HSIS

Highway Safety Information System

SUMMARY REPORT

Using GIS in the Analysis of Truck Crashes

COMPUTERIZED CRASH ANALYSIS SYSTEMS IN WHICH CRASH DATA, ROADWAY INVENTORY data, and traffic operations data can be merged are used in many States and municipalities to identify problem locations and assess the effectiveness of implemented countermeasures. By integrating this traditional system with a GIS which offers spatial referencing capabilities and graphical displays, a more effective crash analysis program can be realized. In a recent FHWA-sponsored study, a crash referencing and analysis system within a GIS was developed within the Highway Safety Information System (HSIS) State of North Carolina for the area of Wake County and provides the functions needed to edit both tabular and spatial crash and roadway data as well as perform crash analyses related to intersections, roadway segments, and special highway features such as bridges. A complete description of the GIS-based crash referencing and analysis system is provided in a separate HSIS summary report.[1]

With the system complete, a second phase of the project began with the identification of an analysis effort that could be undertaken to truly illustrate the advantages of a GIS-based crash analysis system. The problem selected was the identification and analysis of high-truck-crash locations, both along designated truck corridors and on other roadways within the county. The goal of the study was to determine if there are benefits to using a GIS-based crash referencing system over the traditional data bases that contain crash, roadway feature, and operations data that can be linked by location. Specific objectives for the project included: 1) identifying high-truck-crash locations using the GIS-based system, and 2) exploring the applicability of non-traditional data bases to this type of analysis.

Within Wake County, specific roadways are designated as part of the truck route network. All trucks greater than 8 ft in width or 45 ft in trailer length must travel on the designated routes with two exceptions. First, all trucks are allowed to travel up to 3 driveable miles off the network to reach their destination. For example, a truck could turn onto a roadway that intersects with the designated truck route, travel two miles and then turn onto another connecting roadway and travel another mile. The second exception refers to trucking terminals that are outside the 3-mi buffer; trucks are allowed to reach their terminals, but the route must be approved by the NCDOT. Of the 1,821 mi of roads in the county, 135 mi (7% of the total) are designated truck routes. An additional 692 mi (38%) are roads that are within 3 driveable miles of a designated truck route. Combining these values, more than 45% of the roadways in the county are considered to be part of the designated truck system.

The Highway Safety Information Systems (HSIS) is a multi-State safety data base that contains accident, roadway inventory, and traffic volume data for a select group of States. The participating States, California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington, were selected based on the quality of their data, the range of data available, and their ability to merge data from the various files. The HSIS is used by FHWA staff, contractors, university researchers, and others to study current highway safety issues, direct research efforts, and evaluate the effectiveness of accident countermeasures.

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Identification of High-Crash Locations

Locating high-truck-crash locations within the county required the development of a program that could identify crashes both along the primary routes (truck-designated and undesignated) and the connecting roads that were within the 3-mi buffer. High-crash locations along the primary routes could be identified using the *sliding scale program* that had been developed as part of the initial crash referencing and analysis system.[2] This program is used to identify roadway segments with a high crash occurrence by “sliding” along a route in an incremental manner and examining pre-defined segment lengths. The user defines the segment length and the increment length for analysis. For example, if the segment length is defined as 0.50 km and the increment length is 0.10 km, the program starts at the beginning of a route and analyzes the first segment from 0.00 to 0.50 km, then slides 0.10 km and analyzes the second segment from 0.10 to 0.60 km. If the crash rate of any strip meets or exceeds the user-defined threshold, the segment is extended by the incremental distance, and the process is repeated. A segment is ended when the maximum milepost of the route is reached or when the user-defined number of allowable extensions without a crash is exceeded. Based on other user-defined parameters, intersections can either be ignored, excluded based on a buffer around each intersection, or included without any buffer and inclusive of crashes within a specified distance on intersecting routes.

