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## Safety Management System Needs Assessment

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## Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Nebraska Department of Roads.



## Abstract

The safety of the traveling public is critical as each year there are approximately 200 highway fatalities in Nebraska and numerous crash injuries. The objective of this research was to conduct a needs assessment to identify the requirements of a statewide safety management system for Nebraska. When fully operational, the envisioned system will allow staff from different Nebraska public agencies to remotely access the system and input and output crash data, identify and analyze high crash locations, identify countermeasures, conduct economic analysis, provide project implementation priority, and evaluate implemented solutions. To achieve the objective, the available literature on traffic safety management systems and software packages were reviewed first. Next, identification of the safety management system stakeholders in Nebraska was conducted, which resulted in the consideration of all Nebraska counties and cities as stakeholders. An online questionnaire was then designed for a survey in which the stakeholders were invited to participate. In this survey, stakeholders were asked about the possible needs they have in a traffic safety management system, and their responses were used to compile their needs. Based on the results of the survey, a conceptual design of a highway safety management system was prepared. This system is based on a database and a set of analysis modules that public agencies can use to help them improve public safety in their affiliated counties and cities.

## Chapter 1 Introduction

### 1.1 Objective

The objective of this research was to conduct a needs assessment to identify the requirements of a statewide safety management system for Nebraska. Implementation of such a system will make crash data more accessible to different public agencies in Nebraska, thereby allowing local jurisdictions to easily identify and analyze high crash locations, identify countermeasures, conduct economic analyses, provide safety-related project implementation priority, and empirically evaluate implemented safety solutions.

The safety of the traveling public is critical as each year there are approximately 200 highway fatalities in Nebraska and numerous crash injuries. Many agencies responsible for public safety in Nebraska have limited resources for collecting and analyzing safety data. The availability of an automated system that staff can access at such agencies will significantly help with more informed decision-making and improving public safety. The system will serve as the main repository of safety data and analysis that is accessible to state, county, and city agencies.

This project was a first step toward establishing an automated statewide safety management system by identifying stakeholders, assessing their needs for such a system, designing a system concept based on the identified needs, and system implementation requirements. This initial needs assessment attempted to quantify the need for a comprehensive statewide system that could support and encourage the proactive consideration of safety in infrastructure planning and safety investments.

### 1.2 Outline

This research was conducted in six stages. In the first stage, after an initial meeting with the Technical Advisory Committee (TAC) members and discussing the research approach and

available research literature, including research papers, members reviewed state DOTs' projects and systems and safety management software packages. Those useful to this research were summarized and included in chapter 2 of this report. The second stage was devoted to identification of the safety management system stakeholders in Nebraska, which resulted in identification of all counties and cities of Nebraska as stakeholders.

Chapter 3 includes details of the stakeholder identification process. An online questionnaire was designed and the stakeholders were invited to participate in a survey during the third stage. In this survey stakeholders were asked about their possible needs related to a traffic safety management system. Responses to the survey were used to compile respondents' needs during the fourth stage and reported in chapter 4 of this report, along with the survey process. In the fifth stage of this project a highway safety management system was designed as a concept based on the results of the survey, and is presented in chapter 5 of this report. The last stage of this project was documentation of the projects and preparing this report, along with a presentation to the TAC members.

## Chapter 2 Literature Review

### 2.1 Objective

The purpose of this chapter is finding and reviewing existing literature on safety management systems. Research papers, state DOTs' projects, and systems and safety management software packages are reviewed and presented in this chapter.

### 2.2 Research Papers

Papadimitriou, Yannis, and Muhlrud (2012) investigated the relationship between road safety performance and road safety management in different European countries. In order to do this, they described the road safety system in terms of a five-level hierarchy: structure and culture, programs and measures, intermediate outcomes (safety performance indicators), final outcomes (fatalities and injury), and social costs. The dependent variable was defined as road safety outcomes, and the explanatory variables were structural and cultural indicators, road safety management indicators, and safety performance indicators. Three hypotheses were tested: road safety management is associated with (i) final safety outcomes, (ii) safety outcomes' development, and (iii) intermediate safety outcomes. The data used in the study was collected from 30 European countries and Beta regression and Quasi-Poisson regression models were estimated. Results showed that road safety management indicators were associated with the operational level of road safety, and there was no direct relationship between road safety management and final outcomes (measures of frequency and severity of traffic crashes).

Xiaobing, Chao, and Feng (2013) designed a traffic safety information management platform based on cloud computing, data warehousing, and data mining that could be used as a tool to connect traffic authority, staff, and the public. The objective of the platform was defined as a tool to control the road safety information database in an attempt to generalize, judge, and

forecast various safety measures, such as traffic crash black-spots, vehicle types exposed to crashes, and weather, as well as gather, tackle, and share detailed traffic conditions without delay. This concept is designed and presented in this study and further real-world implementations are suggested as future studies.

## 2.3 Systems and Projects of State DOTs

### *2.3.1 Virginia*

In 1993, in order to design and create a safety management system (SMS) for the commonwealth of Virginia, a state project by the Virginia Department of Transportation was defined (J D Jernigan 1994). This project, based on the federal regulations on highway safety management systems, was developed in five major areas: coordinating and integrating safety efforts more fully; identifying hazardous highway safety problems and establishing priorities to correct them; ensuring early consideration of safety in all transportation projects; identifying safety needs of special groups in planning and design; and routinely maintaining and upgrading safety hardware. The following steps were taken into account in this strategic plan:

- Identification of the agencies and key personnel who are to represent each agency with an interest in Virginia's SMS.
- Development of the mission statement, goals, and objectives for Virginia's SMS.
- Identification of the highway safety-related data needs of each agency and the role each agency plays in the planning, design, construction, maintenance, and operation of highways.
- Identification of existing data sources that might be useful in identifying highway safety problems, and identification of data systems that could be better coordinated.

