Reducing Traffic Fatalities Using GIS Data as a Deployment Guide

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ABSTRACT
In an effort to reduce fatalities on Alabama’s highways we propose a variety of trooper deployment advisory tools. Each tool contributes to our strategy, to deploy troopers to road segments at the times when their citations will be most effective. First, we describe our background and our access to necessary data sources. Second, we define our hot-spot taxonomy. Third, we illustrate some of preliminary tools. We then end with a brief summary.

1. BACKGROUND AND DATA SOURCES
We will first present how CRDL’s (CARE Research and Development Laboratory at the University of Alabama) existing applications relate to this work’s two primary data sources, crashes and citations.[6].

1.1 CARE
CARE, Critical Analysis and Reporting Environment, has been used for the past fifteen years to study Alabama crash and road data. CARE was designed to be used by transportation safety engineers[5]. Alabama’s crashes are currently documented on paper then later recorded in an electronic format for storage and analysis. Complete electric crash data is available approximately three months behind the current date. While CARE was originally created for crash analysis, other datasets such as citations can be used. In Alabama, only the crash that occur on mile-posted routes, the state routes and interstates, can be mapped. We refer to the non-mappable crashes as ”‘off system”’. Since our initial goal is to build an advisory system for the state troopers, the fact that the ”‘off system”’ crashes out number the ”‘on system”’ by two to one should not be a problem.

Current GIS functionality in CARE includes.

1. Plotting events. Figure 1 shows 2006 alcohol crashes.
2. Displaying graduated lines along roadways that represent event counts by segment. Figure 2 shows the same 2006 Alcohol crashes, this time as five mile line segments.
3. Displaying graduated lines along roadways that represent event counts by segment and normalized by ADT (Average Daily Traffic).
4. Displaying combined layers. Combined layers are count layers whose end weights are the sum of the counts from multiple filtered datasets multiplied by user supplied constants. Combined layers have been used to compare crashes with citations and give special emphasis to a specific group of crashes.
5. Displaying events along road segments that are considered hot-spots.
6. Creation of filters (rules to group events for further analysis) by selecting events on a map.
7. Corridor filter creation that selects all of the events with in a defined distance of a given roadway. Figure 3 shows the selection of crashes within 3 miles of a 40 mile stretch of a Wyoming highway.

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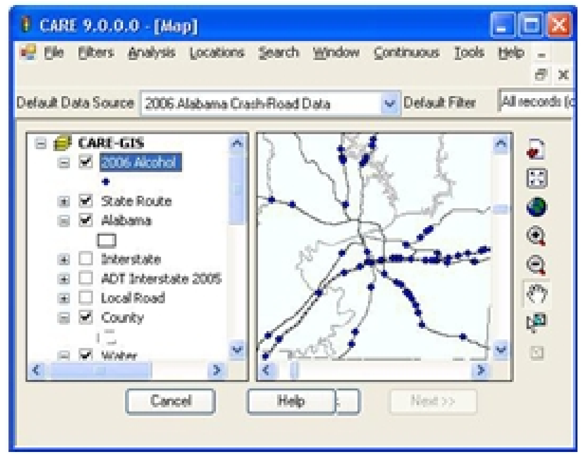

Figure 1: 2006 Alcohol Crashes

1.2 E-Citation
E-Citation is an application used by officers in their patrol cars to issue and record citations using a laptop (see Figure 4). The application requires peripherals such as a license scanner, printer and GPS receiver. It was deployed

