Systematic Identification of High Crash Locations

Proposal

Submitted to
The Iowa Highway Research Board
Iowa Department of Transportation
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Prepared by
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PROJECT TITLE
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INTRODUCTION
Federal and state policy makers increasingly emphasize the need to reduce highway crash rates. This emphasis can be witnessed at the state level in Iowa's recently released draft "Iowa Strategic Highway Safety Plan" and, at the federal level, by the U.S. Department of Transportation's placement of "improved transportation safety" at the top of its list of strategic goals (1,2). This increased emphasis on safety has placed additional pressure on highway agencies to find improved methods to enhance highway safety.

This research project seeks to develop a tool and a process by which Iowa engineers can identify potentially hazardous roadway locations and designs. By identifying design features or characteristics that may lead to higher crash risk, engineers can proactively avoid such hazards in future roadway designs or eliminate them in existing roadways. Through a series of case studies, the project will identify the relationship between crash rates and specific roadway design features, geometry, or other characteristics (e.g., high levels of truck traffic). The proposed process will be developed based on a system of integrated, geographically referenced databases, whereby the safety performance of Iowa's highways, highway segments, specific design features, and individual locations can be monitored.

This project will use a variety of existing databases in geographically referenced environments. The principal databases to be included are Iowa's crash records database and the Iowa highway base record, but other databases (traffic records, cartography files, as-built files, digital photos, etc.) will be included as appropriate. These databases will be integrated to focus on safety analysis and monitoring, resulting in a composite database in which the roadway characteristics leading to heightened crash rates can be determined.

An important feature of the proposed research is that it interconnects databases that have not previously been used together systematically but that, when fused, create a rich environment for conducting safety analyses. Compiling the data sets needed for this project is possible only because of previous investments by the Iowa Department of Transportation's in the development of multiple geographically referenced databases.

In summary, the project will develop a process to identify contributing factors that lead to crash occurrences under given roadway and/or environmental characteristics. This process will further assist the research team to identify the existing and potential "problem" areas throughout Iowa. For example, in order to identify statewide locations of high number of accidents occurring during wet weather conditions, the integrated databases will be searched for all wet weather related accidents. Each selected crash record contains detailed information about the accident site and the crash characteristics. Statistical analyses of the selected crash data will then determine whether engineering

and/or human errors are the most significant factors in the causation of crashes during wet weather conditions. Having determined the "problem" type, the statewide "problem" areas can also be identified. The graphical representation of the proposed process is shown through a data flow diagram in Figure 1.