- Identification of existing programs that are designed either to identify safety problems or to correct identified safety problems.
- Development of evaluation measures and a monitoring system that stress the results of safety efforts in reducing highway safety problems.
- Identification of ways to build safety into each phase of highway planning, design, construction, maintenance, and operation as a first level consideration.
- Development of a plan for establishing a training program with the Virginia Transportation Technology Transfer Center (VTTTC) to assist localities in the implementation of Virginia's SMS.
- Development of a strategy for implementing Virginia's SMS.

In the final report of the subsequent project (Jack D Jernigan 1996), which investigated some options that have the potential to enhance the ability of Virginia's SMS to facilitate traffic safety in the commonwealth, the committee was recommended to consider these options in this system: (i) establish an SMS coordinator position, (ii) formalize a strategic planning process, (iii) use the SMS to vitalize local traffic safety commissions, (iv) encourage the use of the holistic corridor approach by community traffic safety programs, (v) provide for more integral involvement of the public health community in Virginia's SMS, (vi) determine whether electronic communication would further Virginia's transportation safety goals, and (vii) provide for the implementation of improved traffic records.

### *2.3.2 Indiana*

In order to develop a highway safety management system in Indiana, a project was sponsored by the Federal Highway Administration and Indiana Department of Highways (Farooq

et al. 1995). Similar to the Virginia project, the proposed system in this project was based on the federal regulation on highway safety management systems. The project tasks are defined as:

- Establish Indiana SMS steering committee.
- Identification of Indiana SMS focal point.
- Identification of existing agencies, programs, procedures, and activities.
- Establish an Indiana SMS safety coalition.
- Conduct a traffic records assessment.
- Database development and coordination with other management systems.
- Statewide crash- and safety-related data analysis.
- Selection of safety management strategies.
- Establish needs assessment and prioritization mechanisms.
- Local implementation.
- Training implementation.
- TIP/STIP implementation.
- Advocacy group input.
- Management evaluation.
- Identify resources for SMS work plan and implementation.
- Assure coordination with other ISTEA management systems.
- Develop safety outreach plan.
- Participate in national and regional SMS planning.

### *2.3.3 Iowa*

The Traffic Safety Data and Analysis website of the Iowa Department of Transportation (“Traffic Safety Data and Analysis, Iowa Department of Transportation” 2015) is an online

system that enables users to access the available traffic records and safety reports in Iowa. The website also provides users with contact information for data managers who can assist in providing additional information. This system consists of six different categories of traffic- and safety-related reports and summaries: crash, roadway, driver, vehicle, Injury Surveillance System (ISS)/Bureau of Emergency and Trauma Services (ETS), and citation/adjudication.

## 1. Crash Reports

The crash reports provide different types of information, including:

- Fatalities reports that include daily traffic fatality count (daily updates), annual fatal crash details, annual rural interstate fatal crashes, annual motor vehicle crashes, annual holiday traffic fatalities, monthly motorcyclist fatalities and motorcycle crashes, and registration and licensure.
- A portal to Iowa State Police Patrol crashes. On this website, reports of non-injury, injury, and fatal crashes in Iowa counties can be accessed.
- Crash data based on counties, cities, DOT districts, and school districts.
- Crash data categorized by key emphases (e.g. speeding-related, unbelted persons, heavy truck, etc.) for injury and non-injury crashes.
- Top 200 Safety Improvement Candidate Locations (SICL) – Intersections are also introduced on this website.
- Crash rates and crash densities in Iowa by road system.
- Annual crash data related to drivers' distraction by use of phone or other devices.
- Fact sheets of Governor's Traffic Safety Bureau.



## 2. Roadway Reports

These reports include Vehicle-Miles Traveled (VMT) information categorized by counties, cities, different classifications, different types of roads, etc.

## 3. Driver Reports

These reports include information on motorcycle license and crash history, licensed drivers by age and gender, licensed drivers by county, operating while intoxicated revocations by county, and seat belt surveys. This information can be used in traffic safety analyses.

## 4. Vehicle Reports

Seat belt surveys; vehicle registration statistics by year, county, and type; and flex-fuel vehicle registration by year are provided in this section.

## 5. Injury Surveillance System (ISS)/Bureau of Emergency and Trauma Services (ETS)

In this section of the website injury reports, the Iowa Department of Public Health's motor vehicle trauma report, the Iowa Trauma System 10-Year Report, the Iowa Department of Public Health's Iowa Crash Outcome Data Evaluation System (CODES), and the University of Iowa's Injury Prevention Research Center injury reports are provided to users by county.

## 6. Citation/Adjudication reports

Information on different types of convictions, like failure to stop for a school bus, seat belt, and speeding, are provided on this section of the website.

### *2.3.4 Minnesota Department of Transportation Traffic Safety Analysis Software State of the Art*

The Minnesota Department of Transportation conducted research in 2010-2011 to identify and assess existing crash analysis software tools currently in use by other state agencies (Souleyrette 2011). Besides an Internet review, the research team designed and conducted a survey of different state DOTs that asked about their current safety system, its positive and

negative characteristics, and its missing capabilities. *Table 2.1* presents a summary of the survey results.

