial development of the National Park Service

eliminated, and a greater weight for safety in the CBA methodology, or removing some of the other factors altogether.

A more radical option would be to develop a formula that distributed funding among park peer groups rather than regions, or to subdivide the regional allocation among park peer groups before applying the CBA methodology. Another option would be to abandon CBA and base project selection upon expected crash risk reduction until the funding limit is reached.

If NPS plans to conduct RSARs, then a certain percentage of the PRPP funds (such as 5 percent to 10 percent) for each region could be reserved prior to the CBA process. This money could then be used to address short-term, low-cost problems identified in the RSARs; larger projects identified would go into the candidate project pool for the next round of planning.

Projects that do not fall within the realm of the PRPP could be subjected to a separate CBA process to prioritize them so that NPS can seek funding for the most pressing ones from other sources.

The final product of this step is a list of projects and programs that the NPS will implement during the planning cycle. The projects will have been selected to stay within the budget and maximize the potential safety improvement to the extent possible.

5.1.3 Project Implementation

In this step, the selected projects are implemented: RSARs are conducted, road improvement projects are constructed, safety programs are carried out. RIP and BIP need to be updated with changes made to roads as a result of these activities.

5.1.4 Performance Evaluation

Performance evaluation includes evaluating the safety performance of individual projects as well as the safety performance of the NPS traffic system as a whole. For individual projects, a before/after study supported by TSMIS data and reports is warranted to determine if the improvement made a difference. It is likely that comparing safety for several years prior to the improvement to safety for several years after the improvement will be sufficient to determine its effectiveness, although in some cases five-year or longer before/after periods may be warranted. Assessments of projects implemented late in the planning cycle may have to be deferred to the next evaluation period. Performance measures for the goal under which the project was implemented would be the appropriate ones to examine in the before/after study. For example, if the project were implemented to address rollover rates on curves, then the rollover crash rates before and after the project would be compared. However, since the improvement may have peripheral benefits to other types of crashes, it would also be appropriate to examine performance measures with more general applicability, such as overall crash risk.

To evaluate the performance of the TSMS as a whole for the performance period, all of the performance measures associated with the TSMS goals should be evaluated by comparing their values for the current performance period to their values for the previous period. The TSMIS will provide the supporting data and reports for this effort.

Failure to show progress in any area should prompt reassessment of the associated strategies, corresponding modifications to the plan, and development of lessons learned.

5.1.5 Strategic Plan Evaluation

Planning is an evolving process. As progress is made toward goals, new problems and areas of concern emerge and take precedence. Periodic evaluations of the strategic plan assure it reflects current conditions. For example, suppose the NPS addresses the strategic goal of reducing crashes caused by automobiles striking animals by introducing a program of interventions, such as environmental- and animal-friendly ways of discouraging animals from crossing roads, effective warning signs for drivers, and reduced speed limits in problem areas. Over the years, performance measures for this goal, supported by the TSMIS data system, show that this type of crash has become a rare event. Analysis of crash causes now points to pedestrian injuries as an emerging problem area. The strategic plan is then modified to include a new goal, and programs and performance measures based on TSMIS data are developed accordingly, including the collection of new data elements or entire new data sets if required to track progress toward safety goals.

5.2 Roles and Responsibilities

5.2.1 Current Organizational Responsibilities

Park Roads and Parkways (PRP) in the NPS Facility Management Division has overall responsibility for the management systems that deal with road safety: Pavement, Bridges, Safety, and Congestion. PRP staff formulate safety policy and establish safety programs with the aid of regional staff and inputs from individual park personnel, and ensure compliance with legislation. They prepare budget submissions for Congress. They develop the overall NPS strategic plan for roads. They coordinate with other public and private organizations.

NPS Regional Offices deal with parks in their regions and serve as a buffer between them and PRP. They submit requests to PRP and FLH divisions for park resources and roads projects funding. A regional FLHP coordinator administers the FLHP in each NPS region, occasionally with the help of an assistant. The FLHP coordinator, along with park representatives, applies the CBA methodology to roads projects requested by parks to prioritize them for submission to the FLH program planner. The FLHP coordinator is also part of the project development team for projects being constructed in his/her region's parks.

FLH Divisions[21] are responsible for prioritizing, funding, planning, scoping and implementing roads projects. The FLH division's chief planner compiles project lists from the NPS regions within the FLH division and jointly prioritizes them. For each project funded, a project development team, consisting of the appropriate FLHP coordinator, a project manager and design engineer, and others as needed, produces a Plans, Specifications and Estimates (PS&E) package containing the project scope, design, schedule and budget. This forms the basis of an RFP for a project construction contract. The development team project manager is responsible for overseeing the contractor as they implement the project. In all cases, FLH funds roads projects and the project managers are responsible for seeing they get done.

Individual parks are responsible for all the activities involved with the day-to-day operations of the parks, park planning, infrastructure maintenance, visitor amenities, visitor safety, resource preservation, and perhaps most importantly to the TSMS, reporting their crash data to the FOTSC. They monitor road condition and identify candidate locations for road improvement projects.

The FOTSC is responsible for maintaining the STARS database, inputting data submitted by parks in paper 10-413 forms, troubleshooting on CIRS problems, and responding to requests for ad hoc and regular crash summary reports from NPS, FLHP and others.

5.2.2 Responsibilities under the TSMS

The TSMS assumes organizations will continue their current responsibilities, but will now have the additional information they need to make safety a regular consideration in all road management decisions. In continuing to develop the overall NPS transportation safety strategic plan, PRP will be responsible for convening annual planning meetings where regional FLHP coordinators, FLH planners and road design engineers, and park representatives assess progress made during the year toward strategic plan goals, determine what combinations of safety improvements best addressed high risk locations in parks and servicewide problems, identify lessons learned, modify the strategic plan as necessary, allocate funding to the regions for the next year's improvements, and set priorities for projects. PRP will likely use a contractor to produce an annual report on NPS traffic safety to distribute to regions, parks and other interested parties that documents the activities of the previous year, the TSMS goals and strategies, and the progress in improving safety on NPS roads.

PRP needs to encourage parks to submit their crash data, emphasizing that in the new data-driven environment, safety improvement projects for parks cannot be identified without timely submission of their crash data. PRP needs to build crash data submission into park ranger, police, superintendent, and supervisor job descriptions. Safety training awareness training should be part of all job functions. Unless PRP reaches out to all

[21] Federal Lands Highway is organized into the headquarters Federal Lands Highway Office (FLHO), and three divisions: Eastern Federal Land Highway Division (EFLHD); Central (CFLHD); and Western (WFLHD).

users, it is unlikely that crash data submission will be given high priority among the wide range of duties of each park position. In the event a park is not responsive, PRP must determine a policy, set consequences, clearly communicate them, and be willing to impose them if necessary.

The NPS regions and FLH divisions will share most of the analytical responsibilities of the TSMS. Throughout the year, FLHP coordinators will review the analytical and other periodic reports coming out of the TSMIS to identify high-risk locations and other traffic problems in their regions. They will be the primary users of the analytical features of the TSMIS, directly exploring the TSMIS database and using the GIS to investigate problems indicated in the periodic reports. They will prepare the materials to support the annual strategic planning meeting organized by PRP, including the performance measures.

With direct access to the TSMIS, FLH project development teams will conduct project safety studies using outputs on the historical crashes at project locations, and perform the research to determine candidate treatments for problems identified, using combinations of road improvements, education and enforcement as appropriate. They will evaluate the performance of the road improvement project and conduct before/after studies.

FLH divisions will be responsible for implementing the selected projects. They will procure contractor services and monitor the project implementation.

In addition, the NPS regions will solicit input from park personnel and local entities on their safety issues. Parks can provide first-hand knowledge to the regions on crash causes and appropriate solutions that will be especially helpful when regions are conducting safety studies for high-risk locations.

The data collection function resides at the park level with the park rangers and park police who respond to crashes and complete crash reports, and with the staff who input the data into the data collection system. Transportation safety data, their analysis and reporting form the foundation of the TSMS. The reliability, timeliness, and accuracy of safety data are absolutely critical to effective safety management.

Parks also need to focus on their park's traffic characteristics and safety needs. They may find it helpful to get together with parks from their peer groups or in their vicinity (e.g., the National Capital Parks) to share common experiences and lessons learned. Access to TSMIS will enable park personnel to display crash locations, obtain crash summary reports, and identify candidate locations for road improvement to pass on to the FLHP coordinator. The "instant" access to their crash data will give them an overall perspective on the traffic safety situation in their parks that heretofore was not available. They will become aware of potential problems in their own parks and will be able to address them with the means available to them in a more timely fashion than in the past. These capabilities will serve as an incentive for parks to input crash reports to IMARS (or alternative data collection system prior to IMARS) on an ongoing basis throughout the year. With parks' buy-in to the data reporting process, PRP may be able to avoid imposing penalties on parks that fail to provide their crash data to the system.

The TSMIS will likely reside at the FOTSC, where a system administrator will manage the day-to-day operations of the TSMIS. His/her responsibilities will encompass activities such as computer equipment maintenance, troubleshooting, back-ups, archiving, software upgrades and modifications, running the user help desk, user permissions, etc. Monitoring park participation will be an important function, and the system administrator will forward periodic reports to PRP staff, for dealing with non-responsive parks.

The FOTSC will also be responsible for periodic report generation. Periodic reports will provide feedback to analysts and managers at PRP, regions and parks on safety performance on an ongoing basis, as well as provide the data needed to support the strategic planning process. Users at all levels will be able to choose from a variety of standard report formats that will provide basic crash summaries and performance measures, as well as devise and save custom report formats with information of special interest to them. Users may set up a schedule for the TSMIS to run these reports automatically and make them available to users either online or through email. Large reports requiring access to the entire TSMIS database and/or historic snapshots of the database will be run by the FOTSC offline during low usage hours.

Table 3. Summary of Roles and Responsibilities of TSMS Participants

Participant	Role in TSMS
NPS Park Roads and Parkways	Overall responsibility for TSMS Convene Annual Strategic Planning Meeting Annual safety report (likely through contractor) Monitoring park crash reporting
NPS Regional FLHP Coordinator	Safety analyses: • Identifying high-risk locations and safety problem areas • Tracking performance measures • Conducting before/after studies • Evaluating effectiveness of completed projects and programs Prioritizing safety projects and programs in region Participating on Roads Project Development Teams Oversight of RSARs
FLH Division Planner	Prioritizing roads projects in FLH division Oversight of roads projects implementation
Project Development Team: • FLH Project Manager • FLH Design Engineer • NPS FLHP Coordinator • Others as needed	Reviewing crash history for roads project segment Scoping roads project Developing PS&E package Monitoring project implementation Evaluating project effectiveness

TSMIS Administrator	Computer system maintenance Help desk for park, NPS staff and FLH users Set user permissions Database backups Downloads of external databases used by TSMIS Periodic report generation
Park	Review and approve crash records Use analysis features of TSMIS to: • Display crash locations in their park • Generate summary reports • Identify trouble spots and patterns
Crash Responder: • Park Ranger • Park Law Enforcement • Local Responder	Record crash data including lat/long Input data into TSMIS

5.3 The Annual TSMS Cycle

This section demonstrates the sequence of activities that would occur throughout the yearly planning cycle and the participants in each activity.

5.3.1 Annual Strategic Planning Meeting

The key event in each year's schedule is the annual strategic planning meeting, to be held several months into the fiscal year to allow time for preparations. The annual strategic planning meeting will be attended by most of the people who are involved with the TSMS throughout the year: the PRP director and staff, FLHP coordinators from all regions, FHWA safety discipline leaders, FLH division safety engineers and analysts, the TSMIS system administrator from the FOTSC, and several representative park superintendents.

The main agenda items are:

- Agenda Item 1: How did we do last year?
- Agenda Item 2: Does the strategic plan need modification?
- Agenda Item 3: What are the candidate projects and their justifications?
- Agenda Item 4: Which projects should we implement in the coming year?

NPS may determine that it is more effective to discuss the broader issues of Agenda Items 1 and 2 among all the participants and break up into regional groups for Agenda Items 3 and 4, or they may want to limit the focus of the national annual meeting to broader issues and relegate the other agenda items to regional annual meetings. Regardless of how the meetings are held, the expected accomplishments remain the same.

5.3.2 Preparation of Annual Reports

The NPS should prepare an annual report for both internal and external consumption. It should document the previous year's activities within the framework of the strategic plan. It should list the goals and strategies and the projects/programs that were accomplished during the year under each goal along with their effects on traffic safety. Performance measures should be presented in graphical form so that progress toward goals may be easily tracked. In addition, it should provide the reader with an overall picture of road safety in the NPS. It should highlight projects planned for the coming year and how they support the plan's goals and strategies. Finally, it should identify projects that have been identified as critical but must be postponed until a later time due to a budget shortfall.

A subgroup of the annual meeting attendees should design the initial report. Likely participants would include a headquarters representative, a FLHP coordinator, a FLH planner and the TSMIS system administrator. Once they developed a report design, the actual preparation could be handed off to a contractor.

5.3.3 Ongoing Activities

Ongoing activities involve all the participants in the TSMS throughout the year:

- Data collection is a function of the park rangers, park police and others who respond to or complete crash reports. They input the data into the TSMIS via portable computers in the field when available, or park staff enter crash data at office workstations. Data may also be transmitted to parks or to the TSMIS directly by local or state law enforcement agencies, depending on the particular arrangements that parks have with these agencies for crash response on shared roads.
- Management of the TSMIS is the responsibility of the system administrator at the FOTSC. He/she may also be responsible for designing and running ad hoc reports and/or large reports requested by users, as well as monitoring the generation and distribution of periodic reports.
- Regional FLHP coordinators and parks will review the periodic reports to track progress in performance measures, examine the circumstances of crashes occurring in their areas of interest, become aware of any new safety issues that are emerging, determine if parks are reporting, etc.
- FLH project development teams will conduct before/after studies on completed projects, and will conduct safety studies on high-risk locations identified in the periodic reports. They will also conduct ad hoc exploratory analyses as needed.
- FLH project development teams and contractors will implement the projects selected at the annual meeting.
- Parks will engage local and state partners in obtaining their positions on park traffic safety as it affects them, and enlisting their help where possible.

5.3.4 Preparation for the Annual Meeting

The conclusion of the reporting year, fiscal or calendar, should trigger a series of activities in preparation for the annual strategic planning meeting.