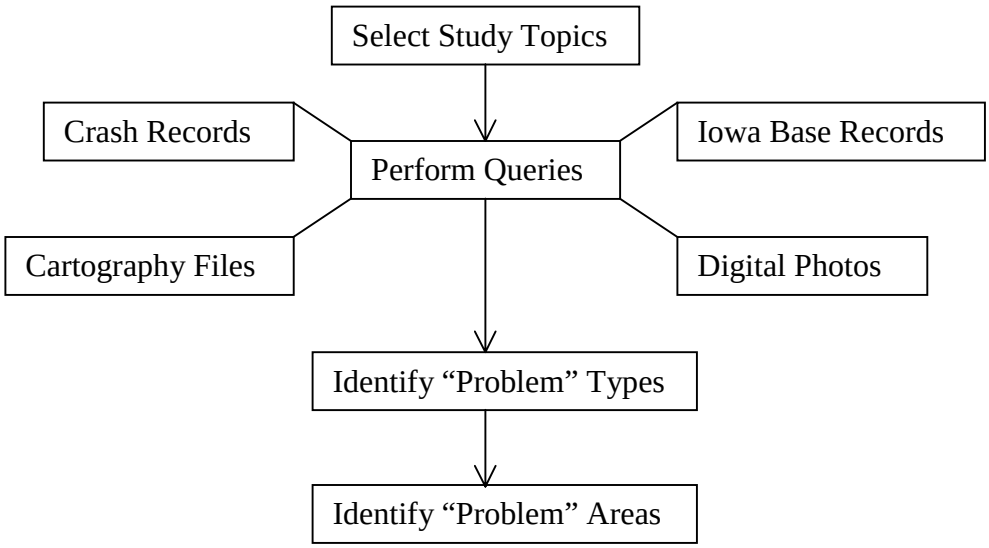

Figure 1. Data Flow Diagram - "Problem" Area Identifications

LITERATURE REVIEW

Roadway characteristics have substantial impacts on traffic safety. In 1988, for example, fatality rates on rural interstate highways were reported to be less than fatality rates on rural federal and non-federal-aid primary arterials by factors of two and five, respectively (3). Potential factors that make accident rates different from one roadway class to another are physical roadway characteristics such as geometric design, markings, signs, and traffic conditions. Understanding the relative importance of design features to the safety of a facility can help engineers reduce or eliminate the use of certain unsafe features and incorporate other features that enhance safety.

A number of studies have investigated the empirical relationships between vehicle crashes and individual highway geometric design elements and features through the modeling of statistical relationships between features and crash rates (4, 5, 6, 7). The primary data source used in these studies was the Highway Safety Information System (HSIS). The HSIS, developed by the Federal Highway Administration (FHWA), is a multi-state database containing information about accidents, roadway inventory, and traffic volume data for a select group of states (8). These studies provide useful insights into specific design features, but because they are based on national averages their use in Iowa is questionable.

A preliminary review of research relating traffic safety to highway geometry provided guidance regarding design features that have a significant safety impact. Further, earlier research also provides important insight into statistical approaches for modeling relationships between highway features and geometry and highway safety.

The proposed research provides additional analysis of these relationships for Iowa-specific case studies and a process by which Iowa can provide engineering and safety specialists feedback on the safety performance of Iowa transportation facilities. Developing the relationships is only the first phase of the proposed process. The second phase is to apply the relationships and identify potential "problem" areas with the data available in Iowa.

PROBLEM STATEMENT

Transportation agencies are continually faced with decisions concerning the design and operations of highway systems. An important aspect of this decision-making process is the design impact on the highway safety.

Most safety related improvements in Iowa are generally reactive. In other words, the safety countermeasures are applied to the roadway after high crash rates have been observed. According to the current Iowa safety practice, a candidate location is selected from a list of high accident locations, which are determined based on their crash history. The high accident locations are determined based on crash frequency, rate, and financial impact. The current ranking procedure makes, for example, an intersection with ten crashes (which may have occurred due to drivers' recklessness) a good candidate for safety improvements. In other words, the approach may result in the selection of location for which a safety improvement will have no impact. Meanwhile, locations with solvable safety problems remain untreated. These are usually the locations that might benefit more from engineering improvements.

By quantifying the impact of highway geometry and design features on crash rates, this research would enable agencies to proactively identify and deal with "problem" areas. In other words, instead of waiting for crashes to occur in order to determine if a highway section warrants a countermeasure, they will be able to predict an expected crash rate of the section.

An important aspect of this research is that it exploits and builds on two existing Iowa databases: the Iowa crash record system and the Iowa highway base record system. Iowa governments have spent considerable resources on these databases, and this project will mine these databases to provide additional safety returns.

PROPOSED RESEARCH

The proposed research will include the following tasks.

Task I. Form an Advisory Committee
An expert advisory panel will be established to help direct the project. Members of the advisory panel will include Iowa transportation and safety professionals (state, county and city) and/or national experts on traffic safety.