**Table 2.1** Different safety systems used by different states (Souleyrette 2011)

State	Safety System(s)	Capabilities	Positive Characteristics	Negative Characteristics	Missing Capabilities
<b>Virginia</b>	Roadway Network System (RNS)	Crash Frequency Crash Rate Crash Density Comparison of Jurisdictions	Ability to display crashes on a map or LRS and retrieve information on the crash Reduce manual input Ability to query crash information in multiple ways	Needing high-capacity data storage devices	Geo-spatial functionality More mapping capabilities
<b>South Carolina</b>	The South Carolina Safety System	Crash Frequency Crash Rate Crash Differentials Comparisons	Being dynamic (modifiable)	Dependence of the results' accuracy upon crash data accuracy which is a paper crash form	-
<b>Maine</b>	The Maine Safety System	Crash Frequency Crash Rate Crash Differentials Crashed per City/Town/County	The ability to respond to crash data requests electronically	Not synchronized with the network system being used	An ad hoc query tool A map based location tool A map-based reporting tool
<b>Michigan</b>	Crash Processing System (TCRS) Crash Analysis System Roadsoft	Traffic Crash Locating Traffic Crash Mapping Daily Safety Analysis Network Analysis Mapping Analysis	Mapping capabilities Timely and accurate crash data Highway alignment data statewide Additional data elements as specified for various HSM analyses	The Lack of Roadway Information off the State System. The number and redundancy of analysis systems The Lack of point of change safety asset data	The mentioned negative characteristics

## 2.4 Software Packages<sup>1</sup>

### *2.4.1 Safety Analyst*

“Safety Analyst is a set of software tools used by state and local highway agencies for highway safety management. Safety Analyst implements state-of-the-art analytical procedures for use in the decision-making process to identify and manage a system-wide program of site-specific improvements to enhance highway safety by cost-effective means. The software automates procedures to assist highway agencies in implementing the six main steps of the highway safety management process, including: network screening, diagnosis, countermeasure selection, economic appraisal, priority ranking, and countermeasure evaluation. Safety Analyst was developed as a cooperative effort by FHWA and participating state and local agencies” (AASHTOWare 2015).

### *2.4.2 FHWA GIS Safety Analysis Tools*

It is a safety management software package in which crash data, roadway inventory data, and traffic operations data can be merged to identify problem locations and assess the effectiveness of implemented countermeasures. By integrating this system with a geographical information system (GIS), which offers spatial referencing capabilities and graphical displays, a crash analysis program can be realized. The analysis tools in this package include five separate programs to evaluate crashes: Spot/Intersection Analysis, Strip Analysis, Cluster Analysis, Sliding-Scale Analysis, and Corridor Analysis (FHWA 2015).

### *2.4.3 Roadsoft*

Roadsoft is a roadway asset management system for collecting, storing, and analyzing data associated with transportation infrastructure. It includes a set of safety analysis tools which

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<sup>1</sup> Software package information was mostly obtained from the respective websites.

is able to filter, sort, and analyze patterns in the crash data using network-screening algorithms. Roadsoft includes NCHRP (National Cooperative Highway Research Program) documentation to find countermeasures that will reduce the frequency and severity of crashes. It also has a collision diagram tool that provides a visual representation of crash data at a given intersection and a trend analysis tool that lets you compile, summarize, and graph specific aspects of a crash (Roadsoft 2015).

#### *2.4.4 Regional Transportation Safety Information Management System (RTSIMS)*

In order to deal with the high crash rate of the Phoenix metropolitan region and develop a reliable and efficient method to assess the safety performance of the regional transportation system, the Regional Transportation Safety Information Management System (RTSIMS) was developed in 2013 (Guntupalli and Joshua 2013). It is a comprehensive safety data analysis software package that has the built-in capability to generate reports with statistics and graphics. It is capable of performing microscopic and macroscopic road safety analysis, crash data analysis for freeway and arterial street facilities, and network screening to identify high crash risk intersections. This software package uses ALISS (Accident Location Identification Surveillance System) and is able to access the Arizona Department of Transportation's crash database.

## Chapter 3 Stakeholder Identification

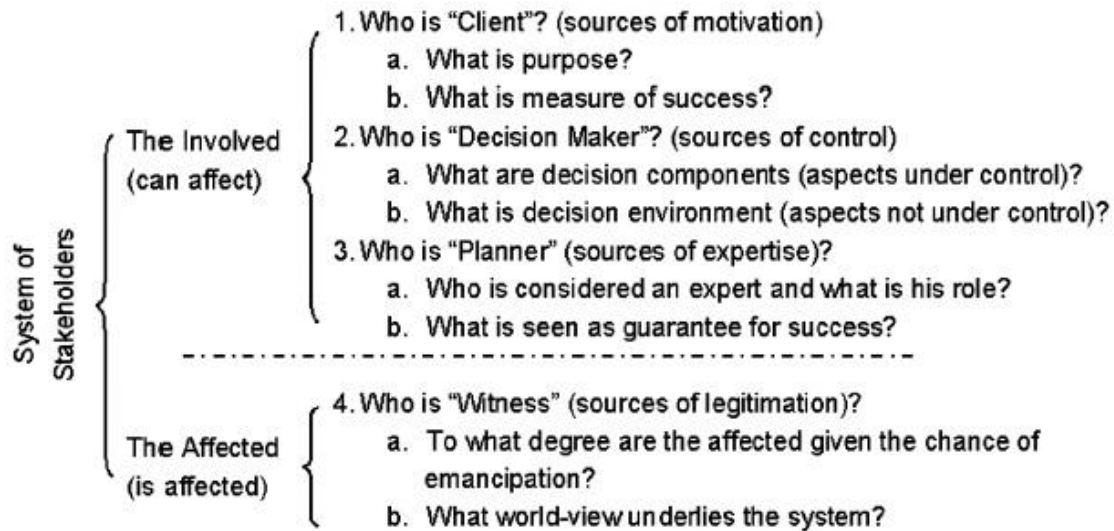
### 3.1 Objective

The identification of potential stakeholders in a safety management system should be undertaken to assess their relevant needs. Stakeholders can be defined as those groups or individuals who may be using the system in any manner. In this project, the identified stakeholders were invited to participate in an online survey to state their needs for a traffic safety management system.

### 3.2 Methods

As a management issue, identification of stakeholders is not an easy task and it should be performed by considering a modeling approach, a normative issue, and their connection. The modeling approach answers the question of who the stakeholders are (e.g. consumers, suppliers, governments, employees, trade unions, social communities, etc.), and the normative issue answers which of these stakeholders we should take into account (Vos 2003). Mitchell, Agle, and Wood (1997) state that attributes of stakeholders are power, legitimacy, and urgency and they can be prioritized based on these attributes.