- Reports containing the performance measures for the year should be distributed to all parties. Parks would receive performance measure reports for their parks, regions for their regions, and PRP and other analysts who focus on crashes servicewide would receive performance measure reports based on all crashes.
- FLHP coordinators and FLH planners and design engineers in NPS regions would receive (or produce themselves) reports that identified high-risk locations. One (or more) of the methods discussed in Section 4.4.2 (statistical outlier, indexes, or performance models) would highlight the high-risk locations. These reports would conform to the funding allocation scheme decided on. For example, if NPS continues to use a regional allocation formula, and then CBA within the regions, the high-risk location reports would be organized by region. If NPS allocated funding by park peer group, then the reports would be organized by peer group. In any case, analysts would need to study the high-risk locations, determine candidate projects to address the safety problems, and estimate their costs and effectiveness.
- The analysts are also responsible for identifying emerging safety problem areas and devising programs to address them, using TSMIS outputs and through exploratory safety analysis using GIS and TSMIS analysis features.

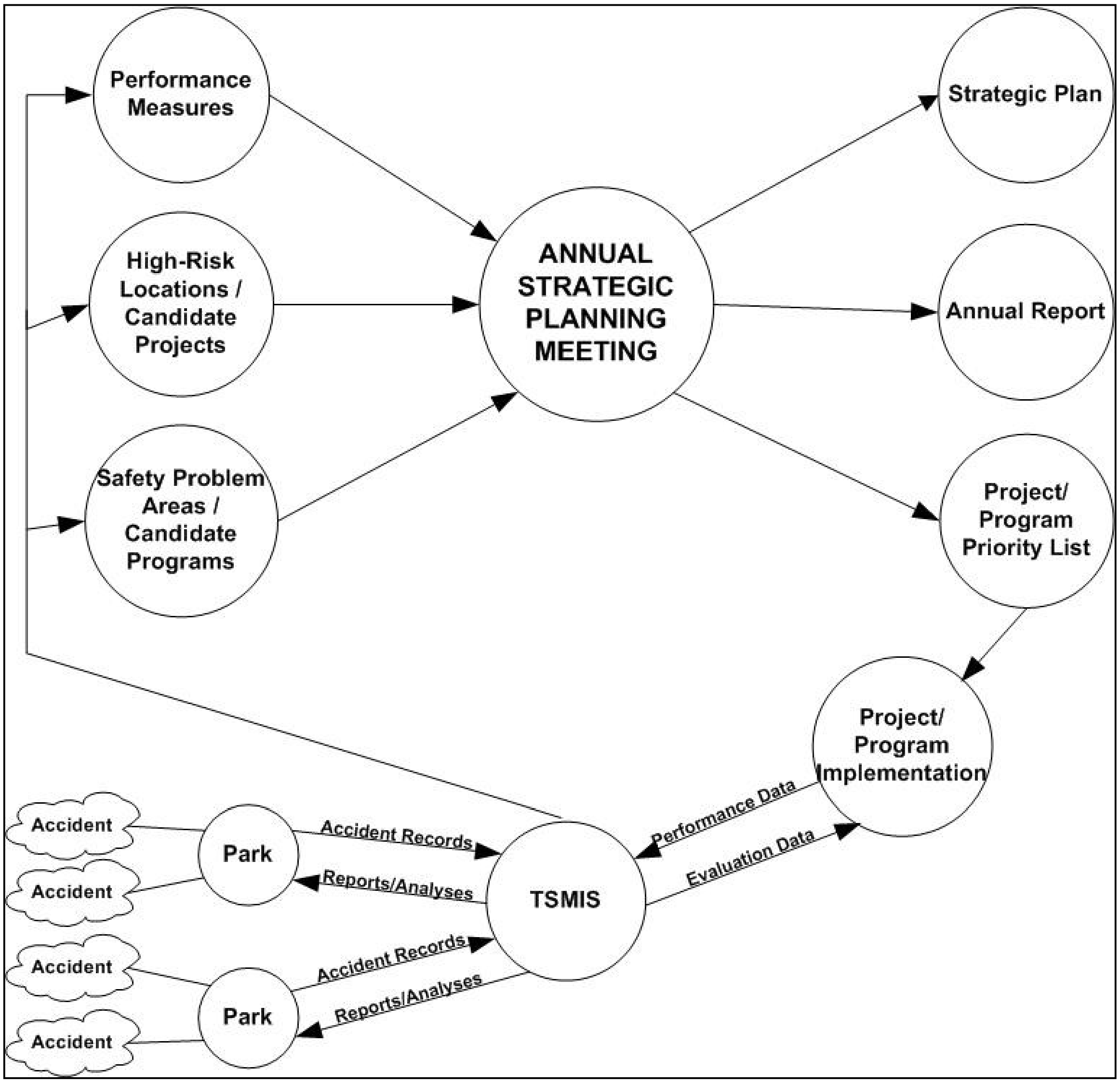

Figure 8. The Annual TSMS Cycle

6 Benefits of the TSMS

While the numerous benefits of the TSMS have been alluded to throughout this report, this section brings them together. Many of the benefits are qualitative in nature, that is, it is not possible to express them in quantitative or monetary terms, though they have intangible value. Safety benefits, on the other hand, are expressed quantitatively in terms of the crashes, injuries and fatalities prevented, and typically monetary values are assigned to them. Although estimating the safety benefits of the TSMS presents a challenge due to the lack of complete crash data for the national parks, this section makes an attempt at least to provide an order of magnitude for the safety benefits under a number of assumptions.

6.1 Intangible Benefits

- *Increased Consideration of Safety in NPS Planning:* The existence of the TSMS will propel safety considerations into a position on a par with other factors that are significant in the national park planning process, such as preservation of resources, compliant with the NPS mission and goals discussed in Section 2 of this report. All NPS policies, initiatives, facilities, and projects must be in keeping with the assurance of a safe environment for park visitors.
- *Incentive for Parks to Submit Crash Records:* The TSMS provides incentives for parks to submit their crash records to the NPS crash database. The TSMS requires that PRP and/or FLHP coordinators make a concerted effort to encourage parks to submit records, and as a last resort impose consequences for failure to do so. It provides them with the means to track a park's history of crash record submission.

  In return for submitting their crash records, the TSMIS offers parks immediate direct access to their crash data, and its report and analysis options, including the GIS mapping capability. The TSMIS with its easy-to-learn and -use Web-based features encourages parks to examine and analyze their own safety data, facilitating local solutions to local problems, faster recognition of crash patterns and trends within the parks, and faster development of appropriate interim solutions while waiting for larger roads project to be completed.
- *Development of Partnerships with Other Organizations:* Because the TSMIS will require parks to submit data according to the MMUCC and to provide additional information when motor carriers and public transportation vehicles are involved in crashes, NPS crash data will be compatible with those of other safety-related organizations, such as state DOTs, FHWA, NHTSA, FMCSA, and FTA. The sharing of crash information with these organizations will facilitate the development of mutually beneficial partnerships. NPS will benefit from access to their databases for analysis purposes, for example, to compare NPS trends with state or national trends. Safety agencies will gain more data to support their research, and in turn will share their research results with NPS. Secondary

benefits from these partnerships may accrue when planning and implementing other types of projects requiring the cooperation of both parties.

- *Improved Safety Information and Analysis Capabilities:* Safety decision makers will enjoy direct access to current crash data without having to go through a third party (FOTSC). The TSMIS provides the full range of reporting and analysis tools that safety analysts need to perform their work effectively. The TSMIS will move them towards the goal of preventing crashes rather than just reacting to them.

6.2 Tangible Benefits: Reduced Crash Risk on NPS Roads

The current method of identifying safety problems on NPS roads is often anecdotal, rather than data-driven. With more complete, reliable, and timely information from the TSMIS, the NPS' ability to identify specific problems and locations will improve, and the likelihood that NPS roads projects are in fact addressing the most pressing high-risk problems will increase. The TSMS will insure that the high-risk problems are addressed as soon as possible.

A recent example of a railroad's failure to report a grade crossing crash to FRA and state officials illustrates how critical timely crash data collection and analysis can be. In 1993 at a grade crossing in Decherd, Tennessee, two teenage boys were killed when their car was hit by a CSX locomotive. Subsequently, the CSX Corporation failed to report the fatal grade crossing crash to the FRA and state officials. Because this crash was not reported, the grade crossing was never identified as especially perilous, which would have resulted in the state ordering CSX to install automatic gates at the crossing. Four years later, after a second fatal crash at this same crossing,[22] an investigation uncovered the reporting omission as well as safety appurtenances over ten years beyond their service life. These findings have led to a civil suit brought against CSX by the victim's family. Furthermore this is not an isolated incident as other reporting irregularities have lead to multiple civil suits (one resulting in $30 million in total damages), FRA fines, and even federal court sanctions against CSX, Union Pacific, and other railroads in the US.

For the purposes of developing a quantitative estimate of the potential safety benefits to the public of the TSMS, this analysis has developed a benefits estimation model. Because much of the data required by the model is not readily available from current NPS sources, a number of assumptions have been made, as well as placeholder data inserted until such time as the real data become available.

- The overall assumption is that the TSMS would improve NPS' ability to identify high-risk locations by 10 percent, a fairly conservative estimate. In other words, using the TSMS, NPS would be able to identify and implement roads projects at 10 percent of the high-risk locations that its current system of problem identification would have overlooked.

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[22] Bogdanich, Walt, *New York Times* Special Report "A Crossing Crash Unreported and a Family Broken by Grief," July 12, 2004.

- The analysis assumes the types of safety improvement projects implemented by NPS during a one-year period, and the number of each type of project servicewide, as this information was not readily available from NPS. The actual NPS data needed for the model do exist, but it would take some effort to cull them from records and provide them in the appropriate form.[23] Safety improvement projects include 3R and 4R roads projects as well as other measures, such as installing guardrails, lowering the speed limit, improving lighting, and building bike lanes, among others.
- The numbers of crashes occurring at each project location for the analysis period prior to project implementation have been inserted into the model as placeholders to demonstrate how the model would work. These numbers would be available from the STARS database now (or from the TSMIS in the future) for parks that had reported their crash data, if information on the specific locations of projects were available.
- The reduction in crashes due to a safety improvement is based on factors taken from *The Handbook of Road Safety Measures*[24] for individual safety measures.
- The model assumes the following probabilities and costs, based roughly on the HERS model:[25]
    - $62,500 per injury; 0.6 probability of an injury per crash
    - $3 million per fatality; 0.015 probability of a fatality per crash
    - $6,000 property damage costs per crash

Although the model needs refinement, detailed information on NPS roads projects during a one-year period, and accurate historical crash data on project roads, it provides a rough order of magnitude of the safety benefits to the public that the TSMS would produce annually, as shown in Table 4. According to the assumptions above, the model estimates a possible benefit to the public of approximately $650,000. Compared to the ongoing annual TSMS operating cost (see Section 8), this represents approximately $560,000 in net benefits. The model is sensitive to the number of fatalities prevented; if the TSMS-identified projects prevent only one fatality, currently valued at $3 million by the USDOT, the system is well worth the cost.

[23] For example, NPS plans to spend about $113 million per year on average from 2005 to 2009 in the Central Federal Lands region in 3R, 4R and bridge projects. Some of these projects would likely include signage, guardrails, bike lanes, etc., but NPS does not typically break these elements out separately from the overall projects.
[24] Elvik, Rune and Truls Vaa, *The Handbook of Road Safety Measures*, Amsterdam, Elsevier Ltd., 2004.
[25] HERS-ST Technical Report v3.54

Table 4. Example of Estimated Annual Benefits of TSMS[26]

Safety Measure	Total Number Projects per Year	# Projects Identified thru TSMS (10% of All Projects)	Expected # Injury & Property Damage Crashes per Project before Improvement	Expected Reduction % in Crashes after Improvement				Benefits Estimate
				Injury	Property Damage Only	All Crashes	Fatal Crashes	Total
Bike Lanes	50	5	2	5	0			$21,064
4R Projects	40	4	3	20	5			$104,706
Guardrails	25	2.5	2	47	7		44	$200,100
Roadside Safety Treatment	15	1.5	2	33	28			$46,746
Road Widening	10	1	1	7	11			$3,609
Curve Straightening	5	0.5	3			33		$9,900
Junction Redesign	5	0.5	2	17	0			$7,162
Interchanges	5	0.5	1			20		$6,000
Lighting	15	1.5	2	25	25		50	$103,596
Stop Signs (2-way)	15	1.5	2	35	0			$44,234
Traffic Signals	8	0.8	2	30	35			$23,581
Variable Message Signs (crashes, fog, congestion)	10	1	3			44		$26,400
Rail Grade Crossings	2	0.2	1			45		$1,800
Road Markings (edge, center)	30	3	2			24		$28,800
Signalized Pedestrian Crossings	4	0.4	2	12	0			$4,044
Speed Limits	8	0.8	2	14	5	15		$14,717
Other	15	1.5	2			0		$0
Total								$646,458

[26] Appendix E shows the worksheet from which this table was derived.

7 Implementation Analysis

This section delineates the steps involved in implementing the TSMS over an 18-month period, including a 15-month period for initial TSMIS development and rollout to all parks. After that point, the development approach allows for increasing functionality of the TSMIS in the form of new releases over time. Because of the uncertainty of target dates for developing such a complex system as IMARS, this implementation analysis allows for the development of one of the two data collection alternatives described in Section 4.1 that can be phased out when IMARS becomes operational. NPS needs to make a decision on which data collection alternative to proceed with before commencing the design and development of the TSMIS.

The first step is the design, development and implementation of a TSMIS prototype. This will be beta-tested on several representative parks, a FLHP coordinator and FLHP safety analyst. Ideally, all participants in the beta-test will be from the same NPS region, so that the relationships, coordination, and data sharing among them will represent their realistic ways of doing business. The group of participating parks shall include at least two parks with large land areas and high miles of roads, as these parks will not only be heavier users of the TSMIS, but also generate more crashes during the year, as well as a range of other types of parks, such as a parkway, a park used by commuters as a cut through, and one each of small- and medium-size parks in terms of area and crashes.

Upon completion of testing, the TSMIS will be rolled out to all parks, NPS and FLHP regions, at which point other elements of the TSMS would be initiated. As required, expansion of the TSMIS functionality and integration with other available NPS data systems will occur through periodic TSMIS releases. The data collection function will transition to IMARS when the new system becomes operational. Subsequent improvements will occur as circumstances warrant and resources become available. As more rangers acquire remote access to the Internet or mobile data terminals, the TSMIS may expand its data entry options. As users became more familiar with the crash data and desired new analysis methods, the TSMIS may be expanded to accommodate them.

This implementation analysis assumes NPS will want to bring historical crash data for the 30 parks with the greatest number of crashes into TSMIS. For data already in the CIRS/STARS system, TSMIS will require the conversion of the link/node crash location into latitude and longitude coordinates.[27] Paper crash reports that were never entered into CIRS/STARS will have to be manually entered into TSMIS and their lat/long coordinates determined. Mapping software will be needed for non-CIRS electronic crash records.