Task II. Select Study Topics
With the assistance of the advisory panel three study topics will be selected. The selected study topics will be of interest to the Iowa Department of Transportation, and Iowa county, and city transportation agencies. The research team recently met with a representative from the DOT, counties, and cities to generate a preliminary list of highway design features that are of interest and could be investigated through the proposed project. Some of the safety issues identified are listed below:

State
- Safety impact of shoulder surface conditions (e.g., paved or unpaved)
- Safety impact of horizontal curve characteristics (i.e., degree, direction, and radius)
- Safety impact of turn lanes in creating traffic turbulence and weaving
- Safety impact of weather, pavement markings, and elderly drivers
- Safety impact of speed limits of 50 mph or more on expressways
- Analysis of the factors and location that result in high rates of run-off-the-road crashes
- Analysis of the factors and location that result in high rates of fixed object accidents
- Analysis of the factors and location that result in higher rates of red-light-running crashes

County
- Similar safety concerns as the state with federal-aid roadway systems
- Verification of current accident reduction factors
- Analysis of the factors and location that result in high rates of run-off-the-road crashes on gravel roads
- Analysis of the factors and location that result in high rates of crashes resulting from running stop signs

City
- Safety impact of the number of accesses per mile
- Safety impact of signalized turning bays
- Safety impact of speed limit
- Safety impact of traffic volume and traffic mixture
- Safety impact of roadway design on land use

Task III. Develop an Integrated Database
The main source of information for this project will be the Iowa highway base record and Iowa crash record systems. The Iowa DOT base records contain general roadway

information (e.g., lane width, surface type, and shoulder type) for each roadway location. Crash records include data on vehicles, drivers, roadway conditions, and the severity of the crashes. The geographically referenced roadway base record data and crash records [i.e., the Geographic Information System Accident Analysis and Location System (GISALAS)] contains the location and characteristics of all Iowa crashes during the past ten years. Currently, project teams at the Center for Transportation Research and Education (CTRE) are working to relate crash records and traffic volume data to approximate the crash rate at every point on the Iowa roadway network.

Other data sources that might be used in the research include ortho-corrected aerial photos, cartography files, as-built plans, and recently available high-resolution satellite data. Highway features and geometric information data (e.g., the existence and length of turning lanes, the existence and width of medians) will need to be entered into a database manually, through the use of image processing technology (if a completely automated data entry procedure is possible), or through an automated GIS-based technique. The best approach will be determined after further investigation. This database will then be linked with geographically referenced roadway base record data and crash records. This integrated database will provide roadway-related variables such as classifications, alignment, cross-section elements, traffic conditions, and other roadway features for each crash record.

The selected study topics will dictate the content and scope of the database. One integrated database for a particular study topic may include data from several counties or even the entire state, whereas data for another topic may be limited to a single county. The conclusions and recommendations provided for each study topic will depend on the data that forms the basis of their analysis.

Task IV. Identify "Problem" Types – Data Analysis

The integrated database constructed in Task III will allow the roadway and crash data related to the study topics selected in Task II to be determined. The database will be queried to determine the related roadway and crash data. For example, to determine high accident locations along 4-lane undivided roadways (i.e., a roadway-related study topic), the database will be searched for all roadways with this characteristic. To determine wet weather high accident locations (i.e., a crash-related study topic), however, the database will be queried for all wet weather-related crashes.

Statistical analyses of the roadway-crash records will allow identification of the "problem" types. The resulting statistical models will determine the significant factors in causation of accidents. They will indicate whether the resulting accidents are due to engineering and/or human errors.

Any models that need to be developed will use the most applicable statistical approaches and software packages. If required, statistical techniques that allow the quantification of the effects of a variety of roadway design factors on crash rates will be used.

Task V. Identify Potential and Existing "Problem" Areas
Having determined the "problem" types, the research team will then determine (if possible) the "problem" areas throughout the state and/or selected counties. For this research, the problem area identification process will be done for candidate counties (ranging from rural to urban) or statewide roadway systems. These candidate entities will be selected with the assistance of the advisory panel.

Task VI. Document the Process
One product of this project will be the process for integrating existing databases. In the future, these databases may be used to conduct other safety-specific case studies analyses as well as to monitor the safety performance of specific facilities, geometric features, and locations.