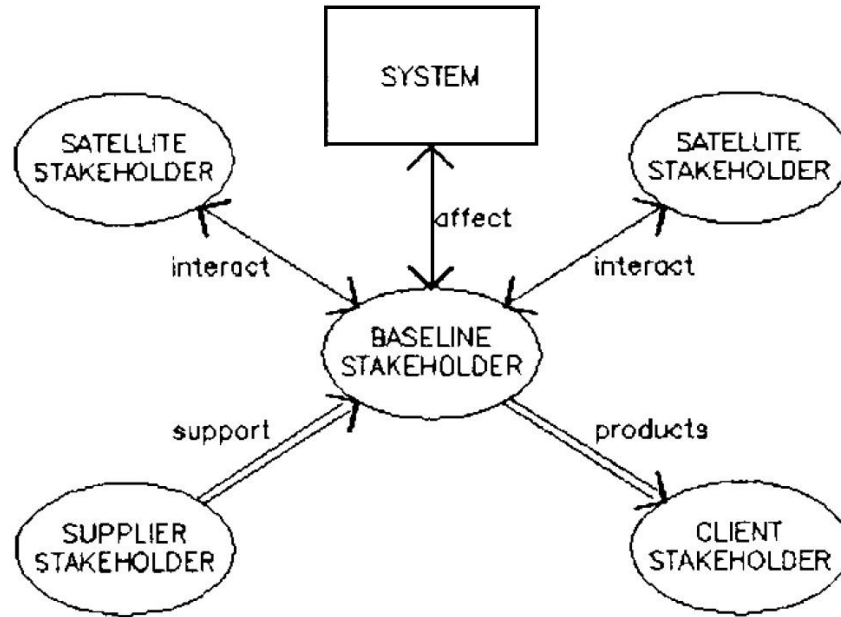
Ulrich (1983) explained that stakeholders were either the involved or the affected. The first set includes clients, decision makers, and planners, while the second set consists of the witnesses who represent the affected, which means that they are indirectly involved in a system. This categorization and the questions that need answers for identification of the categories are presented in Figure 3.1.



**Figure 3.1** A system of stakeholders taken from (Ulrich 1983) and (Vos 2003)

Sharp, Finkelstein, and Galal (1999) define categories of stakeholders as end-users, managers, and others involved in the organizational processes influenced by the system, engineers responsible for system development and maintenance, customers of the organization who will use the system to obtain a service, etc. According to this study, the interactions between the stakeholders include exchanging information, products, or instructions, or providing supporting tasks. This study proposes an approach to identifying stakeholders.

The stakeholders can be divided into different types: baseline, supplier, satellite, and client stakeholders. Baseline stakeholders consist of users, developers, legislators, and decision-makers. Supplier stakeholders provide information or supporting tasks to the baseline, while client stakeholders process or inspect the products of the baseline stakeholders. Satellite stakeholders interact with the baseline stakeholders in different ways. Figure 3.2 displays the main elements of stakeholder identification based on the approach proposed in this study.



**Figure 3.2** The main elements of stakeholder identification addressed by and taken from (Sharp, Finkelstein, and Galal 1999)

A five-step procedure was suggested in this study to explore the web of stakeholders around each of the four baseline groups. The five steps were:

1. Pick a baseline stakeholder group and identify all specific roles within this group;
2. Identify ‘supplier’ stakeholders for each baseline role;
3. Identify ‘client’ stakeholders for each baseline role;
4. Identify ‘satellite’ stakeholders for each baseline role; and
5. Repeat steps 1 to 4 for all other stakeholder groups.

As this approach seemed appropriate and relevant to this project’s scope, it was used to identify the safety management system stakeholders.

### 3.3 Implementation

The five-step procedure mentioned in 0 previous section was implemented in this project. The users, developers, legislators, and decision-makers of the traffic safety management system

as baseline stakeholder groups are identified and reported in Table 3.. It should be noted that the possible stakeholders for this system were not limited to the ones mentioned in this table.

**Table 3.1** Baseline stakeholder groups and their roles in the safety management system

Baseline Groups	Stakeholders
Users	Nebraska state, county, and city agencies
Developers	Transportation/safety engineers Software/database engineers
Policy-makers	Road design, traffic regulators and enforcement personnel Driving and safety policy makers
Decision-makers	Safety and traffic decision makers

The baseline stakeholders introduced in Table 3.1 can be recognized in the state of Nebraska. Based on the baseline stakeholders and the TAC members' recommendation, all of Nebraska 93 counties and 57 cities were recognized as this system's stakeholders and were invited to participate in the online survey.



## Chapter 4 Survey of Stakeholders and Compilation of Stakeholders' Needs

### 4.1 Objective

An online survey of Nebraska stakeholders was conducted regarding needs for a traffic safety management system. All the identified stakeholders received invitations to participate in this survey and express their needs for such a system. This survey was designed to provide information about the existence and characteristics of any current traffic safety system that the participating agencies may be using or have access to, whether they were interested in having access to a new system, and if so, what characteristics it should have and how the agencies want to access to the system.

### 4.2 Questionnaire

Appendix A presents the survey questionnaire used in this research. It starts with an introduction to the survey and mentions the survey objectives. Next, the survey participants were asked to provide information on the following questions.

Question 1 asked the respondent if they had access to a traffic safety system. If they chose the 'yes' option, they were asked to provide information about it, including its name, how long the agency was using it, its capabilities, and any missing capabilities from the agency's point of view that would be considered useful.

Question 2 asked whether the respondent would like to have access to a highway safety management system, and if so, what capabilities were preferred. Eight different capabilities were available for the respondents to choose and they could indicate 'yes' or 'no' for all eight capabilities. The capabilities included the following:

- Online/remote access.
- Input and output/transmittal of crash data.

- Geographic Information System (GIS) capabilities.
- Identification/analysis of high crash locations.
- Identification of countermeasures.
- Economic analysis capabilities.
- Project implementation priority.
- Evaluation of implemented countermeasures.