Parameter	Value
Starting Length	1.6 km (1.0 mi)
Extension Length	0.16 km (0.1 mi)
Maximum Extensions Without a Crash	5
Crash Rate	0
Average Crash Rates (per million vehicle-miles)	0.104–Interstate 0.088–U.S. Routes 0.086–NC Primary 0.063–NC Secondary
Exclusion Distance	0
Y-Line Distance	0

Table 1. Values used for the sliding-scale input parameters.

Using this program, the 7 routes within the county that are designated as truck routes and the 11 other primary routes that are not designated for truck traffic were analyzed using the input values shown in **table 1**. Note that an exclusion distance of zero was used. Thus, truck crashes occurring at intersections along the routes were included in this analysis. From the analysis, there were a total of 18 segments on 8 routes that were identified as high-crash locations, i.e., the truck crash rate for those segments exceeded the critical rate. These high-crash segments ranged in length from 1.0 mi to 1.8 mi, and the number of crashes ranged from 1 to 18. Examination of the plotted results in **figure 1** indicates that only 9 of these 18 high-crash segments were actually on designated truck routes. The remaining 9 segments were on undesignated primary routes. More importantly, three of these segments were outside the 3-mi driveable buffer.

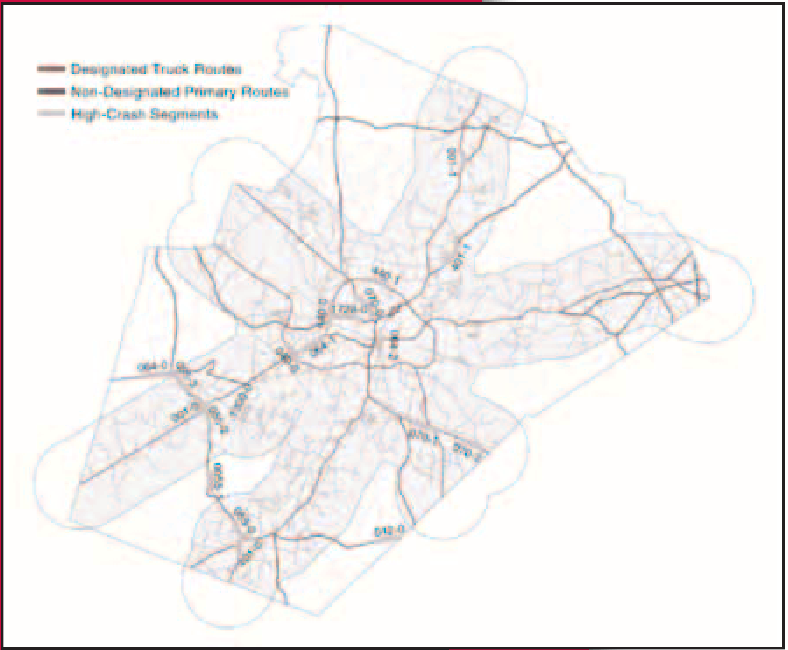

Figure 1. Location of all trucking terminals currently operating within Wake County in relation to the high-truck-crash segments and zones.

When the results were rank-ordered by injury severity index, the three segments with the highest index values (055-2, 055-4, and 042-1) are on roadways where trucks are not generally permitted. Further visual inspection of **figure 1**, however, reveals why these locations attract truck traffic. NC 55 transverses the southwest portion of Wake County and connects several of the designated truck routes (i.e., US 401, US 1, and I-40). NC 42 extends across the southern portion of the county and connects US 401 to I-40. These routes are simply shortcuts used by truck operators to minimize travel times. Unfortunately, some of these trucks are becoming involved in crashes on these roadways that may not be designed to accommodate these large vehicles.