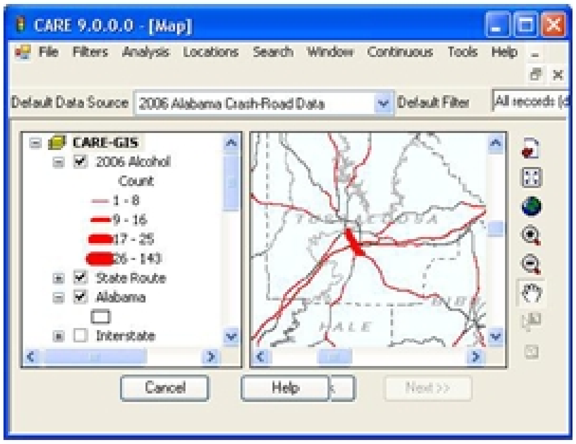

Figure 2: 2006 Alcohol Crashes, 5 mi. Segments

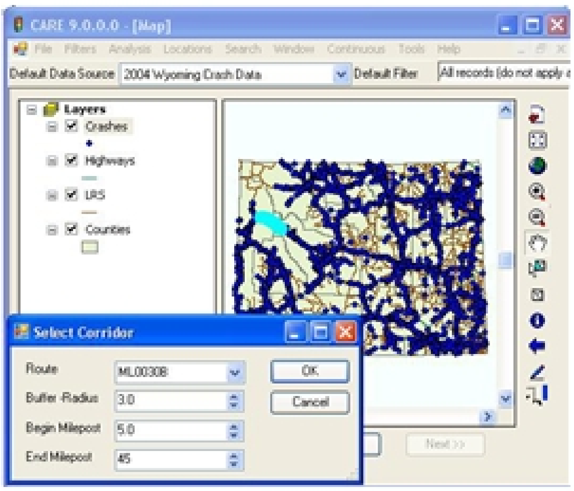

Figure 3: Corridor Selection

five years ago to a subset of Alabama's Troopers. In the past two years its usage has steadily increased. E-Citation is currently used by most Alabama State Troopers and more than 15 municipalities totaling more than 600 officers in Alabama. Officers periodically upload the citations to a central server, typically within a day. On a less frequent basis we make copies of the citation data for analysis in CARE.

When an officer is issuing a citation, E-Citation uses the officers current location to identify the county name and courthouse that should appear on the printed ticket. If the officer is close to a county line when issuing a ticket they are presented with a list of nearby counties. We are also considering providing the officer additional location based data as they patrol such as counts of crashes and citations within a fixed distance of their current position. To do this the event data will have to be stored on their laptops and queried using their current location.

2. HOT-SPOT TAXONOMY

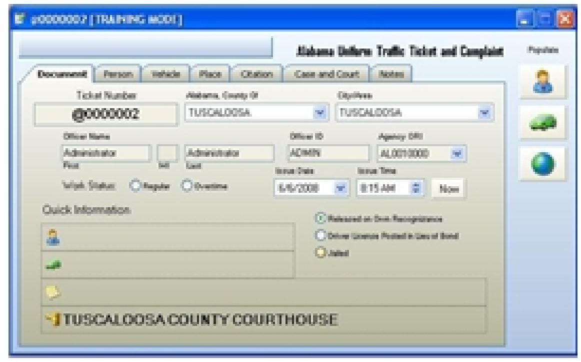

Figure 4: E-Citation

Figure 5 models the cycle of our data collection, hotpot definitions, presentation and feedback. Each of these categories will be described in this section.

2.1 Data Collection

The collection of this projects primary data sources, crashes and citations, was addressed in the first section. Here we will address the "'off system"' crash-location limitation and citation location collection issues. We will also briefly describe a few other domains where our planed advisory system may be used.

First, the inability to locate "'off system"' crashes will soon be solved as Alabama begins using a new crash form that includes lat/long fields. Fortunately, the task of creating an electronic crash form application, E-Crash, is under the leadership of CRDL. After discussions with other states, who have had issues reading accurate GPS locations directly input into their crash form, we have decided to use a combination of direct GPS reading, manual entry, and map clicking. We have not encountered the same difficulty with recent projects in Georgia, Wyoming and Nevada.

Second, collection of citation locations for study purposes has proved to be a challenge. We currently rely on the location of each citation to be read from a GPS unit that is attached to the officers laptop via USB. Often the GPS units are misplaced, malfunction, or are not plunged in for various reasons. When the units become a hassle they are just not used. We are providing additional location based features to E-Citation to encourage a more regular use of the GPS unit. These features include auto populating the current county, city and other location fields. We hope to get greater gps usage as the potential for this project is recognized.