Question 3 asked about the type of crash information that the agency would like to have access to, and multiple choices could be checked. The choices included the following.

- Crash locations (maps).
- Crash frequencies.
- Crash rates.
- Crash report forms.
- Network-wide analysis.
- Safety countermeasures.
- Other.

Question 4 asked the agency to provide contact information in case of need of further information.

#### 4.3 The Survey Results

An invitation to the survey and two reminder emails were sent to county and city mailing addresses at the beginning of April, mid-April, and mid-October 2015, respectively. Among the invited agencies, eleven agencies participated in the survey. These agencies included the counties of Morrill and Garden, and the cities of North Platte, Seward, Wayne, Blair, York, Superior, Ogallala, Grand Island, and Omaha.

- Question 1: The City of Omaha provided information about its current GIS-based safety management system that has been in use since 2008. Crash data is entered manually into the GIS database and information is queried in GIS and exported to MS Excel in tabular format for further analyses; the limitations of this system were listed as follows:
  1. Manual entry of crash records into the GIS.
  2. Limited reporting capabilities and no capability to generate collision diagrams.
  3. No economic analysis capabilities.
- Question 2: **Table** summarizes the answers and results of this question. The capabilities' priorities needed in the safety management system based on the survey results are presented in **Table 2**.

**Table 4.1** Results of question 2

Agency	Online/remotely Access	Input and output/transmittal of crash data	GIS capabilities	Identification/analysis of high crash locations	Identification of countermeasures	Economic analysis capabilities	Projects implementation priority	Evaluation of implemented countermeasures
<b>Morrill County</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of North Platte</b>	No	No	No	Yes	Yes	Yes	Yes	Yes
<b>City of Seward</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of Wayne</b>	Yes	No	Yes	No	Yes	Yes	No	Yes
<b>City of Blair</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of York</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of Superior</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of Ogallala</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of Grand Island</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>City of Omaha</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>Garden county</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>Number of "Yes"</b>	<b>10</b>	<b>9</b>	<b>10</b>	<b>10</b>	<b>11</b>	<b>11</b>	<b>10</b>	<b>11</b>
<b>Number of "No"</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>
<b>Percent of "Yes"</b>	<b>90.91</b>	<b>81.82</b>	<b>90.91</b>	<b>90.91</b>	<b>100.00</b>	<b>100.00</b>	<b>90.91</b>	<b>100.00</b>
<b>Percent of "No"</b>	<b>9.09</b>	<b>18.18</b>	<b>9.09</b>	<b>9.09</b>	<b>0.00</b>	<b>0.00</b>	<b>9.09</b>	<b>0.00</b>

**Table 2.2** Priority ranks for the safety management system capabilities

Priority Rank	Capabilities	Percent of answers of "Yes" in the whole answers
1	Economic analysis capabilities	100.00
1	Evaluation of implemented countermeasures	100.00
1	Identification of countermeasures	100.00
2	GIS capabilities	90.91
2	Identification/analysis of high crash locations	90.91
2	Online/remotely Access	90.91
2	Projects implementation priority	90.91
3	Input and output/transmittal of crash data	81.82

- Question 3: *Table* summarizes the answers and results of this question. The types of crash information’s priorities needed in the safety management system, based on the survey results, are presented in *Table 4.4*.

**Table 4.3** Results of question 3

Agency	Crash locations (maps)	Crash frequencies	Crash rates	Crash report forms	Network-wide analysis	Safety Countermeasures
Morrill County	yes	yes	yes	yes	yes	yes
City of North Platte	no	no	no	no	no	yes
City of Seward	yes	yes	yes	no	no	no
City of Wayne	yes	no	no	yes	no	yes
Blair, Nebraska	yes	yes	yes	yes	yes	yes
City of York	yes	yes	yes	yes	yes	yes
City of Superior	yes	yes	yes	yes	no	yes
City of Ogallala	yes	yes	yes	yes	yes	yes
City of Grand Island	yes	yes	yes	yes	yes	yes
City of Omaha	yes	yes	yes	yes	yes	yes
Garden county	yes	yes	no	yes	no	yes
Number of "Yes"	<b>10</b>	<b>9</b>	<b>8</b>	<b>9</b>	<b>6</b>	<b>10</b>
Number of "No"	<b>1</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>5</b>	<b>1</b>
Percent of "Yes"	<b>90.91</b>	<b>81.82</b>	<b>72.73</b>	<b>81.82</b>	<b>54.55</b>	<b>90.91</b>
Percent of "No"	<b>9.09</b>	<b>18.18</b>	<b>27.27</b>	<b>18.18</b>	<b>45.45</b>	<b>9.09</b>

**Table 4.4** Priority ranks for the safety management system types of crash information

<b>Priority Rank</b>	<b>Types of crash information</b>	<b>Percent of answers of "Yes" among the whole answers</b>
<b>1</b>	Crash locations (maps)	90.91
<b>1</b>	Safety Countermeasures	90.91
<b>2</b>	Crash frequencies	81.82
<b>2</b>	Crash report forms	81.82
<b>3</b>	Crash rates	72.73
<b>4</b>	Network-wide analysis	54.55