Task VII. Document the Findings
A final report of project findings will be prepared. An interim report will also be completed to provide updates to the Research Board. These reports will document the research activities, statistical analyses, and results. The software used or developed, and the procedures followed in this research will also be documented and presented in the final report.

ESTIMATED COST

Personnel	**Iowa DOT Expenses**	**MTC Match**
Reg Souleyrette, Co-PI		
1 month - summer	$7,788	
Fringe Benefits, 23.17%	$1,805	
Ali Kamyab, Co-PI		
50 Percent, 12 Months	$27,533	
Fringe Benefits, 29.18%	$8,034	
Keith Knapp, Faculty Associate		
1 Month	$6,452	
Fringe Benefits, 23.17%	$1,495	
Aemal Khattak, Statistical Analyst		
1 Month	$3,740	
Fringe Benefits, 29.18%	$1,091	
Zach Hans, GIS Coordinator		
20 Percent, 12 Months	$9,261	
Fringe Benefits, 28.18%	$2,702	
Secretary/Account Clerk		
15 Percent	$4,842	
Fringe Benefits, 35.47%	$1,717	
Graduate Research Assistant		
One Half-Time for 12 months	$7,250	$7,250
Fringe Benefit	$400	$400
Undergraduate		
500 hours	$2,500	$2,500
Total Personnel	$86,610	$10,150
Other Direct Expenses		
Supplies, Copies, and Misc.	$500	
Telephone and communications	$250	
Total Other Direct	$750	$0
Total ISU Direct Expenses	$87,360	$10,150
ISU Indirect Expenses	$38,875	$4,517
Project Total	$126,235	$14,667

RESEARCH PERIOD

The proposed research will begin January 15, 2000 and will be completed by January 15, 2001.

REPORTS

Two reports will be provided:

- Interim report in June 2000
- Final report in January 2001

PRINCIPAL INVESTIGATORS

Reginald Souleyrette and Ali Kamyab will serve as co-principal investigators on this project. Dr. Souleyrette will provide technical support and oversee the project policy and vision. Dr. Kamyab will be responsible of the day-to-day management of the project and documentation of procedures. Keith Knapp will be responsible for geometric design implications of the project, and Aemal Khattak will be in charge of statistical analyses of data. Zach Hans will perform the integration of databases.

REFERENCES

1. Iowa Safety Management System, "Iowa Strategic Highway Safety Plan," Iowa Department of Transportation, Ames, Iowa, Draft, August, 1999.

2. United States Department of Transportation, "Strategic Plan for Fiscal Years 1997 – 2002," http://www.dot.gove/hot/dotplan.html

3. Shaw-Pin, M. and H. Lum. *Statistical Evaluation of the Effects of Highway Geometric Design on Truck Accident Involvements*, Transportation Research Record 1407, Transportation Research Board, National Research Council, Washington D.C., 1993, pp. 11-23.

4. http://tfhrc.gov/humanfac/rd93-046/rd93-046.htm, *The Association of Median Width and Highway Accident Rate*, Summary Report FHWA RD-93-046, Federal Highway Administration, Mclean, Virginia, 1993.

5. Shaw-Pin, M., P. S. Hu, T. Wright, A.K. Rathi, and S.C., Davis. *Relationship Between Truck Accidents and Highway Geometric Design: A Poisson Regression Approach*, Transportation Research Record 1376, Transportation Research Board, National Research Council, Washington D.C., 1992, pp. 10-18.

6. Shaw-Pin, M. and H. Lum. *Modeling Vehicle Accidents and Highway Geometric Design Relationships*, Accident Analysis and Prevention, Vol. 25, No. 6, 1993, pp. 689-709.

7. Milton, J. and F. Mannering. *The Relationship Among Highway Geometrics, Traffic-Related Elements and Motor-Vehicle Accident Frequencies*, Transportation, No. 25, 1998, pp. 395-413.

8. http://www.hsrc.unc.edu/hsis/hsis_brochure.html, *Highway Safety Information System (HSIS)*, Federal Highway Administration, Mclean, Virginia.