Identifying high-truck-crash locations off the primary designated truck routes required a separate program that was developed specifically for this study. This program, referred to as the *corridor analysis program*, provides the capability to link and analyze multiple routes within a corridor as a group. With respect to this analysis effort, it allowed for the determination of high-truck-crash locations off the primary route, but within the 3-mi driveable buffer. The program was designed to traverse down each route, locate each intersection, traverse 3 miles in all directions from each intersection on all possible roads, compute a crash rate for these roads, and compare this rate to a critical rate computed for this same set of roads. As with the sliding scale analysis above, the high-crash locations are those that have crash rates that are equal to or greater than the critical rate.

The analysis resulted in 20 sites that were considered high-crash locations, where a site included each access point or intersection along a designated truck route and all roadways within 3 driveable miles. Since some of the roadways within the 3-mi driveable buffer could be accessed from more than one intersection along the truck route, there were cases where the same crash on one of these roadways was linked to more than one intersection. Being that it was not possible to know which intersection the truck was traveling to or from, it was appropriate to link the crash to all intersections that were within 3 driveable miles. By grouping the intersections containing identical crashes and removing the redundant crashes, a total of eight distinct high-crash zones were identified as shown in **figure 2**.

High Crash Zone	Number of Terminals	Number of Crashes	Ratio
1	5	17	3.4
2	14	97	6.9
3	64	100	1.6
4	10	75	7.5
5	15	24	1.6
6	8	5	1.6
7	2	8	4.0
8	3	6	2.0

Table 2. Number of trucking terminals and crashes associated with the high crash zones.

Exploration of Other GIS Applications

With the high-crash locations identified, the next step was to demonstrate how the GIS-based crash referencing system could be used to further analyze these high-truck-crash segments and zones. The intent here was not to conduct a detailed analysis of the truck crashes identified but rather to illustrate how the GIS can be used to increase the understanding of the problem. Both traditional and non-traditional data bases can be used with GIS in analyzing the results. For example, any of the traditional variables maintained in the HSIS roadway inventory data base (e.g., lane width and shoulder type) can be associated with the identified high crash sites in an attempt to determine if there are geometric deficiencies which may be contributing to the problem. The results of such an analysis plotted using the GIS can be used to determine the percentage of crashes occurring on roadways with narrow lanes or no paved shoulders and could then be used to determine where shoulders need to be added and lanes need to be widened to accommodate trucks.

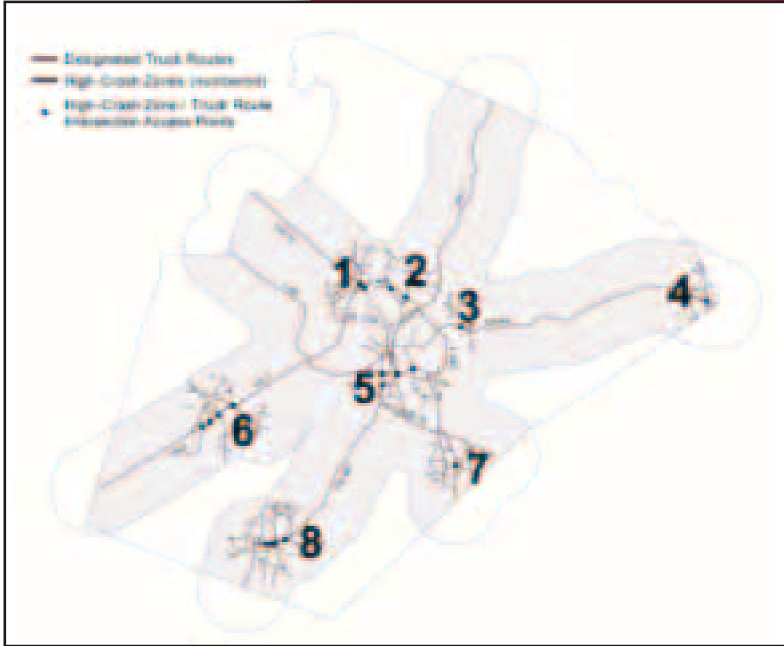

Figure 2. High truck-crash zones within the 4.8-km (3-mi) driveable buffer identified using the *corridor analysis program.*