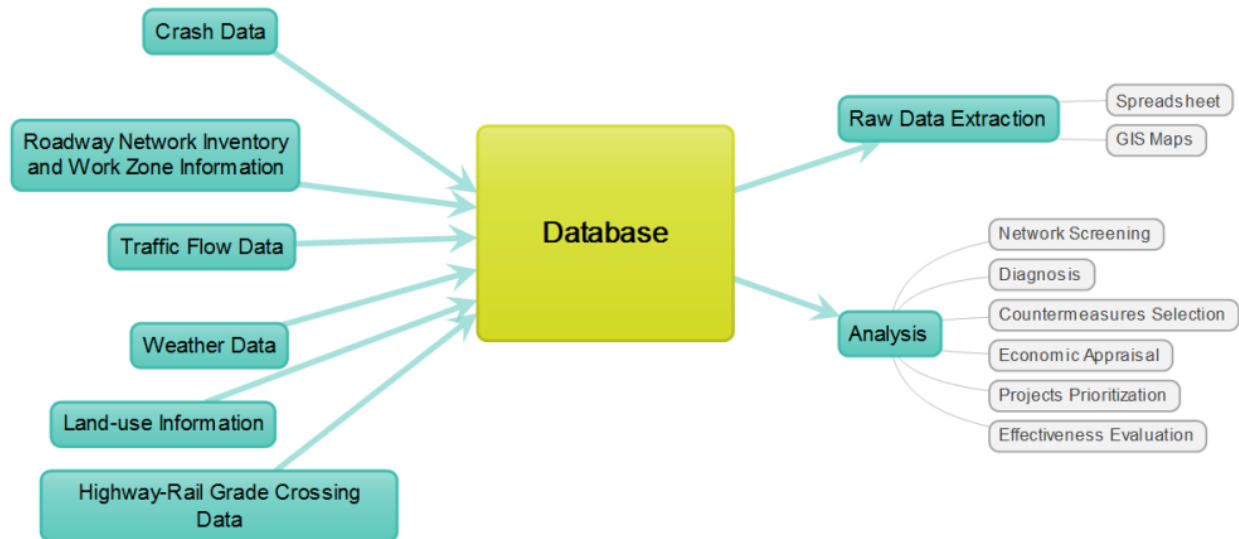
## Chapter 5 Conceptualization of the Safety Management System

### 5.1 Objective

Based on the results of the survey, this chapter presents a conceptual safety management system. It should be noted that this is an ideal sketch that disregards the costs and challenges of developing such a system.

### 5.2 System's Outline

The system consists of a database and a set of input and analyses modules. The database will be updated with new crashes and other information on a predetermined basis and agencies will be able to use the system as a tool to help them decrease the imposed costs of traffic crashes in their affiliated cities and counties. *Figure 5.1* shows the main structure. Components of the system and a detailed description of each are presented in the following sections.



**Figure 5.1** Safety management system concept

### 5.3 Accessibility

Agencies will have online access to the system through a Graphical User Interface (GUI). This GUI can enable users to easily access different parts of the system. Exporting raw data from the system as a spreadsheet or GIS files, and/or using analysis modules to perform a more thorough safety analysis will be possible via this GUI. Raw data, or the data used in the analyses, can be customized depending on the users' preference and can be limited to one or more than one city or county, various time periods, and different variables (e.g. 2012-2015 nighttime rollover crashes in Sarpy County).

### 5.4 Database

The database is made up of six subsets: Crash, Roadway Network Inventory and Work Zone Information, Traffic Flow, Land Use, Weather, and Highway-Rail Grade Crossings (HRGC). Each crash that is stored in the database is associated with a unique identification number, geographic coordinates, and time of occurrence. Using these three pieces of information, the other characteristics stored in the other five subsets can be matched to each crash. It should be noted that characteristics of roadway, traffic flow, land use, weather and HRGCs change over time. Therefore, each crash should be matched with the information related to its time of occurrence, assuming that information is available. If not available, the nearest available information in time will be identified and used. These six subsets are as follows.

#### *5.4.1 Crash*

Crash data is a list of all the crashes and their characteristics reported in Nebraska using the standardized crash form (DR Form 40/41). The SMS's database will get this online information from the Nebraska Department of Roads (NDOR), which is the custodian of statewide crash data. The process for collecting and storing crash data in Nebraska is based on an

interaction between the Highway Safety Division of NDOR and various cities and counties of Nebraska. While most jurisdictions report their crash data to NDOR electronically, some still use non-electronic means of submission. The entire submission process may take time depending on a number of factors, such as error checking and formatting.

Newer methods of crash data collection using online systems can be used in the safety management system, which can be designed consistently for all over the state, resulting in near real-time or a more up-to-date transfer of data to the system. Such data collection may reduce data errors that occur in the data transmission, resulting in more reliable data. Real-time crash data can be used in traffic incident management strategies, such as providing drivers with information about alternative routes using variable message signs or emergency operations in case of an incident. Moreover, the agencies will have the option to input crash data into the system. This will be the crash information that the system is missing and the agency is aware of. This information will not be added to the database until it is verified and confirmed by the Nebraska Department of Roads.

The crash dataset, along with type of crash, crash injury severity, weather, location, lighting and time conditions, vehicles' speed, and other traits and characteristics of drivers, passengers, and pedestrians will include information about other factors that are shown to be effective on frequency and severity of crashes in highway safety literature.

#### *5.4.2 Roadway Network Inventory and Work Zone Information*

The roadway network inventory includes characteristics of the roadway infrastructures in the state of Nebraska. This information is collected and stored by the Materials and Research Division of NDOR and will be utilized in the safety management system. This information should be available as a historical database to ensure that the relevant inventory information at



the time of each crash is used in the safety analyses. The availability of aerial photos and maps in this history database can be useful to system users. The roadway network inventory database will include roadway characteristics that are available from NDOR.

While crashes reported in work zones are identified on the crash form, work zone information on elements such as, signage, traffic control and markings, reduction in speed limit, acceleration/deceleration lanes, channelization, attenuators, etc. is usually not readily available. Such information is critical for improving work zone safety and is therefore recommended to be part of the database.

#### *5.4.3 Traffic Flow*

The traffic flow subset of the database will include different measures of traffic volume, speed, density, and traffic composition in the transportation network. Similar to the roadway network inventory, traffic flow information is collected, estimated, and stored by the Traffic Engineering Division of NDOR and will be utilized in the safety management system. Again, this information will be needed as a historical database to be matched to relevant crashes. Elements in the traffic flow database will consist of those available from NDOR (traffic volume, traffic composition, etc.).