Other development efforts at CRDL will provide data for related efforts. First, weight logs from weigh stations, WIM (weigh in motion) devices, and periodic measurements of road rutting can be used to define additional target zones. Second, we plan to use crime locations, drivers license information, and auto registration addresses as part of a social networking project aimed at aiding officers in building suspect lists. Lastly, we have developed a tool, SIREN (System for Intelligent Reporting of Every Narcotic), that will be used to locate drug crimes by drug type. We hope that an extension of our advisory system can be used to recommend

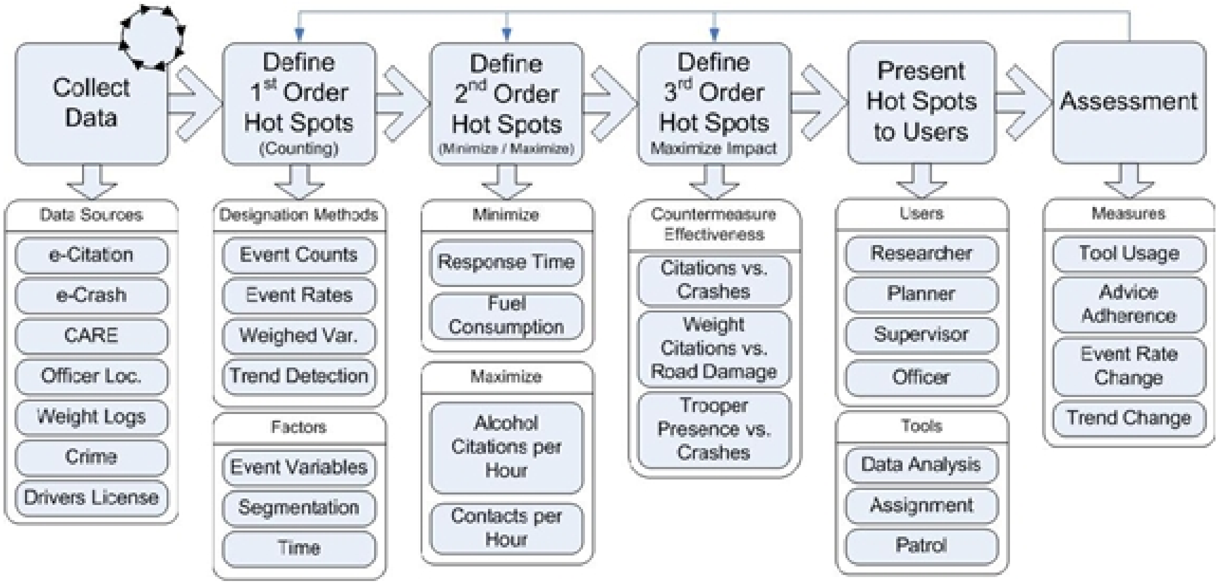

Figure 5: Hot-Spot Model

effective times and positions for countermeasures of these types of crimes.

2.2 1st Order Hot-Spots

First order hot spots are intented to give a high level view of events occurring along the roadways. In this section we will list several first order hotpot designation methods and consider a few key factors that must be considered.

2.2.1 Designation Methods

To begin, we use Hakkert's traditional hot-spot definition for our first order hot spots, "'Those sites whose accident frequency is significantly higher than expected at some prescribed level of significance"'[3]. McGuigan and Cheng's definitions of roadway hot-spots also include the notion of identifying road segments that have high event frequencies as compared to similar locations.[4][2] As discussed in section one, CARE provides this functionality for both crashes and citations by displaying graduated lines along segmented roadways according to event counts. CARE also provides event rates, which normalize the counts by ADT or any other roadway characteristics such as number of lanes or road type. Third, hot-spots can be defined using weighted variables. CARE allows the user to weight each event using any combination of variables (such as accident severity or alcohol involvement). Lastly, CARE can define hot-spots using trend detection (aka early warning). The trend detection hot-spots can alert the user to changes in event rates possibly due to road or patrolling changes. Currently these tools are only available using the CARE desktop application. We hope to soon make the tools more available to officers via a CARE web application.