Figure 9 summarizes the steps from initiating the TSMIS prototype development to full TSMS operation.

[27] Refer to Volpe Center Technical Memorandum on GIS Conversion of STARS Incident Data from Gary T. Ritter of the Volpe Center to Mark Hartsoe, Park Roads and Parkways Program, NPS, April 2, 2004.

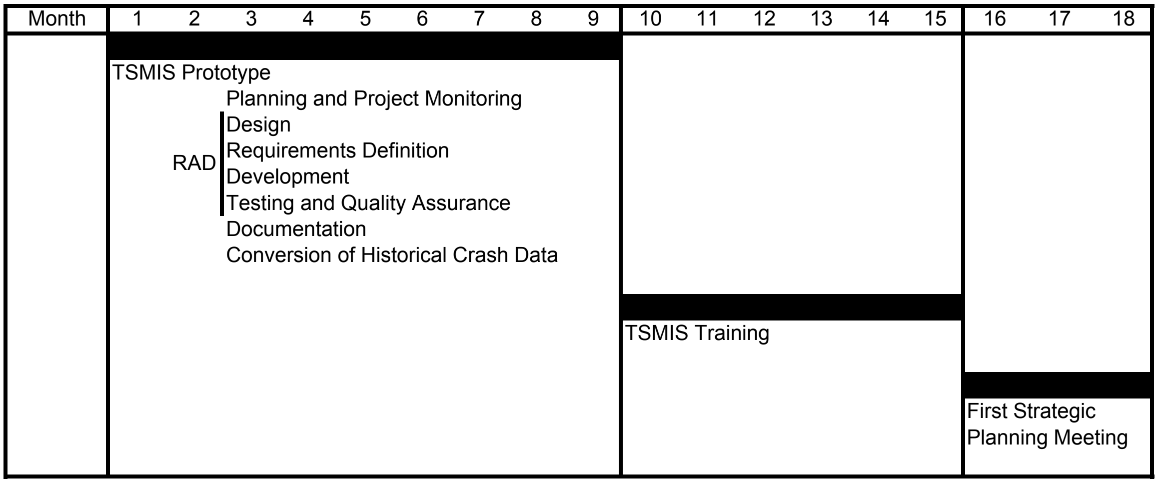

Figure 9. Timeline for TSMS Implementation

7.1 TSMIS Prototype Development and Beta-testing

The first step in implementing the TSMS is the development of a TSMIS prototype that would embody the data collection, reporting and analysis functions. To minimize the development time, it would be developed over a nine-month period using the RAD method discussed in Section 4.1.1, where end users and developers work interactively to design and develop a working prototype. It would be tested on a willing FLHP coordinator and FLHP safety analyst and a group of volunteer parks from one FHWA region, representing the range of park types from small rural parks with few roads to large parks with many roads to parkways. Feedback from these testers would be incorporated into the prototype.

The TSMIS prototype would include the following functions and attributes:

- Beta-test limited to three to six parks and one FLHP coordinator from the same NPS region, and one safety analyst from the corresponding FLH division.
- Data collection would either be an adaptation of the current data collection system or a custom Web-based data collection component, as described in Section 4.1.
    - Adaptation of current system would use CIRS or other crash database system used by the parks, based on Form 10-413 with the addition of lat/long crash location.
    - Web-based component would
        - allow data entry to be performed on any PC with Internet access
        - feature drop-down menus with codes for data entry ease, and internal consistency editing checks for data entry accuracy
        - use the MMUCC
        - provide the ability to indicate crash location on a GIS park map display to obtain lat/long coordinates

        - have the ability to upload photographs and crash diagrams as picture objects, as well as crash diagramming software
        - require basic crash record approval
        - online crash diagramming software
- Web-based reporting and analysis application with:
    - Full user permission and security provisions
    - Full crash record approval
    - Interface with RIP, BIP, traffic, FMSS and congestion management databases, to the extent they are available
    - The ability to generate individual crash reports, basic canned crash summary reports, such as crashes by park, location within park, time of crash, type of crash, etc., and customized reports using parameters
    - Expanded GIS analysis capabilities including the ability to view crashes on park GIS road map display, obtain road segment characteristics, identification of high-risk locations, addition of aerial image layers where available, display of selected sets of crashes
    - Ability to specify criteria for selecting groups of crash records (filtering)
    - Full graphical and statistical analysis capabilities
    - User documentation
    - Page and field specific online help
    - On-line training module
    - Ability to download selected crashes to export to offline databases
- Conversion of historical data for top 30 parks

The TSMIS development tasks are the standard tasks associated with developing any software system:

Task 1. Planning and Project Monitoring

First, this task involves the up-front planning required to kick off the project such as team selection, project plan development, purchases, and other such responsibilities.

Second, the status of the project needs to be monitored by the project manager. Typical responsibilities include:

- meeting frequently with the team to monitor their progress,
- tracking and resolving any issues (technical or otherwise), and
- ensuring team efforts are properly coordinated.

The duties of this task could be divided between two people, one responsible for the administrative duties concerning budget and schedule, and the other for technical monitoring. This task runs through the duration of project development.

Task 2. Design

The goal of this task is twofold, to identify the appropriate system architecture for the TSMIS and to begin determining the development methodology that will be used. (A separate project outside the scope of this effort will be to evaluate the overall architecture of the various traffic safety systems currently being developed by the NPS.) Certainly, these two efforts will be complementary; however, the design task of the prototype is also focused on identifying the coding standards and object structures to be used in developing the TSMIS.

The first part of this task will focus on identifying, purchasing, and installing the following elements of the prototype:

- hardware requirements,
- networking requirements,
- database requirements and application,
- development platform, and
- development environment tools.

The second part of this task involves developing, documenting, and communicating the software development methodology that will be used for building the TSMIS.

Task 3. Requirements Definition

High-level user requirements will be defined prior to commencement of development, more detailed requirements will be defined in parallel with the development effort. Close communications and interactions between the requirements team and the development team are required to ensure all the functionality is documented and developed.

Task 4. Development

The three major components of the development effort are the user interface, the database, and the GIS integration. Developers in this area will work in close coordination with each other as well as the requirements team. This task is the most intensive, beginning once the initial requirements are specified, and running through the quality assurance period.

Task 5. Testing and Quality Assurance

In this task the TSMIS undergoes detailed requirements testing to uncover any hidden bugs and assure that the system performs according to user requirements. Under the RAD process, this task may be undertaken simultaneously with Tasks 2 through 4, with the assistance of the representative parks, FLHP coordinator and FLH safety analysts. The development team will address any problems discovered during this period.

Task 6. Documentation

This task covers both system documentation as well as user documentation. System documentation will conform to accepted software standards. The user manual will be a handy reference for the park users. In addition to the manual, this task also will develop the materials for user training sessions, and an online training module.

Task 7. Implementation (covered in more detail in Section 7.2)

The developer will conduct training sessions for the participating users in group settings to the extent possible, and provide a help desk for responding to user questions and problems. Any deficiencies in the software uncovered during this period will be addressed by the development team and implemented on the TSMIS server. Users will be informed of any relevant changes when they log onto the TSMIS home page or by email, as appropriate.

7.2 Rollout of TSMIS Prototype to All Parks and Regions

This step takes the tested TSMIS prototype to the remaining parks and regions for real-time use for data collection, reporting and analysis, assuming that RIP and BIP can provide the GIS with the road networks for the parks. It will be approximately nine months in duration.

To begin with, the system developers will conduct training sessions in various locations around the country to minimize travel time and expense for park and regional personnel. Parks will send representatives to be trained from the group of people who will be responsible for collecting (rangers, park police) and inputting (office staff) crash data as well as using the reporting, GIS and other analysis tools (administrators, safety analysts). Part of the training will be to familiarize participants with the online training modules, to minimize demand for a help desk. All FLHP coordinators and FLH safety engineers and analysts, as well as interested PRP representatives will also be trained. A one-day training session will be sufficient for park personnel, while a two-day session will be required for FLHP coordinators and safety analysts intending extensive use of the reporting, GIS and analysis tools. It is expected that this activity will take place over a six-month period.

Upon completion of the training sessions, NPS will set a date for the parks to transfer to the new interim data collection method. From that point on, the TSMIS database will be the repository for NPS crash data.

Rollout will trigger a kick-off TSMS annual planning meeting. This will serve the purpose of making initial decisions on various aspects of the TSMS and how it will work, as well as communicate to all attendees the importance of the TSMS and emphasize the role it will be playing in the PRPP from that point on. The implementation schedule allows about three months for planning this meeting and putting the decisions into action.

The TSMS kick-off will produce the following accomplishments:

- Initial goals, strategies and performance measures to be tracked throughout the year, and reviewed and assessed at the next annual meeting
- List of ongoing reports, their contents, method of distribution, and distribution list, that will be produced on a regular basis throughout the year and at the end of the year for the next annual meeting
- Decision on the preferred method of identifying high-risk locations (statistical outliers, indexes, performance models) and assignment of parks to park peer groups
- Decision on how to allocate funds to regions or park groups or other basis, and weights for CBA factors giving safety increased influence

7.3 Full Operation of TSMS

At this point, the TSMS is in full swing, with users inputting crash data into the TSMIS, receiving standard reports, generating reports, viewing crashes on the GIS displays, and conducting analyses as needed. They are tracking performance measures, conducting safety studies on locations identified as high-risk, developing potential treatments to address safety issues identified, and performing road improvements. Annual planning meetings take place producing the list of projects to be implemented over the year and the performance measures to be tracked. An annual report is written and distributed to the appropriate parties.

Improvements to the TSMIS will be implemented in periodic releases, likely quarterly in the first year of operation, and semi-annually or as needed in later years. The releases will include additional capabilities and features users have identified as desirable for the TSMIS, as well as upgrades to analysis models as the supporting research is completed, and links to new NPS databases as they come online.

The Web-based delivery will permit efficient implementation of releases, because modifications are made only once on the server and are available to all system users. Notification of changes, additional features, upgrades and other information is easily accomplished on user login. Rather than training sessions, users will be informed of the training tools available to them via the Web at logon. They will be able to use online help modules to learn how to use the new features, but will have the support of the help desk when needed. However, NPS may find it necessary to conduct refresher training for some users every few years, or hold periodic training sessions for new hires or data entry replacements. The system administrator may be able to handle refresher training without additional cost.

7.4 Transition of Crash Data Collection Function to IMARS

When the DOI implements IMARS, it will assume the crash data collection function. At this time NPS does not know the exact form the IMARS data collection module will take, but since NPS has actively participated in the requirements definition for IMARS, it is likely that IMARS will conform to most of the same specifications for the TSMIS Web-based crash data collection module. It should collect the same data fields, as well as offer crash diagramming software and the ability to scan in photos and diagrams. Once the transition takes place, NPS personnel wishing to enter crash data into the crash database will access the IMARS Website.

The degree of effort required for crash data reporters to transition to IMARS will depend on the interim data collection alternative chosen by NPS for the TSMIS. If NPS chooses to go with the alternative that calls for development of a custom data entry module, IMARS and the TSMIS custom module will have enough similarities and features that the transition will be relatively painless for crash data reporters. If NPS chooses the alternative that calls for continuing with whatever data collection system the parks are currently using with the addition of lat/long, then the transition will require all reporters to learn the entirely new, albeit more user friendly, Web-based data entry system of IMARS. In either case, it is likely that DOI will mandate some form of user training in IMARS to make the transition as smooth as possible.

Although IMARS will take over the crash data collection function, the TSMIS Website will continue to provide the reporting and analysis features. It is the desire of NPS that users be able to use the TSMIS reporting and analysis modules with as few changes as possible. To accomplish this, about six months before IMARS is ready to be rolled out, the TSMIS system developers must begin developing the software that will interface with IMARS and access crash data, map the IMARS data into the TSMIS crash database, and make it a seamless experience for TSMIS users. By extracting data from the IMARS database into the TSMIS database, little or no modification to the TSMIS reporting and analysis modules will be required, and users will continue to be able to access the historical TSMIS data collected prior to IMARS. As with other upgrades and changes to the TSMIS, TSMIS users will be apprised of the status of IMARS and data collection changes via the Web upon logon.

8 Costs to Implement and Operate the TSMS

This section presents the costs to implement and operate the TSMS. It discusses three alternative approaches NPS could pursue in developing the TSMIS, in addition to the costs associated with other aspects of the TSMS. The three TSMIS alternatives include: (1) Web-based reporting and analysis application with Web-based data collection module; (2) Web-based reporting and analysis application with adaptation of current data collection method; and (3) desktop application. The first two alternatives were discussed earlier in this report; the third alternative is presented for comparative purposes to highlight the relatively low cost of a desktop system versus a Web-based system, and the relative advantages and disadvantages of each. Adapting existing state incident reporting systems, such as TraCS or TSIMS (see Appendix E), has not been considered for NPS, as these systems are not Web-based.

Costs are presented in 2005 dollars. They are the total costs of implementing and operating the TSMS on an ongoing basis. The incremental cost to NPS may be less, as current resources devoted to the crash data input, maintenance and operation of CIRS and STARS, and crash and safety analyses could be reallocated to the TSMS, thereby reducing the additional funding level needed by NPS.

Costs are based on the assumption that GIS road networks for parks will be provided by the RIP/BIP programs at no cost to the TSMIS.

8.1 TSMIS Alternatives

8.1.2 Alternative 1: Web-based Reporting and Analysis Application with Web-based Data Collection Module

Description

This alternative embodies the TSMIS concept as portrayed in Section 3. The TSMIS concept is a system that users would access through a Web-based client designed to collect traffic crash reports and supporting photographs and crash diagrams, store them in a database, produce standardized and ad hoc reports, and provide tools including GIS, trend analysis and other statistical methods, for traffic safety analysis.

This alternative, as well as the other two, assumes NPS would want to bring historical crash data for the 30 parks with the greatest number of crashes into TSMIS. For data already in the CIRS/STARS system, TSMIS would require the conversion of the link/node crash location into latitude and longitude coordinates. Paper crash reports that were never entered into CIRS/STARS would have to be manually entered into TSMIS and their lat/long coordinates determined. Mapping software would be needed for non-CIRS electronic crash records.