#### *5.4.4 Land Use*

Numerous studies have reported land use characteristics of an area as effective factors on the number and severity of traffic crashes. These characteristics include sociodemographic information and neighborhood characteristics in the vicinity of the transportation network. In the SMS, most of the demographic information will be obtained from the US Census Bureau. Supplementary information can be provided to the system by the cities and counties of Nebraska. Accurate by-block population and employment information may not be available for the exact

dates that the crashes occurred. In such cases, the nearest available information or an estimation can be used in the safety management system. Elements of the land use data may include:

- Population
  - Accurate from census
  - Estimation
- Demographic information
  - Average household income
  - Average residents' age
  - Average rate of male/female
- Population density
- Employment information
- CBD/non-CBD
- Rural/Urban

#### *5.4.5 Weather*

Besides the weather conditions recorded on the crash form, more detailed weather characteristics can be useful for crash analysis. These details could include amount of precipitation, temperature, wind speed, gust speed, and micro-weather events (e.g., hail), among others. Detailed weather information can be obtained from several sources such as NDOR's Road Weather Information System (RWIS), the National Weather Service (NWS), the University of Nebraska High Plains Regional Climate Center, or commercial vendors. Arrangements for regular updates would be needed so the information is up-to-date. If weather information is not available for a specific location or a point in time, a spatial or temporal average value can be used. Weather characteristics consist of the following variables:

- Atmospheric
  - Air temperature and humidity
  - Visibility distance
  - Wind and gust speed and direction
  - Precipitation type and rate
  - Cloud cover
  - Tornado or waterspout occurrence
  - Lightning
  - Storm cell location and track
  - Air quality
- Pavement
  - Pavement temperature
  - Pavement freezing point
  - Pavement condition (e.g., wet, icy, flooded)
  - Pavement chemical concentration
  - Subsurface conditions (e.g., soil temperature, if available)
- Water level data
  - River, stream, and lake levels near roads

#### *5.4.6 Highway-Railroad Grade Crossing (HRGC) Inventory Database*

Characteristics of HRGCs are needed for consideration in analyses of crashes reported at or near rail crossings. These characteristics can be used and stored in the system's database through the Federal Railroad Administration's (FRA) inventory database. There is also a history

inventory database accessible through FRA, which is appropriate for use in the SMS in order to use the characteristics of the crossings at the time of crash occurrence.

### 5.5 Analysis Modules

Besides having access to the database and extracting the desired sets of data, users of the SMS will have the ability to perform safety analyses using the available system modules. These modules are designed considering the Highway Safety Manual's six steps of safety analysis (AASHTO 2010).

- Network Screening

This module is able to divide highways of the area under study into segments with variable lengths, including the intersections, interchanges, and roundabouts, and sort and prioritize these segments based on a safety measure and consequently, rank their potential for safety improvements or further investigation. The safety measures can be chosen among crash frequency, expected crash frequency, crash rate, crash severity (in terms of injury and/or monetary costs), or a combination. The sliding window method or peak searching method can also be available in this module as an alternative to the ranking method (for more information on these methods one can refer to [AASHTO 2010]). The results will be in terms of tabular reports and GIS maps. The duration of the crash data that is used in this analysis should be long enough to overcome the possibility of regression-to-the-mean bias.

- Crash Diagnosis

The purpose of this module is finding the factors that contribute to the frequency and severity of crashes. Depending on the need of the SMS's users, this analysis can be done in two different ways. The first is when the user is interested in finding out the

effective factors on frequency or severity of crashes in a specific location, such as an intersection or a few adjacent blocks. In this case, the system will be able to generate collision diagrams and conditions diagrams for the considered crashes. These diagrams can be helpful in finding the specific effective factors on crashes in the specified location. The second way is when the user is interested in doing a broader type of analysis, for example, finding the effective factors on the frequency of crashes that occurred at intersections in the city of Lincoln. In this case, the module will be able to perform descriptive statistical analysis, such as generating bar charts, pie charts, or tabular summaries; or more accurately, use statistical modeling techniques, which will include regression and discrete choice modeling approaches for modeling frequency and severity of crashes, respectively.

- Selection of Countermeasures and Economic Appraisal

After finding the contributing factors to frequency or severity of crashes using the crash analysis module (or using other methods by the analysts not using the SMS), appropriate countermeasures that deal with the specified factors are presented to the users using this module. Based on engineering judgement and the feasibility of implementation of countermeasures (physically, politically, or financially), some of the presented countermeasures may be excluded from the possible options. In order to select the best countermeasure or combination of countermeasures for each location, a benefit-cost analysis will be available in this module. So, the benefits and costs of each presented countermeasure should be quantified.

The costs of implementing each countermeasure in the state of Nebraska will be available in this module, and the details of each countermeasure can be modified by the

user to get a relatively accurate value. Also, the costs value can be modified by the users manually in order to consider the indirect costs that a countermeasure may impose upon society. Quantifying the benefits of implementing each countermeasure is more complicated than its costs. If the crash diagnosis module is used before getting to this step and crash frequency and/or severity models are already developed, the decrease in crash frequency and severity, and consequently, the benefits of each countermeasure in terms of decrease in crash costs after implementing each countermeasure can be calculated using those models. Otherwise, the users have to manually calculate the benefits and enter them into the module.

- **Prioritization of Projects**

After the economic evaluation of the countermeasures using the economic appraisal module, the best countermeasures for each of the sites are determined. But because of budget and other possible constraints, it is almost never possible to implement all the countermeasures and the projects should be prioritized based on their specific costs and benefits to the community. This module will be used to find a feasible set of projects that have the most possible positive effects on the safety conditions of the area under study compared to all other feasible sets of countermeasures. In this module, projects prioritization can be done using ranking methods, incremental benefit-cost methods, and optimization methods depending on the users' preference and available information.