2.2.2 Factors

Our current system relies on the user to make many choices when defining first order hot-spots. The user starts by selecting a subset of events by building a filter using any of the

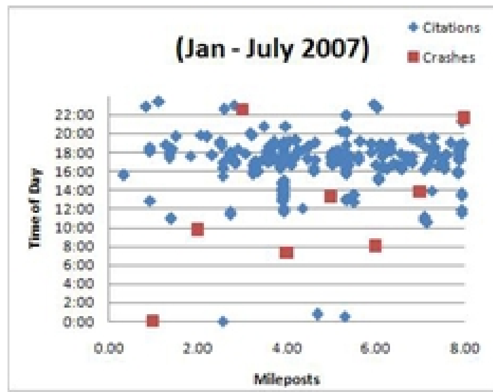

Figure 6: Time of Day Factor

associated event variables. In the case of Alabama crashes there are more than 200 variables to work with (more than a typical officer will need on a regular basis). Another important factor is how to segment the road, fixed or dynamic. Currently CARE only offers fixed segmentation and relies on the user to choose the length. It is also important to use time of day as a factor. Counts of crashes and citations for a given road segment vary greatly by time of day. Figure 6 shows the time of day when crashes and citations occurred on an eight mile road segment in Alabama from January to July 2007.

2.3 2nd Order Hot-Spots

Second-order hot-spots are based on where to position countermeasures to maximize or minimize something. For example, a department or individual officer may decide to try to maximize alcohol related citations. Second order hot-spots would be used to identify the locations and times when alcohol citations have historically been the greatest per time period. Second order hot-spots are characterized by their ”‘per time period”’ nature. A cynic would say that that second order hot-spots will be used to maximize revenue per time period (while this is possible, it is not likely). Second order hot-spots could also be used to minimize response time by positioning officers in ”‘optimal”’ locations.

2.4 3rd Order Hot-Spots

Third order hot-spots are a more expressive extension of first and second order hot-spots. Third order hot-spots not only express concentrations of events but relationships between them. Figure 5 lists three examples of third order hot-spots. The first example, Citations vs. Crashes, will show where citations have been the most effective in reducing crashes. It could also be used to show the opposite, areas where crashes tend to increase when citations increase.

2.5 Presentation

The appropriate presentation of the first and second order hot-spots will vary by user. We anticipate having four distinct groups of users (researchers, planners, supervisors, officers). Each group of users will have one or more tools geared toward their goals. First, extensions of the current CARE interface will play a dominate role for researchers. It provides the most power and freedom but at the cost of complexity. Second, We intend to build a planning tool to be used by officials orchestrating events such as ”‘Take Back Our Highways”’[1]. These periodic events require special planning and organization of large numbers of officers. Third, supervisors such as post commanders need a tool to plan patrols for a fixed area on a daily basis. We would like to give the supervisors flexibly to use various patrol strategies to impact the hot-spots. We will begin by recommending patrol routes that target hot-spots in proportion to their rank. We also plan to provide an alternative recommendation strategy, based on the chemotherapy model, that rotates intense treatment to each of the hot-spots.

The last, and largest, set of tools we will discuss here are designed for officers on and off patrol. First, we are working on a simplified web-interface that uses the CARE engine and allows officers to map events and hot-spots using sets of predefined filters. Figure 7 shows a CARE Web map of alcohol related crashes. Each map or chart result in the a CARE Web Application can be saved for repeat use as a gadget in Google, Yahoo, or our own portal designed for E-Citation users, E-Citation Dashboard. Figure 8 shows a second officer tool, E-Citation Dashboard, with a map of crashes per county. These gadgets will allow the officer to quickly view events that occurred during the previous month, week, day or shift. The content of the maps are sent to the viewing tool via a GeoRSS feed. Third, we have prototyped a hot-spot navigation system called Tour Guide. Tour Guide will provide audio commentary of approaching hot-spots as the officer drives or can be used to virtually navigate the roads while parked. Figure 9 shows a five mile segment of interstate 59. The user can navigate to a road segment by clicking on the map in the upper left corner. This tool will be especially valuable to help new officers learn where the hot-spots are located. Finally, we plan to build a route planning tool for the officer that includes approximate times and places to ”‘sit”’. The tool will use the officers current location, the current time, a destination-location and time, the patrol history, and sets of predefined hot-spots to recommend a route. When an officer’s plans change, possibly because of working a crash, the tool will be able to update the suggested route accordingly.

Figure 7: CARE Web Application

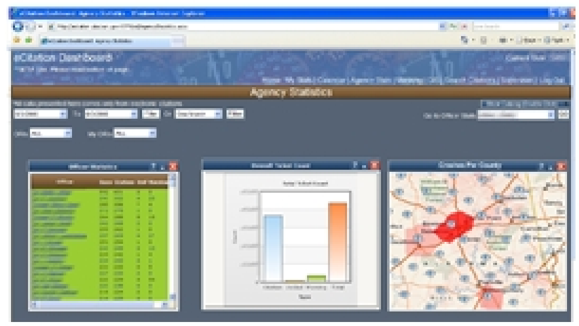

Figure 8: E-Citation Dashboard

2.6 Assessment

Before these tools are in place we must have a plan to assess their effectiveness. We will need to establish measures that answer the following questions:

1. How often are the tools used (measured per tool)?
2. When the tools are used, are the recommendations followed?
3. When the tools are not used, how close is the actual patrol behavior to what would have been recommended?
4. How dose the user rank the recommendations they receive?
5. How do the target event rates change?
6. Do crash trends shift?

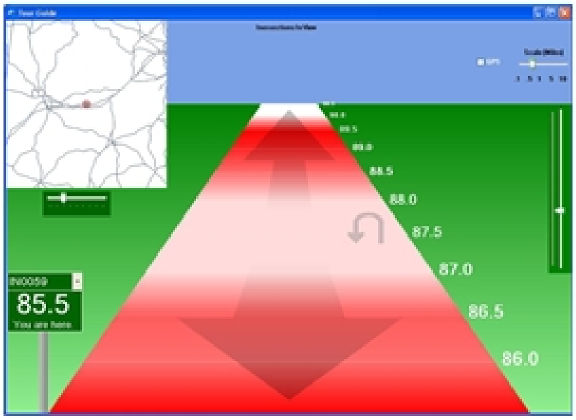

Figure 9: Tour Guide

Lessons learned from these questions will be fed back into the process of defining first, second, and third order hot-spots. The answers may also inform the design of the hot-spot presentation.

3. SUMMARY

We believe that believe that the issuance of citations makes our roadways generally safer by changing driver behavior. It is our goal to improve this positive influence by optimizing the times and locations of citations using historical data as an aid. The hot-spot taxonomy we presented is used to differentiate between types of targets and goals. The tools we discussed target our various user groups. We look forward to assessing the effectiveness of the taxonomy and tools.

4. REFERENCES

[1] Alabama state troopers save lives, enhance safety in 'take back our highways' initiative. American Association of Motor Vehicle Administrators.

[2] W. Cheng. Experimental evaluation of hotspot identification tools. Accident Analysis and Prevention, 37:870-881, April 2005.

[3] A. S. Hakkert and D. Mahalel. Estimating the number of accidents at intersections from a knowledge of the traffic flow on the approaches. Accident Analysis and Prevention, 10:69-78, March 1978.

[4] D. McGuigan. The use of relationships between road accidents and traffic flow in blackspot identification. Traffic Engineering and Control, 22:448, 451, 453, August 1981.

[5] A. Parrish, B. Dixon, D. Cordes, S. Vrbsky, and D. Brown. Care: an automobile crash data analysis tool. Computer, 36:22-30, June 2003.

[6] D. A. Steil. Toward a trooper advisory system using crash and citation data. In 2008 ESRI South Eash Regional User Group. ESRI, 2008.