Advantages

There are a number of benefits to developing a web-based application:

- A user-friendly Web-based TSMIS would provide parks with an incentive to reverse their declining crash-reporting trend.[28] In return for entering their crash records into the TSMIS, parks could obtain immediate gratification in the form of summary crash reports and maps showing crash locations.
- Further, introducing parks to Web-based data entry through TSMIS would serve as a test of the concept for IMARS, and would facilitate the later implementation of IMARS.
- The Web-based application avoids hardware, software and installation problems often encountered with systems and clients that have to be installed on users' own desktop computers. A user needs only Internet access and a Web browser (Netscape, Internet Explorer) to be able to take full advantage of the TSMIS. System modifications, upgrades, and modifications are made only once on the server, and are available to all users of the system. Notification of changes, additional features, upgrades and other information is easily accomplished upon user login.
- The number of users of a Web-based system can easily be expanded without additional cost.
- A Web-based system would facilitate sharing of data with the public, other agencies, etc.
- A Web-based system could also allow for non-NPS jurisdictions that respond to crashes within national parks to access the system, and submit crash reports.

Drawbacks

This alternative would be the most expensive of the three to develop, maintain and administer, although it ultimately would serve more users than the other two alternatives. Additionally, it would require a park to learn a new method of data entry that would change, though not substantively, once IMARS was implemented. As with the other options, it would not eliminate the need for NPS to develop software to map fields from non-CIRS electronic data collection systems to the TSMIS crash record format, because historical data not previously submitted to TSMIS will need to be included for non-CIRS parks, and non-CIRS parks may object to changing their current data input systems.

[28] This incentive does not eliminate the need under any TSMIS alternative for NPS upper management to make accident reporting a high priority for parks and to enforce the reporting requirements.

Costs

TSMIS Development

Task	Cost
Project Planning	$107,000
Architecture Design	$36,200
Technical Requirements	$66,000
Development	$221,600
Quality Assurance	$62,600
Documentation	$33,000
Total	**$526,400**

TSMIS Hardware

Item	Cost
Web Server	$12,400
Database Server	$12,400
Development Server	$6,200
Total Costs	**$31,000**

TSMIS Software

Item	Cost
Database License	$20,600
GIS License	$10,300
Development Software	
Integrated Development Environment	4 @ $1,030 / license
Database Tools	6 @ $515 / license
Version Control	8 @ $1,030 / license
Total Costs	**$46,350**

Historical Data Acquisition[29]

Item	Cost
STARS Data Conversion (30 parks @ 27 hrs)	$49,700
Integration Software (3 different systems)	$24,700
Total	**$74,400**

[29] This cost covers software to map data elements into the STARS database from various accident database systems (assuming three different systems) parks are now using that are incompatible with CIRS/STARS, and then determining the lat/long location for the historical accident data in STARS for 30 parks.

Rollout Training

Item	Unit Cost	Total Cost
Transportation Costs -- one-day trip		
Parks with one representative	125 @ $100	$12,500
Parks with two representatives	25 @ $200	$5,000
Transportation Costs -- two-day trip		
Safety analysts	25 @ $1,000	$25,000
Trainer time and transportation		
One-day sessions	10 @ $2,000	$20,000
Two-day sessions	2 @ $4,000	$8,000
Total		**$70,500**

Note: Training is assumed to be included under the trainees' expected duties and labor costs are not attributed to the TSMIS. Only the cost of transportation is included in this section for NPS personnel.

Alternative 1 Total Development Cost: $748,650

Ongoing Maintenance and Administration

Item	Year 1	Future Years
System Administrator (1/3 labor year)	$63,900	$63,900
Back-up Crash Database		
System Maintenance/Web Server Exception Management		
Archiving Reports		
Overall Monitoring & Problem Identification & Resolution		
Help Desk	$63,900	$25,750
Total	**$127,800**	**$89,650**

New Releases

Item	Minor	Major
Project Planning	$21,400	$35,700
Technical Requirements	$13,200	$22,000
Development	$44,320	$73,900
Quality Assurance	$12,550	$20,900
Documentation	$6,600	$11,000
Total	**$98,070**	**$163,500**

Note: New releases would occur as needed. A release containing relatively minor additions or changes to the existing system might cost one-fifth the cost of developing the original system, while a major release might cost one-third the original development cost.

Transition to IMARS

Item	Cost
System Developer (1/2 labor year)	$96,000
Total	**$96,000**

8.1.3 Alternative 2: Web-based Reporting and Analysis Application with Adaptation of Current Data Collection Method

Description

The main difference between Alternatives 1 and 2 is that Alternative 2 would not include the development of a Web-based data collection module. Parks would continue to use their current crash reporting methods (CIRS, other electronic format, or hard copy), and in addition would report crash locations either in lat/long coordinates or by marking them on park maps. For electronically stored crash data, integration code would be developed that migrates crash data from its original format to the TSMIS format. Hard copy submissions would be entered by hand at a central location into CIRS. Crash diagrams and photographs would be scanned in and attached to the electronic crash record. This method of data entry would be used until IMARS was implemented. It would save approximately one third of the up-front development, quality assurance and implementation costs over Alternative 1, but would incur the additional cost of manual data entry for parks that submitted handwritten crash reports.

All other aspects of TSMIS would be identical to Alternative 1 and development would occur in two phases with the same timing.

Advantages

The main advantage of this option is that it would save the development of an interim Web-based data collection module that would become obsolete once IMARS was implemented. Additionally, parks would not have to learn a different, though user-friendly, data entry method, and could continue with their current procedures.

All the other advantages not related to the data collection component cited for Alternative 1 would also apply here, including user-friendliness, ease of installation and upgrades, and scalability.

Drawbacks

The main drawback of this alternative is that without the ability to enter data into TSMIS, parks would not have as much exposure to TSMIS. The additional exposure of entering data into TSMIS may prompt users to explore its other reporting and analysis features, such as the powerful GIS crash location displays, that are outside of their core workflows.

This additional access to the system would lead to an increase in the parks' awareness of their potential problem areas and potential traffic safety improvements. Without the need to access the TSMIS for data entry, parks would not be as likely to enjoy these benefits. In fact, unless NPS headquarters were able to provide other incentives to parks to submit their data, the current downward trend in crash reporting by parks would likely continue.

Substantial savings over Alternative 1 will not be realized with the elimination of the data collection module, because the remaining system must still support the underlying Web-based architecture.

Costs

Development

Task	Cost
Project Planning	$107,000
Architecture Design	$36,200
Technical Requirements	$66,000
Development	$150,000
Quality Assurance	$41,100
Documentation	$23,700
Total	**$423,900**

Hardware

Item	Cost
Web Server	$12,400
Database Server	$12,400
Development Server	$6,200
Total	**$31,000**

Software

Item	Cost
Database License	$20,600
GIS License	$10,300
Development Software	
Integrated Development Environment	4 @ $1,030 / license
Database Tools	6 @ $515 / license
Version Control	8 @ $1,030 / license
Total	**$46,350**

Data Acquisition

Item	Cost
STARS Data Conversion (30 parks @ 27 hrs)	$49,700
Integration Software (3 different systems)	$24,700
Total	**$74,400**

Training[30]

Item	Unit Cost	Total Cost
Transportation Costs -- one-day trip		
Parks with one representative	125 @ $100	$12,500
Parks with two representatives	25 @ $200	$5,000
Transportation Costs -- two-day trip		
Safety analysts	25 @ $1,000	$25,000
Trainer time and transportation		
One-day sessions	10 @ $2,000	$20,000
Two-day sessions	2 @ $4,000	$8,000
Total		**$70,500**

Alternative 2 Total Development Cost: $646,150

Ongoing Maintenance and Administration

Item	Year 1	Future Years
System Administrator (1/3 labor year)	$63,900	$63,900
Back-up Crash Database		
System Maintenance/Web Server Exception Management		
Archiving Reports		
Overall Monitoring and Problem Issue Identification and Resolution		
Help Desk	$63,900	$25,750
Total	**$127,800**	**$89,650**

Ongoing Data Acquisition

Item	Annual Cost
Semi-annual Batch Uploads for Non-CIRS Systems	$8,200
Manual Data Entry	$10,300
Total	**$18,500**

[30] Training costs are in addition to NPS and FLH labor costs.

New Releases

Item	Minor	Major
Project Planning	$21,400	$35,700
Technical Requirements	$13,200	$22,000
Development	$30,000	$50,000
Quality Assurance	$8,220	$13,700
Documentation	$4,750	$7,900
Total	**$77,570**	**$93,600**

Note: New releases would occur as needed. A release containing relatively minor additions or changes to the existing system might cost one-fifth the cost of developing the original system, while a major release might cost one-third the original development cost.

Transition to IMARS

Item	Cost
System Developer (1/2 labor year)	$96,000
Total	**$96,000**

8.1.3 Alternative 3: Desktop Application

Features

The TSMIS of Alternative 3 would be an application offering the same reporting, GIS and analysis features as the previous two alternatives, but would be installed on the user's own desktop computer instead of accessed via the Internet. Users would download crash data from a TSMIS website. Software updates would either be downloaded from the web site, or sent to users on a CD.

Data collection would occur as in Alternative 2, that is, parks would continue to use their current crash reporting methods augmented by lat/long coordinates or marked maps showing the crash locations.

Advantages

This alternative would cost significantly less to develop and maintain than the other two alternatives because it eliminates Web-based architecture.

Drawbacks

The Alternative 3 system is not scalable to a large user base if demand increases significantly. The reasons are:

- High cost per user to deploy -- $4,000+ per user in license and hardware

- Burdensome installation process requiring dedicated resources to assist users to resolve issues

The development costs per user are much higher than the other alternatives.

The system may also require more investigative support (i.e., bug fixes, help tickets, etc.) than the other alternatives because each user's computer can be configured differently affecting the execution of the application. However, with a Web-based client desktop, specific issues are not relevant because the client runs within the framework of an existing application (Web browser).

Costs

The cost of Alternative 3 is dependent on the number of TSMIS users that would have the system installed on their computers. The following costs have been calculated under the assumption there would be ten users.

Development

Task	Cost
Project Planning	$26,800
Application Design	$14,400
Technical Requirements	$26,800
Documentation	$21,400
Development	$109,000
Quality Assurance	$25,000
Implementation/Training	$16,000
Total	**$239,400**

Hardware

Item	Cost
GIS Development Workstation	$5,150
User Workstations for Each End User (10)	$20,600
Total	**$25,750**

Note: For each end user of the TSMIS, it is necessary to purchase a desktop machine powerful enough to run the application, at $2,060 per user.

Software

Item	Cost
GIS License	$20,600
GIS License per Deployment (10)	$20,600
Total	**$41,200**

Data Acquisition

Item	Cost
STARS Data Conversion (30 parks @ 27 hrs)	$49,700
Integration Software (3 different systems)	$24,700
Total	**$74,400**

Alternative 3 Total Development Cost: $380,750

Ongoing Maintenance

Item	Annual Cost
GIS License Maintenance	$10,300
Ongoing Support (Enhancements, Bug Fixes, Support, Help)	$51,500
Total	**$61,800**

Ongoing Data Acquisition

Item	Annual Cost
Semi-annual Batch Uploads for Non-CIRS Systems	$8,200
Manual Data Entry	$10,300
Total	**$18,500**

New Releases

Item	Minor	Major
Project Planning	$5,400	$8,950
Application Design	$2,900	$4,800
Technical Requirements	$5,400	$8,950
Development	$21,800	$36,350
Quality Assurance	$5,000	$8,350
Documentation	$4,300	$7,150
Implementation/Training	$3,200	$5,350
Total	**$48,000**	**$79,900**

Note: New releases would occur as needed. A release containing relatively minor additions or changes to the existing system might cost one-fifth the cost of developing the original system, while a major release might cost one-third the original development cost.

Transition to IMARS

Item	Cost
System Developer (1/2 labor year)	$96,000
Total	**$96,000**

8.1.4 Trade-offs

Table 5. Comparison of the Costs of TSMIS Alternatives

	Alternative 1	**Alternative 2**	**Alternative 3**
Analysis	Web-based	Web-based	Desktop
Data Collection	Web-based	Current system + lat/long	Current system + lat/long
Users	10 safety analysts and 150 parks	10 safety analysts and 50 parks[31]	10 safety analysts
Development & Implementation Cost	$749k	$646k	$381k
Development	$526k	$424k	$239
Hardware	$31k	$31k	$26k
Software	$46k	$46k	$41k
Data Acquisition	$74k	$74k	$74
Rollout Training	$71k	$71k	N/A
Annual Recurring Cost[32]	$128k, Year 1 $90k, Out-years	$147k, Year 1 $109k, Out-years	$80k
Maintenance	$128k, Year 1 $90k, Out-years	$128k, Year 1 $90k, Out-years	$62k
Data Acquisition	N/A	$19k	$19k
Development Cost per User	$4.7k	$10.8k	$31.8k
Scalability, Easy Updating	Yes	Yes	No, $4k+ per new user

8.2 Other TSMS Activities

The other activities of the TSMS include those associated with the strategic planning process:

- Annual strategic planning meeting
- Annual report
- Identification of safety problems and high risk locations
- Identification of candidate solutions

[31] Analysis assumes that with Alternative 2 there would be no new incentive for parks to report, so the number of parks reporting accident data would remain at the current level of around 50.
[32] New funding may not be required to cover all annual recurring costs, as funds now used to operate and maintain STARS may be redirected toward TSMIS operations and maintenance.

- Choosing projects
- Evaluating performance

This analysis assumes that participants would accomplish most of the analysis activities associated with the TSMS in the course of their normal duties, so no additional resources would be required for their analytical responsibilities. NPS headquarters and regions currently conduct a number of periodic meetings throughout the year, one of which could serve as the venue for the annual strategic planning activities. The annual report would be an additional expense, as NPS does not produce such a report at this time. It is estimated that such a report would cost approximately $75,000 the first year, and $50,000 thereafter for annual updates.

9 Next Steps

The uncertain timeline for IMARS[33] implementation and recognized shortcomings of current NPS servicewide safety data collection and reporting provide strong motivation for NPS to initiate action on TSMIS development. A delay in IMARS development, a possibility in view of the complications that often arise with such complex projects, could result in NPS reliance on the TSMIS for many years. Regardless of the IMARS timeline, since IMARS is mainly a data collection and database management system, the reporting and analysis features of the TSMIS will continue to be needed after IMARS is implemented (they could become a module of IMARS). Moving forward on the TSMIS will provide value as a beta-test for the IMARS concept, enabling NPS to hone its requirements for data collection, editing, management, reporting and analysis for IMARS. Its interim use before IMARS would stimulate the interest of individual parks in crash data and their analysis, and reverse the current decline in submitting data to the FOTSC.

In anticipation of a decision to adopt the TSMS as conceived in this report, NPS should take the following preparatory and requisite steps for TSMIS development:

- Further research into safety indexes and performance monitoring models to identify those most appropriate for inclusion in the TSMIS
- Standardizing the definitions for reportable crashes and reporting procedures among all parks
- On an individual park basis, determination of whether crashes on non-park-owned access, circumferential, or cut-through roads will be included in the park crash database
- Conversion of crash location to lat/long for historical crash data for the top 30 parks
- Formation of a group of parks, NPS and FLHP safety analysts for participation in the TSMIS beta-test
- Formation of park peer groups, that is, parks with similar characteristics regarding traffic volumes, road mileage, and road function, for comparing crash risk among members within each peer group
- Modification of park job descriptions to include safety awareness training, and crash data requirements for park rangers, park police and others involved in crash data collection and submission to TSMIS

Within an 18-month development and rollout period NPS could begin to experience the benefits of the TSMIS in full operation in support of safety management activities.

[33] As of June 2005, DOI has determined that proposals submitted in response to a January 2005 Request for Proposals (RFP) for IMARS development were unacceptable. They plan to reissue the RFP later in the year, and the timeline for a pilot test will be extended at least into 2006.

Appendix A. Crash Data Reporting Systems Currently Used by National Parks

INCIDENT DATA COLLECTION METHODS FOR NPS UNITS

CIRS			CRIMES	WORD	ACCESS	OTHER
AGFO	KAHO	WHSA	ACAD	AMIS	BICA	ASIS - ARMS 2.1a (was on CIRS 12/03)
ALPO	KALA	WRBR	BOST	APIS	BITH	AZRU - hard copies
ANJO	KIMO	ZION	CAVE	BAND	BLCA	BADL - hard copies
ANTI	KNRI		DEVA	BICY	BLRI	BEOL - hard copies (no LE)
APPA	LAME		FOCL	CARE	CURE	BWMP - hard copy
ARCH	LAMR		FOLA	DETO	DENA	CACH - forms engine
BIBE	LARO		HALE	ELMA	EVER	CAGR - hard copies (no LE)
BISO	LIBI		LAVE	ELMO	GRTE	CANY - hard copies
BITH	LIHO		MORA	FOLS	SAJH	CATO - inc tracked by NCR Comm Ctr
BRCA	LOWE		NOCA	FONE	SUCR	CAVO - hard copies
BUFF	MACA		PORE	GLBA	WACA	CEBR - hard copies
CABR	MANA		THRO	GLCA	WHIS	CHCH - computer forms, db for tracking
CAHA	MANZ			INDE	WUPA	CHIS - home grown system
CALO	MAWA			JOTR	YOSE	CORE - home grown system
CANA	MEVE			KLGO		CRMO - hard copies
CASA	MOCA			LAVO		EBLA - (no incidents)
CHAT	MOMA			LYJO		FIIS - hard copies
CHCU	MONO			MOJA		FOBU - home grown paper system
CHIC	MORR			NIOB		FODO - were on CIRS till 1/04 now word
CHIR	MORU			ORPI		FOFR - Hard copy, have few incidents
COLM	NATR			OZAR		FOSC
COLO	NAVA			PECO		FOUN - hard copies (no LE)
CORO	OLYM			PIPE		FOVA - hard copies (no LE)
CRLA	PAAL			SACR		GAAR
CUGA**	PAOS			SHEN		GLAC - home grown "DataMax" since 76
CUVA	PARA**			WABA		GOGA - hard copies
DEWA	PEFO			WEAR		GRCA - combo access & word
DINO	PETE					GUIS - "Smartcop" for 3 years
EFMO	PETR					GWMP - hard copy
EUON	PEVI					HAFO/MIIN - hard copies
FOMA	PINN					HOCU - .2 FTE for LE, small database
FOPU	PIRO					ISRO - hard copies
FOR A	PRWI					KATM - hard copies
FORA**	PUHE					KEMO - home grown system
FRSA	RICH					NERI - ARMS Acccess Rept Mgmt Syst
FRSP	ROMO					NPSA - hard copies (no LE)
GATE	SAAN					OBRI - hard copy only **
GETT	SAGU					OCMU - hard copies/computerized

GEWA SAPU				ORCA - hard copies
GOSP SARA				PERI - (although was on CIRS till 12/03)
GRSM** SCBL				PISP - hard copies (no LE)
GUMO SEKI				ROCR - hard copy
HAFE SLBE				ROVA - hard copies
HAVO STEA				SAMO - "e-forms"
HEHO STRI				SPAR - "in-out" program
HOFU THST				SUIT - home grown system
HOME TICA				TONT
HOSP TUZI				VIIS - home grown system
INDU UPDE				VOYA - excel based software
JEFF USAR				WHMI - hard copies
JELA VAFO				WRST
JOFL VICK				YELL - hard copies
JOMU VICK				YOSE - hard copies
				YUCH - hard copies
Total 109	12	27	14	53

Crash Data Reporting System	Number of Parks
CIRS	109
CRIMES	12
WORD	27
ACCESS	14
Hard Copy Only	29
Other	24
Subtotal	215
Unknown	173
Total	388

Appendix B. Comparison of NPS Form 10-413 and the MMUCC Guidelines

B.1 Background

Currently, the National Park Service (NPS) uses Form 10-413 to collect crash data. Form 10-413 was developed to address the specific needs of the NPS. The fields included were based on NPS requirements and the American National Standard Institute (ANSI) guidelines for data definition. When developed, it complied with the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) guidelines. In 1997, NPS recommended that the form be revised to include additional information identified by NHTSA and FHWA in the Critical Automated Data Reporting Elements (CADRE) published in 1992. This recommendation was not carried out in full: several new fields were not added, but additional codes were added to seven existing fields.

The Traffic Safety Management System (TSMIS) concept recommends collecting future crash data using the Model Minimum Uniform Crash Criteria (MMUCC). The MMUCC is a set of guidelines developed by the Governors Highway Safety Association (GHSA – formerly National Association of Governor's Highway Safety Representatives and NHTSA) in 1998 and updated in 2003. The goal of the MMUCC is to use a set of core data elements that allows standardized data collection and uniform comparison among states and other entities.

B.2 Task Description

The purpose of this appendix is to understand the differences between Form 10-413 and the MMUCC, to determine whether the MMUCC contain all the data NPS needs, or if additional fields will be needed for the TSMIS data entry screens. It will also classify data fields as mandatory or optional depending on whether they are required for the types of safety analyses that NPS is likely to conduct. Mandatory fields would be required before an crash record would be accepted into the TSMIS database.

B.3 Approach and Methodology

This task was completed using the Servicewide Traffic Crash Reporting System (STARS) Revision[34] of Form 10-413 and the latest edition of the Model Minimum Uniform Crash Criteria (MMUCC)[35] published in 1997 and 2003, respectively. The data in the two formats were compared in terms of the four major data categories: crash, vehicle, person and roadway. The first step was to compare the formats, particularly in terms of data classification, layout and general contents. Data elements common to both

[34] Balloffet and Associates, Inc., "Servicewide Traffic Accident Reporting System Form 10-413 Revision," June 1997.
[35] USDOT, GHSA, & NCSA. DOT HS 809-577, "Improving Accident Data for Safer Roads Model Minimum Uniform Accident Criteria (MMUCC)," 2nd Edition, April 2003.
http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/MMUCC/2003/MMUCC_02.pdf

formats were identified and those appearing in only one were noted. Next, a list of core data fields was developed that NPS would likely use for traffic safety analyses. It was assumed that NPS is concerned with identifying physical improvements and perhaps some behavioral enhancements, but would not focus on comprehensive research-based evaluations and strategies.

B.4 A Comparison of the MMUCC and Form 10-413

This section identifies the major differences between the MMUCC and Form 10-413. Tables B1 to B5 summarize the results.

Table B1. Data Classification and General Contents of the MMUCC and Form 10-413

MMUCC Data Categories	Form 10-413 Data Categories
Crash Vehicle Person Roadway Note: Each group can include three types of data elements (collected, derived or linked). Each group of elements has a unique identifier (e.g., crash data element numbers are preceded with a C; vehicle data with a V). [Each type of data has a unique identifier (e.g., CD is used to identify crash data elements that are derived.)]	Crash Vehicle Person Note: Does not include much data on roadway elements (e.g., roadway functional classification, traffic control type at intersection, access control). However, these data can be obtained after linkage to other databases such as roadway inventory.

The MMUCC collects all four basic categories of crash data, while Form 10-413 collects only three (Table B1), relying on the NPS RIP and BIP databases to supply roadway characteristics instead of requiring this background information to be recorded at the scene.

Table B2. Crash Data Elements in the MMUCC and Form 10-413

MMUCC	Form 10-413
Crash case identifier	Park specific identifier (case number)
Crash date and time	Crash date and time (Note: NPS needs to specify that midnight is defined as 00:00, not as 24:00.)
Crash county	Park number and name
Crash city/place	Park number and name
Crash location (lat/long coordinates)	Route number, distance & direction to node, road name
First harmful event	Type of fixed object struck, crash class (no specification of non-collision crash type)
Location of fist harmful event	Crash location on/off roadway
Manner of Crash/collision impact	Type of collision between vehicles
Source of Information	Investigated by
Date and time crash reported to law enforcement agency	OMITTED
Weather condition	Weather

Lighting condition	Light
Roadway surface condition	Surface condition
Contributing circumstances, environment	Contributing circumstances, environment
Contributing circumstances, road	Contributing circumstances, road
Relation to junction	OMITTED
Type of intersection	OMITTED
School-bus related	Vehicle body type
OMITTED	Park property damage
Work-zone related	Option under Crash location but no details (e.g., type of work zone, workers present, specific location within the work zone)
Photos/Crash diagrams	Photo/Crash diagrams

Several crash data elements (Table B2) recommended by the MMUCC are not included in Form 10-413: "Relation to junction," "Type of intersection," and "Date and time crash reported to law enforcement agency." The last is not critical to NPS traffic safety analysis, but would be of interest to the investigative law enforcement agencies. The first two would be very useful for NPS in identifying site-specific safety problems.

As suggested by the MMUCC, the method of recording location information will be upgraded for the TSMIS to a coordinate system, either Latitude/Longitude Coordinates or the Linear Reference System. This method will be essential for mapping, problem identification and linkage purposes.

Table B3. Vehicle Data Elements in the MMUCC and Form 10-413

MMUCC	Form 10-413
Motor vehicle identification number	OMITTED
Motor vehicle unit type and number	Includes vehicle unit number but not unit type (e.g., motor vehicle in transport or parked vehicle)
Motor vehicle registration state and year	Vehicle registration state and year
Motor vehicle license plate number	Vehicle registration plate number
Motor vehicle make	Vehicle make
Motor vehicle year	Vehicle year
Motor vehicle model	Vehicle model
Motor vehicle body type category	Vehicle body type
OMITTED	Park service vehicle
Total occupants in motor vehicle	Can be derived from collected data.
Special function of motor vehicle in transport	Only specify if a USPP/NPS vehicle was involved
Emergency vehicle use (emergency vehicle involved in crash)	OMITTED
Motor vehicle authorized speed limit	Vehicle speed limit
Direction of travel before crash	Vehicle direction
Trafficway description	OMITTED, but available from RIP, BIP
Total lanes in roadway	OMITTED, but available from RIP, BIP
Roadway alignment and grade	Road character, but could be more specific (e.g., instead of 'curved on grade' could be 'curve left-uphill')

Traffic control devices type	OMITTED, but available from RIP, BIP
Motor vehicle maneuver/action	Vehicle maneuver, but should include ‘negotiating a curve’ as one of the options
Area(s) of impact	Damage location area
Sequence of events	OMITTED, possibly in narrative
Most harmful event for this motor vehicle	OMITTED
Underride/override	OMITTED
Hit and run	Hit and run
Extent of damage	Vehicle damage
Contributing circumstances, motor vehicle	Contributing circumstances
Motor carrier identification	No special provisions for commercial vehicles
Gross vehicle weight rating	No special provisions for commercial vehicles
Commercial motor vehicle configuration	No special provisions for commercial vehicles
Commercial cargo body type	No special provisions for commercial vehicles
Hazardous materials Placard (cargo only)	No special provisions for commercial vehicles

As seen in Table B3, Form 10-413 does not record the type of traffic control device present at the crash scene. This information is particularly important because the type of control may impact the type, severity and number of crashes. Knowing the type of traffic control at the time of a crash is important to identify the need for an upgrade or to evaluate any changes in control (no control, two-way stop, four-way stop or signalized intersection).

NPS records roadway alignment and grade data, however this could be more specific (e.g., instead of “curve on grade” use “curve-left-uphill”). This information may help to identify the need for traffic control devices (e.g., warning signs), modifying the traffic flow (one-way street) or prohibiting certain type of vehicles (e.g., sport utility units and recreational vehicles).

The MMUCC is a comprehensive document, which includes data fields that are important for nationwide evaluation and research but may have no significant impact on national parks. However, if NPS intends to share their data records with state and federal agencies and gain access to theirs for analytic purposes (comparing NPS and state crash rates on the same road type, for example), it would be beneficial to collect at least the same information required by the states. For example, vehicle data elements on motor carriers should be retained by NPS for sharing with the Federal Motor Carrier Safety Administration (FMCSA) for their mutual safety benefit.

Form 10-413 includes almost all of the person data elements (Table B4) in the MMUCC that would be critical for NPS traffic safety analyses with the notable exclusion of:

- Air bag deployed
- Results of alcohol testing
- Results of drug testing

Additionally, Form 10-413 lacks detailed codes for the source of driver distraction, non-motorist location at time of crash, and non-motorist safety equipment, and does not distinguish between non-motorist actions prior to and at time of crash. This information would provide insights into human behavior that would help NPS determine appropriate safety approaches to implement, such as signage, enforcement, or education.

Table B4. Person Data Elements in the MMUCC and Form 10-413

Level	MMUCC	Form 10-413
All persons involved	Date of birth & age	Driver date of birth, passenger age
	Sex	Sex
	Person type	Driver, passenger, pedestrian/cyclist type
	Injury status	Injury classification
All occupants	Occupant's motor vehicle unit number	Driver and passenger vehicle unit number
	Seating position	Passenger seat
	Occupant protection system use	Safety equipment (belt) use
	Air bag deployed	OMITTED
	Ejection	Ejection
All drivers	Driver license jurisdiction	Driver's license state (does not record info about US government vehicles, Mexican states, Canadian provinces)
	Driver license number and class	Driver license number, does not include license class
	Driver name	Driver name
	Driver actions at time of crash, allows for up to four actions	Contributing circumstances: driver, allows for up to five actions
	Driver condition at the time of crash	Contributing circumstances: driver, e.g., 'fell asleep, fainted, etc.,' 'under influence of alcohol,' 'under influence of drugs'
	Violation codes, allows up to four codes per driver	Violations charges, allows up to three violation charges per unit
	Driver distracted by, lists six choices for source of distraction	Contributing circumstances: driver, 'failed to give full time and attention'
All drivers and non-motorists	Law enforcement suspect alcohol use	Contributing circumstances: driver, 'under influence of alcohol'
	Alcohol test	OMITTED
	Law enforcement suspect drug use	Contributing circumstances: driver, 'under influence of drugs'
	Drug test	OMITTED
Non-motorists	Non-motorist number	OMITTED
	Non-motorist action prior to crash	Pedestrian/cyclist action, does not specify if it is prior or at the time of crash.
	Non-motorist action at time of crash	
	Non-motorist condition at time of crash	Contributing circumstances: pedestrian/cyclist, 'under influence of alcohol,', 'under the influence of drugs'
	Non-motorist location at time of crash	Location of pedestrian/cyclist prior to impact (could be more specific, e.g., 'non-intersection crosswalk,' 'shared use path,' etc.)