The ranking methods sort the projects based on a measure of benefits, e.g. reduction in number of crashes, from high to low in a list. Then the projects with highest values of the measure can be chosen to implement from the list one by one until the

budget limit is met. The optimization approach formulates the prioritization problem as an integer mathematical program that maximizes the benefits while considering the budget constraint and other possible constraints, e.g. number of available safety equipment. Incremental benefit-cost methods are similar to the ranking methods, the difference being that these methods use a measure of benefits and costs for each project in the ranking procedure.

- Safety Effectiveness Evaluation

Before and after studies need to be conducted to evaluate the effectiveness of the implemented countermeasures. This module will be able to perform this kind of evaluation for a specific site to evaluate a single countermeasure or for a set of sites to evaluate a set of countermeasures. The specific site evaluation module is able to compare two sets of crash frequency and/or severity data collected before and after the implementation of the countermeasure in terms of mean and variance using statistical methods. Two sets of cross sectional crash frequency/severity data should be collected in the set of sites before and after implementation of the countermeasures and statistical methods, such as paired t-test. This will be able to compare these two sets as the other part of this module. More sophisticated statistical analysis modules like the Empirical Bayes method can also be made available in the module.

Moreover, agencies will be able to store and provide other agencies with access to their safety effectiveness evaluation results through this module. These results can be helpful to other agencies in terms of countermeasure selection and effectiveness evaluation.

## Chapter 6 Conclusions and Discussion

This research assessed the needs of different agencies in Nebraska for a statewide traffic safety management system that will serve as the main repository of safety data and analysis. Staff from these agencies will be able to remotely access this system and input and output crash data, identify and analyze high crash locations, identify countermeasures, conduct economic analysis, provide project implementation priority, and evaluate implemented solutions. The outcome from the project included an assessment of the needs of stakeholders, conceptualization of a safety management system, and requirements for implementation of such a system.

This project was completed in six stages. In the first stage, available traffic safety management system research literature and software packages were reviewed. The second stage included the identification of the safety management system stakeholders in Nebraska, where all the counties and cities of Nebraska were identified as the stakeholders. An online questionnaire was then designed for a survey and the stakeholders were invited to participate during the third stage. In this survey stakeholders were asked about the possible needs they have in a traffic safety management system, and their responses were used to compile their needs during the fourth stage. In the fifth stage of this project, a highway safety management system was designed as a concept based on the results of the survey. The last stage of this project was documentation of the projects and preparation of this report, along with a presentation to the TAC members.

As was mentioned in chapter 4, only 11 agencies participated in the survey among 150 invited agencies, which means less than 8 percent participation despite the three invitation emails that were sent to the stakeholders. It also should be noted that, based on the frequency of crashes in 2014 (Nebraska Department of Roads 2015), 36% of the Nebraska's crashes occurred in the cities or counties where the affiliated agencies participated in this study's survey. All further



work in this study, such as conceptualization of a safety management system, was based on those 11 agencies' responses. So, the decision makers should consider this relatively low response rate (and also the relatively high ratio of crashes that these agencies represent, 36%) when making their decision in planning for a safety management system in Nebraska. Also, the decision makers should answer the question of whether this response rate is enough to conclude whether or not Nebraska needs a safety management system.

The concept of the safety management system that was presented in chapter 5 of this report disregards the probable costs and limitations. In the case of budget constraints, the development of different features of the system can be prioritized based on the results of the survey that was conducted in this project. Other limitations, such as difficulty accessing different types of databases that are from different agencies or state departments, unavailability of a crash recognition technology, deficiency in crash history and other types of information datasets, etc., may be present and should be considered in designing and developing a real safety management system.

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## Appendix A



University of Nebraska–Lincoln Nebraska Transportation Center (<http://ntc.unl.edu/>)

### Needs Assessment for a Highway Safety Management System

Dear Sir/Madam: We are conducting a survey of Nebraska agencies to assess their road safety management needs. The effort is to understand what information and analysis capabilities are available to different agencies with respect to management of road safety and what are their desires with respect to management of road safety. Response to any or all questions is voluntary but we will greatly appreciate a fully completed questionnaire. Contact Dr. Aemal Khattak (402-472-8126/ [khattak@unl.edu](mailto:khattak@unl.edu)) or Nicole Frankl (402-472-1226/[nfrankl2@unl.edu](mailto:nfrankl2@unl.edu)) in case of questions. Thank you.

#### Responding Agency Information

Agency Name:

Street Address:

City:

Zipcode:

Phone:

Email:

Contact/Responding Person Name:

1. Does your agency have access to a traffic crash safety system/software?

- No  
 Yes

1a. Please provide information on this system/software (e.g., system/software name, supplying agency or vendor, maintenance and update availabilities, etc.)

1b. How long has your agency been using this system/software?

1c. Please describe the capabilities of this system/software.

1d. What capabilities are missing from your agency's crash safety system/software?

2. Would your agency like to have access to a highway safety management system? This system may have the following capabilities, indicate "Yes" or "No" by each capability below:

- |  |                                      |                          |
|--|--------------------------------------|--------------------------|
| Online/remotely Access                           | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Input and output/transmittal of crash data       | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Geographic Information System (GIS) capabilities | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Identification/analysis of high crash locations  | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Identification of countermeasures                | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Economic analysis capabilities                   | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Project implementation priority                  | <input checked="" type="radio"/> Yes | <input type="radio"/> No |
| Evaluation of implemented countermeasures        | <input checked="" type="radio"/> Yes | <input type="radio"/> No |

3. What type of crash information would your agency like to access (multiple options may be checked)?

- |   |   |
|---|---|
| <input type="checkbox"/> Crash locations (maps) | <input type="checkbox"/> Crash frequencies      |
| <input type="checkbox"/> Crash rates            | <input type="checkbox"/> Crash report forms     |
| <input type="checkbox"/> Network wide analysis  | <input type="checkbox"/> Safety countermeasures |

Other:

4. Whom should we contact in case we need more details?

Name:

Telephone:

Email:

Street Address:

City:

Zipcode: