October 1, 2008

Larry Corsi
State Program Manager
Bureau of Transportation Safety

Subject: Progress Report

Traffic Operations and Safety Laboratory
Master Contract Project I.D. 0072-39-01
Work Order: Local Safety Improvement Decision Support System

Dear Mr. Corsi:

Transmitted is the project progress report rendered by the Traffic Operations and Safety Laboratory at the University of Wisconsin-Madison for the Local Safety Improvement Decision Support System Project.

The key accomplishments as a result of the project are highlighted as below.

1. The framework for Local Safety Improvement Decision Support System is completed. Four key modules as well as their relationships have been identified.
2. The user interface and functions of the Crash Mapping Automation Tool (C-MAT) developed in the previous project “Demonstration of Automatic Mapping of Wisconsin Local Crash Locations” have been improved. The new interface is more user-friendly and more flexible in handling individual datasets with smaller scale such as crash data from a county instead of the whole state. The upgrade allows the online crash mapping application to be completed within a reasonable waiting time.
3. A total of 392,862 crashes occurred on local roads and streets within five years (2002-2006), excluding parking lot and private property, have been processed and mapped using C-MAT. Crash point shapefiles are currently available for the five-year local crashes.
4. With the aid of any GIS software packages such as ArcGIS or ArcView, detailed crash information can be listed along with the crash. The visually displayed crashes in a map format assist users in identifying crash clustering locations with apparent ease.
5. Intersection-related crashes can be aggregated to the intersection-level and thereby, these intersections can be assessed by a weighted average of crash counts, severities and types. The intersection safety performance can be ranked and countermeasures can be prioritized according to the score that each intersection receives.
6. A web-based on-line crash query tool with map interface has been piloted. Crashes can be queried by attribute in the similar context of the WisTransportal Crash Retrieval Facility or queried by location in a spatial context.
a. Query by attribute: For instance, the tool can immediately display crashes on a map queried directly from any attribute or their combinations provided in the WisTransportal Crash Retrieval Facility. Note that it is for now in the piloting stage, so the tool has not been integrated into the WisTransportal Crash Retrieval Facility or connected to the WisTransportal crash oracle database, an emulated WisTransportal Crash Retrieval Facility with a smaller scale using Dane County crash data is being tested.

b. Query by location allows two major operations: query by route and query by area. Query by route allows users to select the begin and end points of a route and search all crashes occurred between point A and point B. Query by area allows users to draw a rectangular box or any irregular shape and query all crashes within the geometry.

c. The summary statistics of the queried crashes by injury severity can be displayed and printed simultaneously. Taking advantage of the strengths of GIS, detailed crash information can also be displayed next to the location of each crash. More importantly, digitized crash police report, if available, can be linked to individual crashes and displayed by a simple click. In summary, the crash location and other information can be interactively changed, exhibited, and summarized with different queries.

The web-based on-line crash query tool provides users a one-stop shop for crash information retrieval and query, crash location visualization for patterns and trends, crash summary statistics, and information integration.

Please find the detailed project progress report in the attachment. If you have any questions or comments, please do not hesitate to call me at 608-262-3649 or send me an email to xqin@engr.wisc.edu.

Sincerely,

Xiao Qin, Ph.D., P.E.

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This project is dedicated to offering safety solutions to the local agencies who need help to improve highway safety in their jurisdictions but do not have sufficient resource to identify safety problematic areas and address appropriate treatments. To date, the project has created crash spot maps for all the counties and jurisdictions in Wisconsin and established an analytical framework for identifying crash hot spots for local intersections road segments. A reporting template has been designed to provide local agencies and engineers with a suite of tools for field engineering investigation. The summary report provides updates on the recent accomplishments in the second phase of the project.

In Phase II, the progress has made on the basis of geocoded crashes which was completed early this year. The key modules of the local safety improvement decision support system have been identified and the functions of each module are described as below.

- Module 1 is a crash address locator in which key data is imported, cleaned and filtered to meet the requirements for further analysis;
- Module 2 is a crash data plotter where crashes are geocoded on the WISLR map, and crash information is digitized for queries and analysis;
- Module 3 is a hazardous locations identifier in which sites can be ranked based on their safety performance to screen the “sites of promise”;
- Module 4 prepares reports to assist users with three-tier safety improvement investment plans.

The flowchart of the system framework is illustrated in Figure 1. Local highway locations, segments, intersections or ramps, along with the crash information can be screened on a periodic basis (quarterly, yearly, or other program cycle). If a specific location is flagged by the system, relevant information is assembled and conveyed to local communities or to the Wisconsin County Highway Association (WCHA) through highway safety circuit riders or regional safety engineers for further safety scrutinies. Otherwise, locations are required to collect more years of data for the support of any safety improvement decisions. In other words, the system can also be used to monitor local safety performance with the addition of new data every year. Key components of the system including user interface design, tools and models are elaborated in the following sections.
Module 1: Locate rural crashes in WISLR database

Module 2: Digitize rural crashes on WISLR maps

Module 3: Identify hazardous locations at intersection/segment level

Module 4: Develop investment tiers

FIGURE 1 System framework flowchart.
Module 1: Crash Address Locator

Module 1, crash address locator, was developed to facilitate crash location recognition in a rapid and automated manner. A brief description of the four-step procedure is presented below and details can be found in project report “Demonstration of Automatic Mapping of Wisconsin Local Crash Locations”:

- **Filter**: In this step, if a crash does not have “on street” information, it is removed. Note that the system is developed for locating rural local crashes. Hence, crashes occurred at municipalities whose population exceeds 5000 or state highways are also removed. Other filtering mechanisms include removing crash records with neither “at highway” or “at street” information, parking lot and private property. The filtering criteria can be adjusted for new definition of rural local crashes.
- **Partition**: Each crash record is parsed into prefix, street name, roadway type, and suffix if they can be. The purpose of partition is to maximize the success of matching using the 4-piece information available in WISLR local roads database.
- **Validation**: Real crash location data is not always cooperative with street names in WISLR. For example, street name may have alias; directional prefix information can be as brief as “N.” instead of “North”; and street name can be written either by number or by alphabet. All the information has to be validated and standardized before proceeding to the next step.
- **Match**: the match process is comprised by five levels of matching based on the amount of street name information used in this step: name matching, prefix-name matching, name-type matching, prefix-name-type matching and prefix-name-type-suffix matching. The logic behind is to start with the most rigorous matching process and gradually relax the condition until a successful match is found.

Module 2: Crash Data Plotter

Crash maps have been widely used for safety analysis because of the visual presentation of crash locations and clusters. To generate a crash map, however, is a labor intensive and time consuming process as Wisconsin has approximately 120,000 plus crashes a year. The objective of the crash data plotter is to digitize GIS-based crash maps by relating crash data with a roadway map (WISLR) in an automatic fashion. Once a crash is identified in WISLR with the proper node, link and offset, a point can be automatically produced on a map using ESRI Map Objects 2.3. Figure 3 shows the interface developed for the automatic crash plotting. Users are required to choose the county from the drop-down list and import the “uniquely found” crash file from the preceding step. This improvement from mapping the entire state at one time limits the data in a manageable size and controls user’s waiting time at a reasonable scale, which is essential to an on-line application. In the course of the application, crash points can be added dynamically to the map one by one through the map window and the progress is indicated through a status bar. Summary statistics is provided in the end. The output of this application is a shape (SHP) file that can be reviewed by most of the GIS products.

In the system testing stage, five-year (2002-2006) crashes in the off-state highway system in Wisconsin, a total of 392,862 crashes, were used. Among them, 267,882 crashes can be successfully digitized using the crash address locator and the crash data plotter, a near 70% success rate.
Module 3: Hazardous Locations Identifier

Geocoded crashes offer considerable convenience for aggregating crashes to individual intersections or segments on which they occurred. Using GIS techniques and spatial relationships, crash hot-spots for intersection-related crashes and weak links for segment-related crashes have been generated and ranked through a hazardous locations identifier module. At current analysis capacity, the number of crashes for each intersection was categorized by crash severity, crash type, and manner of collision using the crash data between January 2002 and December 2006. Crash severity includes property damage only (PDO) crashes, and Type C, B, A and K crashes. These letters indicate the severity of the crash injuries starting from minor (type C) to fatal injuries (type K).

A severity index was generated based on a weighted average of the number of crashes by severity, which can symbolize the total crash severity at a location. The crash type score was measured by summing up the product of the number of vehicles involved and the approximate cost incurred for each crash type. Eventually, a weighted average of the ratios of three individual criteria to their maximum values was calculated to obtain the “site of promise” list. Figure 3 shows...
the output following the previous input parameters. The output interface lists detailed information for each site ranked.

![FIGURE 3 Ranking results window showing crashes at an intersection.]

Module 4: Safety Project Recommendation and Development

Using the safety information generated from the previous three modules, safety engineers can perform further field investigation to recommend appropriate safety countermeasures and develop safety projects in conjunction with the local agencies. For example, working with the Wisconsin safety circuit riders, the research team has created a template for presenting crash information to local agencies. Information has been generated for six counties and delivered to responsible local agencies, including Chippewa, Marathon, Rock, Sauk, St_Croix, and Walworth. With the information, safety circuit riders are able to convince local agencies about their safety problems and assist them with the road safety review or safety audits.

Query Interface and Functions

One of the most important applications is to provide safety stakeholders with access and ability to query, display, and analyze crash information in both disaggregated way (information per crash) and aggregated way (crash information per intersection or roadway segment). The proposed functions allow users to either query via attribute or location. Query by attribute essentially displays all the found crashes from WisTransportal Crash Extract Facility on a map and query crashes by location allows users to search crashes by drawing an area or selecting a section of roadway of interest. The query tool is a web-based on-line application that provides users the access to the crash information wherever the internet connection is available. Note that the
application is protected by the password and the user is required to have an account in order to use it. Crashes can be queried by attribute in the similar context of the WisTransportal Crash Retrieval Facility or queried by location in a spatial context.

a. Query by attribute: For instance, the tool can immediately display crashes on a map queried directly from any attribute or their combinations provided in the WisTransportal Crash Retrieval Facility. Figure 4 shows the query by crash attribute whose interface is almost identical to the one in the WisTransportal Crash Retrieval Facility. The query function demonstrated in the screenshot is for all the alcohol-related crashes in Dane County in 2006. The found crashes are displayed in Figure 5 in which the interface is divided into three sections. Menu section contains all the functions represented by self-explanatory icons. The pane on the left contains a table of crash summary statistics and the pane on the right is the map section.

FIGURE 4  Query interface by crash attribute
b. Query by location includes two major operations: query by route and query by area. Query by route allows users to select the begin and end points of a route and search all the crashes occurred between point A and point B. Query by area allows users to draw a rectangular box or any irregular shape and query all the crashes within the geometry. Figure 5 and Figure 6 show the screenshots of query outcomes of “Query by Route” and “Query by Area”, respectively.
FIGURE 6  Query by route between point a and point b
The summary statistics of the queried crashes by injury severity can be displayed and printed simultaneously. The information is displayed on the left side of the window in the information pane. Taking advantage of the strength of GIS, detailed crash information can also be displayed next to the location of each crash. More importantly, digitized crash police report, if available, can be linked to these crashes and displayed through a simple click.

The web-based on-line crash query tool provides users a one-stop shop for crash information retrieval and query, crash location visualization, crash summary statistics, and information integration.