	Non-motorist safety equipment, allows for two entries per non-motorist	Driver/pedestrian belt, in this case 'helmet' is the only non-motorist equipment listed; list could include additional equipment such as reflecting clothing, protective pads
	Unit number of motor vehicle striking non-motorist	OMITTED
All injured persons	Transported to medical facilities, includes 'source of transport,' EMS response agency,' EMS run number,' 'name of facility taken to'	'Injured taken by,' 'injured taken to,' could be more specific (e.g., 'EMS responding agency ID number,' 'name of medical facility receiving patient')

Table B5. MMUCC Roadway Data Elements

MMUCC Roadway Data Elements
Bridge/structure identification number
Roadway curvature
Grade
Part of National Highway System
Roadway functional class
Annual average daily traffic (ADT)
Width(s) of lane(s) and shoulder(s)
Width of median
Access control
Railway crossing ID
Roadway lighting
Pavement markings, longitudinal
Bikeway
Delineator Presence
Traffic control type at intersection
Mainline number of lanes at intersection
Side road number of lanes at intersection
Total volume of entering vehicles

The MMUCC contains eighteen roadway data elements that are not part of Form 10-413 (Table B5), although almost all would be available by linking to the RIP and BIP databases for each road segment and intersection in the NPS system. Additionally, there is a current effort to obtain up-to-date ADT for each road segment for inclusion in the RIP. These data elements are critical to NPS traffic safety analyses. For example, the roadway functional classification would enable NPS to compare crash rate of similar roads with similar design characteristics. Access control is highly correlated with motor vehicle crashes and helps to identify hazardous locations. Information on the type of traffic control type at an intersection would be required to complete a signal warrant analysis.

B.6 Core Data Fields for NPS Traffic Safety Analysis

NPS safety analysts have indicated that they do not expect to do the same type of broad traffic safety research that NHTSA might conduct. They would be more focused on NPS and park-specific issues, such as determining high-risk locations on park system roads, identifying hazards contributing to crashes that NPS could address through road safety improvements, traffic enforcement, safety appurtenances, education programs, etc., and prioritizing safety projects to gain the most benefit with limited resources.

While all the data elements in the MMUCC are desirable to collect, NPS would not need them all for the types of analyses they are likely to conduct. The following 53 data elements are considered the "core" data elements for NPS purposes. These might, for example, be indicated as "mandatory" on crash reports or in the crash reporting screens of an online data collection system. A crash record would not be saved to the central database unless all the mandatory elements were completed. Other elements that would be desirable to collect might be considered "optional" and would not prevent a crash report from being accepted into the NPS crash database.

Table B6. Core Data Elements for NPS

Data Classification	Level	Data Element
Crash Data (15 elements)	For each crash	Crash case identifier
		Crash date and time
		Crash city/place
		Crash location
		First harmful event
		Location of first harmful event
		Manner of crash/collision impact
		Weather condition
		Lighting condition
		Roadway surface condition
		Contributing circumstances, environment
		Contributing circumstances, road
		Relation to junction
		Type of intersection
		Work-zone related
Vehicle Data (14 elements)	For each vehicle involved	Motor vehicle identification number
		Motor vehicle unit type and number
		Motor vehicle authorized speed limit
		Motor vehicle estimated traveling speed
		Direction of travel before crash
		Motor vehicle maneuver/action
		Extent of damage
		Most harmful event for this motor vehicle
		Sequence of events
		Contributing circumstances, motor vehicle
		Hit and run
		Trafficway description

		Roadway alignment and grade
		Traffic control devices type
Person Data (22 elements)	For each person involved	Age
		Sex
		Person type
		Injury status
	For each occupant	Occupant's motor vehicle unit number
		Occupant protection system use
	For each driver	Driver's action at the time of crash
		Driver condition at the time of crash
		Violation codes
		Distracted by
	For each driver and non-motorist	Law enforcement suspect alcohol use
		Alcohol test
		Law enforcement suspect drug use
		Drug test
	For each non-motorist	Non-motorist number
		Non-motorist action prior to crash
		Non-motorist action at time of crash
		Non-motorist condition at time of crash
		Non-motorist location at time of crash
		Non-motorist safety equipment
		Unit number of motor vehicle striking non-motorist
	For each injured person	Transported to medical facilities
Roadway Data[36] (2 elements)		Roadway functional classification
		Access control

B.8 Summary

Form 10-413 includes most of the data required by the MMUCC, specifically crash, vehicle, driver/passenger and non-motorist information. Additional information about roadway characteristics such as functional classification, type of traffic control at intersections and access control should be collected at the time of the crash or by linking to the road inventory database. Data fields in the MMUCC are extensive and perhaps the NPS may not require some of the information to conduct internal safety evaluations. However, to increase compatibility and accuracy in the data collection process, NPS should collect most of the data, at least those fields required or used by the state police. This report suggests a list of data fields that could be required by NPS database before an crash record would be accepted into the system. This list would enable NPS to conduct effective data analyses, while facilitating the data entry and storage.

[36] If a park does not have a roadway inventory that can be linked to the accident database, at least these two roadway data elements should be collected at the scene.

Appendix C. Description of FAA and FMCSA Safety Performance Monitoring Systems

The FAA's ***Safety Performance Analysis System (SPAS)*** is an automated decision support system developed by the FAA Flight Standards Office. The system integrates data from numerous sources, including aircraft, maintenance, operator certification and medical status, flight and duty time, etc. FAA inspectors use SPAS to "target limited resources on certificate holders (air carriers, air agencies, aircraft and air personnel) that are seemingly deviating from the norm."[37] This system was designed to aid the FAA to target inspection and certification resources on areas that pose the greatest aviation safety risks. For example, SPAS can be used to compare the current-to-past performance of an air carrier to its own records or to the industry average.[38] "SPAS information is displayed in user-friendly graphs or tables that indicate trends and point to potential areas of concern."[39] The system contains data on operators, aircraft types, specific aircraft, and repair stations, schools and all air carriers.

FMCSA's ***SafeStat*** identifies problem carriers through a system that scores the safety of over 600,000 interstate carriers on a scale from 1 to 100, based on an interview survey of 10,000 carriers annually, and focusing on carriers with the historically highest scores. For the most part, analysis using Safestat involves frequency distributions, collation of safety and fitness information about specific motor carriers, production of weighted safety scores for carriers, trucks, drivers, crash experience and fleet management practices. The preferred denominator for calculating a carrier's crash rate is its total mileage. Safestat profiles, based on data from multiple scores, are available on the World Wide Web.[40] Carriers and the public review the scores for comparison with other carriers, and to identify needs for improvement.

[37] http://www.volpe.dot.gov/infosrc/highlts/97/july/d_safety.html
[38] http://www.asy.faa.gov/gain/Concepts/DISTINGUISHING_FEATURES.HTM
[39] http://www.dot.gov/affairs/1995/spass.htm
[40] http://www.safersys.org/

Appendix D. State Highway Safety Management Systems

AASHTO

In 1996 and 1997 the American Association of State Highway Transportation Officials (AASHTO), with the assistance of the FHWA, the National Highway Traffic Safety Administration (NHTSA), and the Transportation Research Board assembled a group of national safety experts in driver, vehicle, and highway issues to develop a strategic plan for highway safety that would help to mitigate the nation's present and predicted statistics on vehicle-related death and injury. The safety plan[41] focused on six main elements or emphasis areas:

- Drivers
- Special users
- Vehicles
- Highways
- Emergency Medical Services
- Management

Each element was divided into crash-related goals toward which research and ameliorative efforts (strategies) could be applied. Specific actions were listed under each strategy. Altogether the plan addressed 22 goals, listed below.

1. Instituting Graduated Licensing for Young Drivers
    a. Implement graduated licensing systems
    b. Develop and implement an improved competency-based and assessment procedure for entry drivers
    c. Develop and implement an evaluation system for drivers moving from the provisional stage to the regular license stage
2. Ensuring Drivers are Fully Licensed and Competent
    a. Increase the effectiveness of license suspension/revocation
    b. Define and implement strategies that most effectively keep suspended/revoked drivers off the road
    c. Develop a model problem-driver identification program
    d. Develop and deploy an informal assessment system that drivers/families/medical personnel can use to assess an individual's capability to drive safely
    e. Link states using databases of driver records and relevant risk factors
    f. Develop and provide technical aids, such as simulators and electronic media, for private self-assessment and improvement of driving skills
    g. Enhance the competency of drivers through an improved renewal system
3. Sustaining Proficiency in Older Drivers
    a. Implement processes to improve the highway infrastructure to safely accommodate older drivers
    b. Implement a comprehensive approach to assist older driver safety

[41] http://safety.transportation.org/doc/Safety-StrategicHighwaySafetyPlan.pdf

   c. Assess the feasibility of Advanced Traveler Information Systems (ATIS) and Advanced Vehicle Control Systems (AVCS) for sustaining mobility and enhancing proficiency
4. Curbing Aggressive Driving
   a. Develop and implement comprehensive programs to combat aggressive driving
   b. Promote the use of advanced technologies to support enforcement efforts
5. Reducing Impaired Driving
   a. Advance stronger legislation in the states to reduce drinking and driving
   b. Develop and implement comprehensive sobriety checkpoints and saturation blitzes
   c. Reduce the incidence of drinking and driving in the 21-34 age group
   d. Create more effective ways to deal with repeat DUI offenders
   e. Build state programs that target drug-impaired driving
   f. Develop and implement a comprehensive public awareness campaign
6. Keeping Drivers Alert
   a. Implement a targeted program to reduce the likelihood of fatigue
   b. Retrofit the rural interstate and other facilities prone to cause fatigue with shoulder rumble strips
   c. Reduce the number of commercial vehicle crashes resulting from loss of alertness and driver fatigue
7. Increasing Driver Safety Awareness
   a. Using established programs, safety research information, and techniques now available, initiate, develop, and market a coordinated national campaign that targets at least the following areas: drinking and driving, occupant protection, aggressive driving (including speeding), fatigue, inattention, roadside hazards, unsafe driving, understanding traffic control devices, work zones, tailgating and rear-end collisions
   b. Create awareness efforts to deal with less understood and emerging safety concerns
8. Increasing Seatbelt Usage and Improving Airbag Awareness
   a. Increase adoption of standard seatbelt laws and eliminate gaps in child seat laws in the majority of states
   b. Implement periodic, intensive, and coordinated enforcement and public information and education initiatives
   c. Improve the effectiveness of air bags
   d. Create improved awareness of air bag safety effectiveness
9. Making Walking and Street Crossing Safer
   a. In cooperation with other professional organizations, update existing and develop new warrants, guides, and standards for the safe accommodation of pedestrians
   b. Implement comprehensive programs (engineering, enforcement, education) to influence impaired (generally alcohol or drug) pedestrians
   c. Encourage states to become active in public outreach and training on pedestrian safety

   d. Develop programs to improve pedestrian and bicycle safety accommodations for intersections and interchanges
   e. Encourage states to enact new or modified legislation and adopt policies to provide safer accommodation of pedestrians on public roads
   f. Implement comprehensive integrated pedestrian safety programs targeting pedestrian crash concern in major urbanized areas and select rural areas
10. Ensuring Safer Bicycle Travel
    a. Seek increased state adoption of policies to better accommodate bicyclists on all public roads, and encourage state legislatures to fund bicycle facilities
    b. Develop and implement a bicycle safety public education/information program targeting all age groups of bicyclists and drivers
    c. Provide educational material to police officers and judicial officials that emphasizes why bicycle laws are important to bicycle safety and provide guidance on how to effectively enforce them
    d. Increase bicycle helmet usage
11. Improving Motorcycle Safety and Increasing Motorcycle Awareness
    a. Reduce the number of alcohol-related motorcycle fatalies
    b. Reduce motorcycle fatalities resulting from errors by other drivers
    c. Increase the application of comprehensive motorcycle rider education programs for novice and experienced riders
    d. Increase highway design, operations, and maintenance practices that consider the special needs of motorcycle operating requirements and dynamics
    e. Increase usage of helmets through the enactment of helmet laws
12. Making Truck Travel Safer
    a. Refocus commercial vehicle programs and regulations to achieve crash reductions rather than focusing on enforcement actions
    b. Reduce the number of commercial vehicle crashes resulting from loss of alertness and driver fatigue
    c. Reduce the number of commercial vehicle crashes resulting from driver error
    d. Implement traffic controls and address highway design problems to reduce the most prevalent truck crashes on Interstates and major highways
    e. Enhance the safe operating condition of trucks and buses
13. Increasing Safety Enhancements in Vehicles
    a. Reduce the number of crashes and injuries resulting from the misunderstanding and misuse of anti-lock brake systems (ABS)
    b. Reduce carbon monoxide poisoning through education and technology
    c. Include motorcycle needs in ITS crash avoidance and collision warning research and implementation
    d. Improve the compatibility between roadside and vehicle designs
14. Reducing Vehicle-Train Crashes
    a. Finalize development and deployment of improved passive warning devices
    b. Establish national guidelines for highway-rail grade crossings