With respect to the nontraditional data bases, one potential exposure measure that was thought to be relevant to truck crashes was the location of trucking terminals. These data existed only as a set of addresses. With the addresses of the terminals entered into the GIS, information such as the number of terminals located within a high-crash zone or along a high-crash corridor could be extracted. Shown in **table 2** are the number of terminals, number of crashes, and a ratio of crashes to terminals for each of the eight high-crash zones shown in **figure 2**. Assuming terminal locations are a valid exposure measure, this analysis would lead one to examine zones 2 and 4 more closely. Other more useful measures that could be used in a similar manner include the number of trips generated by each terminal and origin-destination information.

Other nontraditional data bases explored as part of this research effort included land use files, census files, and zoning data. While this type of information may not be directly correlated to truck crashes, it was feasible to integrate the two data sets within the analysis as proof of concept. The value of such data bases may prove to be quite valuable for other purposes related to truck transportation. Specifically, these data could be used to determine where new truck routes should be designated or to make decisions regarding alternate truck routes during construction projects or emergency situations when large trucks would need to be re-routed.

Conclusions

The overall goal of this project was to illustrate the advantages of using a GIS-based crash referencing system for high-crash identification and analysis. There are several that were applied during the conduct of this study:

Locational Referencing The spatial referencing capabilities of a GIS to locate links and nodes of a highway system in two-dimensional coordinates and connect roadways together is what made the development of the corridor analysis program feasible. As previously described, the program designed for this effort traversed a given route, located each intersection, and traveled up to 3 miles from that intersection in all directions on all possible routes. This type of analysis would have been virtually impossible to do manually.

Incorporation of Nontraditional Data Bases Data bases that are not traditionally used in crash analyses (e.g., census data) can be incorporated and examined for possible relationships to crashes. Data sets that can be translated to spatial coordinates, such as the trucking terminal data used above, may also be incorporated for this type of analysis.

Visual Analysis One of the most powerful features of a GIS-based system is the capability to produce figures or maps that can be used to visually assess the problem. This fact was demonstrated in this effort in several ways:

1) The plot of high-crash corridor segments overlaid on the route system quickly showed that 50 percent of the segments were not on designated truck routes (see **figure 1**).

2) Plotting the truck crashes on the high-crash zone map quickly showed the predominate routes and minor intersections within each zone where crashes were occurring most often (see **figure 2**).

3) The trucking terminal map overlaid on the route system indicates which terminals are inside and outside the 3-mile driveable buffer. For both present and proposed terminals outside the buffer, this system would allow one to determine the most appropriate routes on which to allow those trucks. For example, the lane widths, shoulder types, and crash histories could be shown for all routes being considered and factored into the decision.

Overall, this project produced results which were both useful in terms of the topic analyzed, i.e., high-truck-crash locations, and with respect to illustrating how a GIS crash-based referencing and analysis system can be used to analyze a complex problem.

REFERENCES

1. *A GIS-Based Crash Referencing and Analysis System*, HSIS Summary Report, Publication No. FHWA-RD-99-081, Federal Highway Administration, Washington, DC, February, 1999.
2. *Crash Referencing and Analysis System—User Manual*, North Carolina Center for Geographic Information and Analysis, Raleigh, NC, 1996.
3. D.L. Harkey, "Evaluation of Truck Crashes Using a GIS-Based Crash Referencing and Analysis System," presented at the TRB Annual Meeting, January 1999, to be published by the Transportation Research Board, Washington, DC, 1999.

FOR MORE INFORMATION

This research effort was sponsored by the Federal Highway Administration. The full report, *Evaluation of Truck Crashes Using a GIS-Based Crash Referencing and Analysis System*, is being published in an upcoming Transportation Research Record.[3] The North Carolina Center for Geographic Information and Analysis (CGIA) and the North Carolina Department of Transportation (NCDOT) provided technical assistance to the University of North Carolina Highway Safety Research Center in conducting this project.

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