   c. Improve driver training and licensing relative to safe practices for approaching and traversing highway-rail crossings
   d. Adopt more advanced technology for enforcement and crash prevention at appropriate railroad locations to minimize motorist violation of railway warning devices
   e. Implement the findings and recommendations of the USDOT Grade Crossing Safety Report
15. Keeping Vehicles on the Roadway
   a. Implement a comprehensive program to improve driver guidance through better pavement markings and delineation
   b. Implement a targeted shoulder rumble strip program
   c. Improve the design process to explicitly incorporate safety considerations and facilitate better design decisions
   d. Develop better guidelines to control speed variance through combinations of geometric, traffic control, and enforcement techniques
   e. Establish programs to improve roadway maintenance to improve highway safety
16. Minimizing the Consequences of Leaving the Road
   a. Provide improved practice for the selection, installation, and maintenance of upgraded roadside safety hardware
   b. Implement, in an environmentally acceptable manner, a national effort to address hazardous trees
   c. Implement a national policy to reduce the hazard from roadside utility poles, particularly on two-lane rural roads
   d. Develop and implement guidance to improve ditches and backslopes to minimize rollover potential
   e. Develop and implement guidelines for safe urban streetscape design
17. Improving the Design and Operation of Highway Intersections
   a. Improve the safety of intersections using automated methods to monitor and enforce intersection traffic control
   b. Improve intersection safety by upgrading signalized intersection controls that smooth traffic flow
   c. Utilize new technologies to improve intersection safety
   d. Include more effective access management policies with a safety perspective
18. Reducing Head-on and Across-median Crashes
   a. Develop and test innovative centerline treatments to reduce head-on crashes on two-lane highways
   b. Reduce across-median crashes on freeways and arteries that have narrow medians
19. Designing Safer Work Zones
   a. Implement improved methods to reduce the number and duration of work activities
   b. Adopt improved procedures to ensure more effective practices, including traffic control devices, for managing work zone operations

    c. Enhance and extend training for the planning, implementation, and maintenance of work zones to maximize safety
    d. Enhance safe work zone driving through education and enforcement actions
20. Enhancing Emergency Medical Capabilities to Increase Survivability
    a. Develop and implement a model comprehensive approach that will ensure appropriate and timely responses to the emergency needs of crash victims
    b. Develop and implement a plan to increase education and involvement of EMS personnel in the principles of traffic safety
    c. Develop and implement emergency preparedness models in three high-incident interstate highway settings and use this demonstration to study their effectiveness in reducing fatalities and health costs
    d. Implement and/or enhance trauma systems in at least 25 states
    e. Develop and support integrated EMS/public health/public safety information and program activities
21. Improving Information and Decision Support Systems
    a. Improve the quality of safety data by establishing programs for quality assurance, incentives, and accountability within agencies responsible for collecting and managing safety data
    b. Provide managers and users of highway safety information with the resources needed to make the most effective use of the data
    c. Establish a means by which collection, management, and use of highway safety information could be coordinated among organizations at all jurisdictional levels
    d. Establish a group of highway safety professionals trained in the analytic methods appropriate for evaluating highway safety information
    e. Establish and promote technical standards for highway safety information systems' characteristics that are critical to operating effective Strategic Highway Safety Plan programs
22. Creating More Effective Processes and Safety Management Systems
    a. Communicate the benefits of existing successful Strategic Highway Safety Plans
    b. Implement pilot safety audit processes
    c. Promote strong coordination, cooperation, and communication of safety initiatives within each state
    d. Integrate the planning of highway safety programs and highway safety information systems
    e. Establish an ongoing performance measurement system to evaluate the cost-effectiveness of safety investments at both project and program levels
    f. Develop and ratify a national safety agenda
    g. Implement the safe community-based programs in half of the nation's urban areas of 5,000 or greater population and on at least 300 high-crash corridors to engage local partners in areas of traffic safety that most affect their daily lives

This plan became the standard for states developing their own highway safety plans. States typically modified the elements, goals, strategies and actions to fit their own specific needs. Most of the state SMSs reviewed in this appendix have been based on the AASHTO model.

In a subsequent related effort beginning in 2000, AASHTO in partnership with FHWA, NHTSA, and other organizations sponsored the development of a Transportation Safety Information Management System (TSIMS). TSIMS is a set of tools, technologies and data definitions that serves three major purposes. It is a crash records management database containing automated data capture subsystems and providing extensive data analysis and reporting capabilities; it provides links to other national, state, and local crash record systems; and it is a data storage warehouse of a large amount of other traffic safety information. The system was built as a joint application product by contractors under the auspices of AASHTO and is intended for use by any state in the country. A number of states have contributed funds for TSIMS development and will continue to fund its operation and continued advancement.

TSIMS contains four basic modules:

1) Crash Module
- Crash data capture using latest technology such as laptop PC, pen-based PC, bar code recognition, external data import facilities reducing the amount of data that must be physically keyed into the system.
- Existing crash data capture through document scanning techniques
- Operation in both local client server and web-based environments

2) Crash Location Module
- GIS analysis
- Hazard location

3) Data Warehouse
- Interface with external systems such as roadway inventory, citation/conviction, EMS, commercial motor carrier, GIS, driver and vehicle information
- Retrieve data to create the unified TSIMS Data Warehouse entry associated with the incident

4) Data Analysis and Reporting Module
- Analysis and reporting tools to use comprehensive safety information
- Both statistical and GIS-based analytical methods
- Pre-defined and ad hoc report formats

A future planned enhancement to TSIMS is the development of an Emergency Medical Services (EMS) module to both automatically contact EMS providers as well as download medical information related to a crash. A particularly important aspect of this system is that it is proposed to be compatible with existing legacy systems widely in use now by various agencies throughout the country (e.g., DMV, CODES).

In order for TSIMS to be capable of meeting each state's unique requirements and operating environment, the system will include the requisite installation customization facilities necessary to adapt the baseline software for each state environment. This means that the implementation of TSIMS at each state will require a degree of customization directly related to the size and complexity of the state's information system environment.

Iowa

Iowa speaks of the mission of its SMS as an effort to "reduce human suffering and economic losses resulting from crashes on Iowa's roadways through the identification of causes, resources, and safety implications of policy decisions."[42] The Iowa Strategic Highway Safety Plan uses the AASHTO plan as a model. It contains five of AASHTO's six elements divided into a total of 25 goals, listed below. The majority of Iowa's plan elaborates on the strategies to achieve these goals. Iowa's strategies mirror AASHTO's for the 22 AASHTO goals. The list below lists the strategies for the additional six Iowa goals.

- Drivers
  1. Increasing Driver Safety Awareness
  2. Increasing Safety Belt and Child Restraint Usage
  3. Preventing Drowsy and Distracted Driving
  4. Curbing High-risk Driving Behaviors
  5. Ensuring Drivers Are Fully Licensed, Competent, and Insured
  6. Reducing Impaired Driving
  7. Education and Licensing for Young Drivers
  8. Sustaining Safe Mobility in Older Drivers
- Other Users
  9. Making Walking and Street Crossing Safer
  10. Ensuring Safer Bicycle Travel
  11. Making School Bus Travel Safer
      - Establish a plan for ongoing review and reporting of school bus route hazards
      - Promote increased awareness, observance and enforcement of motor vehicle laws relating to motorists approaching or following school buses that are about to stop on the highway to take on or discharge passengers
      - Promote school bus passenger safety through the systematic purchase and replacement of school buses and

[42] http://www.iowasms.org/pdfs/ishsp.pdf

equipment meeting all state and federal school bus construction requirements, and which have been equipped with the latest driver and passenger safety technology based on scientific research and real-world experiences

- Promote and support school bus driver and passenger safety education programs within schools

12. Improving Motorcycle Safety and Increasing Motorcycle Awareness
13. Making Large Truck Travel Safer
14. Reducing Farm Vehicle Crashes
    - Improve motor vehicle operators' understanding about slow moving agricultural vehicle hazards
    - Strengthen slow moving agricultural vehicle operators' knowledge about public roadway issues
    - Increase visibility of slow moving agricultural vehicles
    - Establish joint research programs to identify and analyze agricultural collisions and develop additional preventative strategies

- Highways
  15. Improving the Design and Operation of Roadway Intersections
  16. Keeping Vehicles on the Roadway and Minimizing the Consequences of Leaving the Road
  17. Reducing Head-on and Across-median Crashes
  18. Improving Work Zone Safety
  19. Accommodating Older Drivers
  20. Reducing Train-vehicle Crashes
  21. Reducing Vehicle-animal Crashes
  22. Implementing Road Safety Audits
- Emergency Response
  23. Enhancing Emergency Response Capabilities to Increase Survivability
- Planning and Management
  24. Improving Information and Decision Support Systems
  25. Creating More Effective Processes and Safety Management Systems

Of particular interest to the NPS SMS are several of the goals under the Planning and Management element. Many strategies and activities under "Goal 24. Improving Information and Decision Support Systems" and "Goal 25. Creating More Effective Processes and Safety Management Systems" deal with the development of a data collection, dissemination, and analysis system. In addition, various reports and papers written by individuals within and contractors to the Iowa DOT stress the importance of accurate, complete, and timely data collection; the importance of user friendly data analysis tools; and access to data by all appropriate personnel. Pertinent issues related to the Iowa SMS are listed below.

Involvement of All Stakeholders in SMS -- The Statewide Traffic Records Advisory Committee (STRAC) is a multidisciplinary safety group that comprises and includes the SMS as well as the Iowa DOT, Department of Public Safety, and Department of Public Health, the USDOT, university research, local law enforcement and traffic engineers, and more. They were engaged in the national project conducted by the National Association of Governor's Highway Safety representatives and NHTSA to develop guidelines for Model Minimum Uniform Crash Criteria (MMUCC), which formed the basis for Iowa's new crash report form implemented on January 1, 2001. As a result Iowa may be the only state that requires all jurisdictions and agencies involved in crash reporting to use the ***same*** form. Thus, unlike in other states, a reporter need file ***only one crash report per crash*** to satisfy the requirements of all the various agencies that need to be notified.

TraCS[43] – In 1994, Iowa began the development of a crash reporting system to increase data accuracy while reducing the time allocated to processing crash reports. The Mobile Crash Reporting System (MARS) included application software combined with mobile computers, a central host workstation, and statewide data communications.

In 1997, Iowa was selected by the FHWA as a partner for the National Model Project. The objective of this partnership was to create a fully integrated safety management system by expanding upon Iowa's nationally recognized leadership in safety data collection. This approach served as a model for all states to draw upon in their efforts to improve their data collection and safety management system processes. The National Model launched the next generation of data collection tools, known as TraCS: Traffic and Criminal Software.

The project was managed as a consortium effort of transportation-related agencies in Iowa and the FHWA Iowa Division. A variety of state, county, and local law enforcement agencies committed to in-field use and evaluation of the statewide systems. Industry support, cooperation, and interest were excellent and increased with the visibility of the National Model. Since the late 1990s the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Transportation Safety Administration (NHTSA) have also contributed funding.

This system contains modules that not only are directed toward crash record keeping but also are intended to cover a wide range of criminal activities. The modules are:

- Mobile Crash Reports (MARS) (using the MMUCC standardized crash report form[44])

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[43] For a more detailed description of TraCS and all its features, development history, report outputs, and more, the reader may refer to the web site: http://www.dot.state.ia.us/natmodel.
[44] http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/MMUCC/2003/MMUCC_02.pdf

- Mobile Operating While Intoxicated (MOWI)
- Electronic Citation Component (ECCO)
- Vehicle Safety Inspection System (VSIS)
- Complaint Investigation Report Form (CIRF)

The underlying concept for TraCS is essentially the same as systems developed by other states (and TSIMS), that is, the automated or semi-automated data collection and analysis of highway crash data and the retrieval of data from existing databases. A particularly attractive aspect of TraCS, however, is the flexibility of the individual modules. Each module can be individually modified to meet the particular data collection and reporting needs of any particular agency and additional modules can easily be built that will operate with and share data with other modules. Additionally, it is not necessary to install all the modules or the technology they support for TraCS to be an effective system.

Another feature of TraCS is that it can accommodate phased upgrading to make it possible to spread costs over time. For example, TraCS can be used on a PC in the central office prior to installation in field units. As resources become available, field units can be added.

Once an crash report is downloaded from the in-vehicle mobile data terminal (MDT) to the agency desktop computer or network, the data and image files are transmitted in a matter of minutes through the IOWA System, Iowa's statewide public law enforcement communications network. Upon receipt of the crash reports at the DOT, the data are automatically stored in the state's crash report database with no user intervention. Local staffs can analyze the data the same day they are collected.

A number of other states have already made the decision to adopt TraCS, including New York, Alabama, Arizona, Arkansas, Colorado, Delaware, Georgia, Nevada, New Hampshire, Oklahoma, South Carolina, Tennessee and Wisconsin. The completeness and adaptability of TraCS lends itself to a relatively easy transition to NPS use, not only for roadway crashes but also for all forms of police and enforcement activities.

GIS-ALAS -- In addition to these modules TraCS has integrated into its system a GIS Crash Location and Analysis System (GIS-ALAS). Iowa intends to include collision diagram software tied to geographic coordinates where an crash occurs. Three fields in the crash database will define these diagrams: vehicle direction of travel, vehicle action, and collision type. Some of the layers intended to be available in the GIS-ALAS are: crash and roadway features, detour locations, and re-routing directions. In addition to the benefits to an overall SMS this GIS module will have significant importance for maintenance, bridge, pavement, and congestion systems. The use of appropriate infrastructure layers, even without the benefit of GPS, will insure that crash sites are more correctly located. The widespread use of the node-link system of locating crashes can eventually be abolished in Iowa. Of course, with the addition of GPS and automatic location data entry, there is less chance for error in identifying a crash location.

Built-in SMS Evaluation and Improvement Process -- The Iowa SMS produced the Iowa Strategic Highway Safety Plan, which in turn includes as a goal the evaluation of its own strategies, making improvements to the SMS, and modifying the highway safety programs, goals and strategies accordingly. The evaluation is based on performance measures derived through the data collection and analysis systems describe above.

"Carrot" Approach to Encouraging the Submission of Crash Reports -- 1) Let police and their local government officials know the far-reaching value of their reports and the many applications of crash data to making streets and highways safer for all citizens. 2) Provide a crash report form that is easy to understand and use, in electronic form if possible. 3) Proper officer training in the completion of the report forms. 4) Enable local law enforcement agencies to have immediate access to their local crash data for analysis and application.

Florida[45]

The mission of the Florida SMS, formed in 1994, is to "provide the safest roadway system possible through the combined efforts of engineering, enforcement, emergency services and education, the 4-E's of safety."

The goal is to reduce the number and severity of traffic crashes by ensuring that all opportunities to improve safety are identified, considered, implemented when and where appropriate, and evaluated.

Early in the SMS development process meetings were held among safety stakeholders, and a Steering Committee (SMSCC) was established to guide and direct Florida's SMS. The members of that multi-disciplinary committee represent over 35 public and private safety advocates from the federal, state and local levels. This group works to establish statewide highway safety goals, objectives and strategies. The Florida SMS strives to address highway safety on all public roads, as opposed to just state or federal highways.

Each SMS partner brings a unique perspective to the group. In the past each discipline typically addressed traffic safety in isolation, with little coordination or input from other safety professionals. As a result of the SMS activities, people are more informed of safety activities occurring throughout the State and often consult with others and work cooperatively on projects.

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[45] The material in this section was largely taken from the following web site: http://www11.myflorida.com/safety/sms/sms.htm.

The SMSCC meets quarterly to discuss safety issues and review safety programs underway throughout the state. Nine subcommittees address the following safety concerns:

1. Traffic Records
2. Driving under the Influence
3. Legislation
4. Education
5. Communication
6. Roadway Safety
7. Traffic Safety & Community Policing
8. Pedestrian/Bike/In-line Skate
9. Occupant Protection

Four major SMS emphasis areas are:

1. Coordinate and integrate broad-based safety programs (such as motor carrier, corridor and community based traffic safety activities) into a comprehensive management approach for highway safety.
2. Identify and investigate hazardous or potentially hazardous highway safety problems, roadway locations and features (including railroad-highway grade crossings) and establish countermeasures and priorities to correct the identified hazards or potential hazards.
3. Ensure early consideration of safety in all highway transportation programs and projects.
4. Identify safety needs of special user groups (such as older drivers, pedestrians, bicyclists, motorcyclists, commercial motor carriers, and hazardous material carriers) in the planning, design, construction, and operation of the highway system.

The SMSCC uses two different approaches for accomplishing its goals, objectives and strategies. It takes the lead for those that require statewide leadership and coordination. However, the SMSCC has taken a somewhat unique and decentralized approach to implementing SMS goals, objectives and strategies that they feel are more effectively managed at a local level. Through the concept of Community Traffic Safety Teams (CTSTs) local city and county jurisdictions have become active in the SMS process, and are focusing on solving highway safety problems at the local level.

Florida is seen as a national leader in utilizing the Community Traffic Safety Program concept with the development of over 50 Teams, which have formed their own Coalition. At this time all of the "top 20" counties with the highest incidence of traffic crashes in Florida have at least one CTST active in their area. Dade County, one of Florida's largest metropolitan population areas, is working to form smaller CTSTs within community or city regions instead of the larger countywide model.

Of particular interest to the NPS SMS, the SMSCC's Traffic Records Committee developed a statewide crash report form that was deployed January 2002, and is compatible with the MMUCC standard. They are also currently addressing issues similar to those facing the NPS SMS including:

- Should Regional Data Centers develop their own software for processing the data or should it be standardized statewide?
- How can crash data users at the local level obtain the most accurate and timely information possible?
- How much historical data needs to be converted to the new format for analysis purposes and how can it be accomplished most efficiently -- locally or statewide?
- How can automated data entry best be implemented? (Various pilot projects are being conducted around the state.) Should they use the Iowa software?
- Should they use the Internet for data dissemination?
- Can they link with other databases, such as hospital?

Wisconsin

Wisconsin is one of ten states participating in the Iowa National Model enhancements. Their *State of Wisconsin Traffic Records Strategic Plan* aims to (1) automate the state crash form and process (and relate that automation to other law enforcement automation initiatives); (2) improve and automate the collection of crash and citation location information; and (3) improve the records of post-crash treatment, outcomes and costs.

Studies and initial demonstrations to accomplish these goals have just begun, and no definitive results are available at this point. They are developing an automated state crash reporting form and adapting the TraCS software to meet the needs and limits of the state's traffic records system. A pen-based palm or tablet data entry system for observational data is being developed. WisDOT along with several other state agencies is testing and demonstrating the usefulness of GIS systems with GPS crash and citation locations. A demonstration of linkage between Wisconsin's CODES in-patient data and mortality files and crash records showed the value of linked databases containing information on crash characteristics, treatment from on scene to discharge and medical outcomes and charges. They are working to implement national standard data elements for all their databases for linkage to a national system of linked databases.

Alabama

Of the list of 22 highway safety issues established by AASHTO, the State of Alabama focused on three general categories of crashes: Motorcycle Crashes, Alcohol-Related Crashes, Crashes Involving Pedestrians and Bicycles; and on improving police traffic services and collecting and maintaining crash records. The State of Alabama came up with these program areas after examining the traffic safety problems in their state and setting priorities for their amelioration. One of the innovations they use for streamlining the problem identification process is the development of the Crash Analysis Reporting Environment (CARE). Among other aspects of CARE is the integration of a graphical user interface for crashes along mileposted roadways, the addition of additional graphical displays for visualization of other aspects of high-crash locations and internet access. Internet access is particularly important to the overall SMS developed by the state because it allows all concerned local and state agencies rapid access to information needed by each organization. Also, CARE contains a set of analysis algorithms that provide generation and analysis of data for standard reports as well as allowing ad hoc analyses on an as-needed basis.

New Mexico

The Mission Statement:

> *The plan's overall performance goal, as well as the mission of the Traffic Safety Bureau, is to continuously reduce traffic-related fatalities and injuries by developing and supporting a comprehensive, multiple strategy approach that includes prevention, education, screening and treatment, regulation, legislation, enforcement and deterrence initiatives.*

In arriving at their root causes for New Mexico's highway traffic crash and fatality rates, they examined crash data in terms of time of day of the crash, weather conditions, demographic details of the drivers and victims, road conditions, vehicle type and condition, degree of driver impairment, involvement of risk taking or unlawful behavior, medical/disability outcomes, and costs associated with vehicle crashes. One major result of this examination was a recognition that the major cause for the most severe traffic crashes was risk-taking behavior (e.g., failure to wear seat belts, drinking and driving, excessive speed and not wearing motorcycle helmets).

The major approach to the SMS plan is essentially the same as the other states, but New Mexico discussed an important element that was either omitted or obliquely referred to by other state plans. In addition to the evaluation of root causes of highway crashes they made a concerted effort to review and assess the ability and willingness of state and local entities to implement the strategies required to reach the goals set forth in the plan. New Mexico seemed to realize that any plan, no matter how well conceived, will be effective only if the enforcing agencies are capable and willing to institute the program.

As with other plans, New Mexico placed a significant reliance on the collection and analysis of crash data. They have a comprehensive crash history repository dating back to 1978 containing data collected according to the Uniform Crash Reporting form used by all New Mexico law enforcement agencies throughout the state. They also make use of a data linkage system maintained by the Division of Epidemiology, at the Department of Health, that relates data from the state trauma registry, vital records, hospital emergency rooms, inpatient records, various ambulance services, and Medicaid.

Hawaii

The Mission Statement:

> *To save lives and reduce injuries, crashes, and their associated economic costs in Hawaii through the leadership, innovation, coordination and program support in partnership with traffic safety activists, professionals and organizations through the state.*

Hawaii focuses their plan on basically the same areas as New Mexico although they do not explicitly state crashes related to risk-taking behavior as a major category. The state pays particular attention to alcohol-related deaths and injuries, since their state has been above the national average in such categories in recent years. The Hawaii DOT does not mention any particular reliance on or enhancements to data collection and analysis in their plan. But in all other ways, their SMS is similar to those of other states.

Texas

Texas analyzed crash data for all cities with a population of over 5,000 and each county for two or three years and came up with the following crash-involved factors:

- Speed-related
- Alcohol-involved
- Adult-no belt
- Child-no restraint
- Motorcycle
- Pedestrian
- Pedalcyclist
- Urban speed (cities over 5,000 population)
- Rural speed (counties)

In addition to these factors the state tracks the following factors on a statewide basis:

- Number of casualties
- Number of crashes
- Casualty rates
- Crash rates
- Rural versus urban crashes
- Crash rates by driver
- Age per 10,000 licensed drivers
- Number of crash-involved drivers by age
- Gender of crash-involved drivers
- Speed as a contributing factor
- Restraint use by crash-involved drivers

- Motorcycles, mopeds, and scooters
- School buses
- Crashes involving pedestrian casualties
- Number of pedestrian casualties
- Crashes involving pedalcycles
- Number of pedalcyclist casualties

As with the other states, Texas set priorities for crash reduction projects according to the results of analyses of the above factors and the locale wherein the greatest number of such crashes occurred. Their goals and objectives were framed in measurable performance criteria in order to assess program effectiveness over time.

California

The County of Riverside, California has developed and is continuing to improve their crash reporting capabilities with a system they call Geographic Information System Based Crash Records System (GIS-BARS). Early work in the system's development included expansion of the centerline layer to include traffic volumes, pavement management data and the creation of a traffic control device inventory. Enhancements to the system are planned to include GPS input and the utilization of portable computers, video, and aerial photography.

As the system was being developed it was noticed that historical crash data did not provide for standardized names and abbreviations for streets, making it extremely difficult to pinpoint the actual location of many crashes. Also, significant errors were discovered in direction or distance values, or the primary and secondary streets either intersected more than once or did not intersect at all. The use of GIS-BARS is intended to eliminate these problems.

One of the major results of the development of GIS-BARS will be the generation of the following reports and maps:

- Report of Intersection Collision Locations by Crash Rate
- Report of Highway Segment Collision Locations by Crash Rate
- Report of Intersection Collision Locations by Crash Occurrence
- Report of Highway Segment Collision Locations by Crash Occurrence
- Intersection Ranking Report
- Segment Ranking Report
- Motor Vehicle(s) Involved
- Primary Collision Factors for Collisions and Victims by Severity
- Motorcycle, Moped, Bicycle, and Pedestrian Collisions and Victims by Hour of Day

- Alcohol Involvement by Age of Involved Parties
- Collisions Involving Pedestrians; Location Details and Victim Data
- Collisions Involving Bicyclists; Location Details and Victim Data
- Collision Location Details; Involved Party and Victim Data
- Average Intersection Crash Rate; by Intersection Category
- Average Road Segment Crash Rate; by Segment Category
- Collision Severity Summary Report
- Societal Loss Summary Report
- Primary Collision Factor Summary Report
- Drug and Alcohol Impairment Summary Report
- Safety Device Usage Summary Report
- Traffic Crash Trend Report
- Jurisdiction Map
- Precinct/District Map
- Collision Pin Map
- Traffic Flow Map
- Collision Diagrams
- Traffic Control Device Diagram
- Video Log Services

In Summary

The AASHTO model for the SMS developed with the assistance of FHWA, NHTSA and TRB demonstrates some elements that the NPS SMS can learn from. Almost all of the state SMSs examined have used the AASHTO model as the basis for their systems, including as the model for TraCS. The key elements and data systems that would be applicable to the NPS SMS include:

- Clear statement of the SMS mission
- Identification of safety problems
- Establishing clear goals and objectives with the ability to measure progress toward their achievement
- Development of projects to address goals and objectives
- Development of a crash data collection and management system (the Iowa TraCS system has become the standard for state systems) that:
    - requires all reporters to use the same standardized crash data form designed according to MMUCC standards
    - automates data input to the extent possible using new technology

  - retrieves data on vehicles, drivers, road features, medical outcomes, etc. from linked external databases to minimize the amount of data field personnel need to collect
  - allows reporters easy access to their data once they are input (some states use the Internet)
  - is flexible to meet the particular data collection and reporting needs of any particular agency and will accept additional modules
- Acquisition of GPS location for use by GIS systems (Iowa's GIS-ALAS is an example of a possible system for NPS to consider)
- Examples of analysis reports that a GIS system can produce
- Involvement of all stakeholders in SMS process
- Built-in SMS evaluation and improvement process
- "Carrot" approach to encouraging reporters to submit their reports
- Building a system that has the buy-in of the people who are needed to make it work
- Allowing local safety personnel to address local problems; tailoring the solutions to local conditions

Appendix E. TSMS Benefits Model Worksheet

Safety Improvement Project Type	Total Number Projects[1] per Year	10% of Total	Expected # Injury & Property Damage Accidents per Project[1] before Improvement	Expected Reduction % for # Accidents after Improvement[2]			Estimated $ Benefits for Reduction in Accidents[4]			
				Injury	Property Damage Only	All Accidents[3]	Injury	Property Damage Only	All	Total
Bike Lanes	50	5	2	5	0		$21,064	$0	$0	$21,064
4R Projects	40	4	3	20	5		$101,106	$3,600	$0	$104,706
Guardrails	25	2.5	2	47	7	44	$99,000	$2,100	$99,000	$200,100
Roadside Safety Treatment	15	1.5	2	33	28		$41,706	$5,040	$0	$46,746
Road Widening	10	1	1	7	11		$2,949	$660	$0	$3,609
Curve Straightening	5	0.5	3			33	$0	$0	$9,900	$9,900
Junction Redesign	5	0.5	2	17	0		$7,162	$0	$0	$7,162
Interchanges	5	0.5	1			20	$0	$0	$6,000	$6,000
Lighting	15	1.5	2	25	25	50	$31,596	$4,500	$67,500	$103,596
Stop Signs (2-way)	15	1.5	2	35	0		$44,234	$0	$0	$44,234
Traffic Signals	8	0.8	2	30	35		$20,221	$3,360	$0	$23,581
Variable Message Signs (accidents, fog, congestion)	10	1	3			44	$0	$0	$26,400	$26,400
Rail Grade Crossings	2	0.2	1			45	$0	$0	$1,800	$1,800
Road Markings (edge, center)	30	3	2			24	$0	$0	$28,800	$28,800
Signalized Pedestrian Crossings	4	0.4	2	12	0		$4,044	$0	$0	$4,044
Speed Limits	8	0.8	2	14	5	15	$9,437	$480	$4,800	$14,717
Other	15	1.5	2			0	$0	$0	$0	$0
							$382,518	$19,740	$244,200	$646,458

[1] or mile as appropriate

[2] Source: Safety Handbook

[3] Shaded -- fatal reduction.

[4] Source: HERS, Table 5-11, average of injury and property damage costs over rural roads; Table 5-10, average of fatality and injury rates over rural roads

Appendix F. TSMIS Mock-up

A mock-up was developed to demonstrate the features of the Web-based data collection alternative and the reporting and analysis modules of the TSMIS. It has the look and feel of the NPS TSMIS concept (see front cover), but is not functional as a data management tool, as there are no software and databases supporting it. An electronic copy of a mock-up of the TSMIS is available under separate cover on a CD. It can be installed on any computer with a Web browser.

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14. ABSTRACT
It is the responsibility of the National Park Service (NPS) to ensure the safety of visitors traveling on its roads. To accomplish this task, the NPS needs to know the status of traffic safety within the parks to understand where improvements are needed. Once safety improvements are made, it is vital that the effectiveness of these safety improvements is tracked and used in future planning. It is for these reasons that the NPS needs to develop a system for managing traffic safety within its over 300 parks. This document describes the concept for a safety management system for the National Park Service that provides NPS with the information, analysis tools, and processes to manage effectively traffic safety on its roads.

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safety management systems, traffic safety, risk, strategic safety planning, safety programs, park roads and parkways, National Park Service, Federal Lands Highway, crash data, crash data collection, crash data management, safety analysis, safety reporting

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